THAIS ASSIS DE SOUZA

RESPONSIBLE INNOVATION IN MOBILITY SYSTEMS:

A SUPPORT FOR GOVERNANCE OF SMART AND SUSTAINABLE UNIVERSITIES CAMPUSES

LAVRAS – MG
2022

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Tese apresentada à Universidade Federal de Lavras, como parte das exigências do Programa de Pós-Graduação em Administração, área de concentração Gestão Estratégica, Marketing e Inovação, para obtenção do título de Doutor.

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INOVAÇÃO RESPONSÁVEL EM SISTEMAS DE MOBILIDADE:
SUPORTE PARA GOVERNANÇA DE CAMPUS UNIVERSITÁRIOS INTELIGENTES E SUSTENTÁVEIS.

L'INNOVATION RESPONSABLE DANS LES SYSTÈMES DE MOBILITÉ :
UN SUPPORT POUR LA GOUVERNANCE DES CAMPUS UNIVERSITAIRES INTELLIGENTS ET DURABLES.

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To my parents, my examples, my safest place, Sebastião and Elaine.

To my sister, my best friend, Alyne.

I Dedicate

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"Research is formalized curiosity. It is poking and prying with a purpose."
Zora Neale Hurston

GENERAL ABSTRACT

There is a global recognition of cities as critical systems to provide sustainable human development. As innovation environments focused on better conditions for collective well-being, cities have been characterized by a high density of population and activities, generating social, educational, cultural and health functions that are developed in a fragile context. This scenario highlights issues related to safety, housing demand, jobs, basic services, infrastructure aspects such as adequate and well-connected transportation systems, and other elements that impact urban life. Mobility, as one of the urban systems, has faced new demands that call attention to the integrity of the natural, economic, and social systems, requiring adequate and integrated planning. For this, it is fundamental to structure a definition of governance that supports the urban practices and processes of regulatory authorities, businesses, and society in a systemic apparatus. Therefore, the aim must be the development of a framework that is more integrative, prospective, responsive, aware of impacts for future generations, and capable of creating, capturing, and assimilating value from the scenario that changes and is increasing in terms of opportunity. In this thesis, to cope with this context, we are proposing discussions based on the concept of smart and sustainable cities and communities, quintuple helix (5H), and responsible innovation (RI). The challenges are proposed to be eased by developing a responsive performance system based on critical success factors (CSFs) analysis. In this sense, the general objective is to identify and discuss critical factors to support the development of a responsible urban mobility system as an element of smart and sustainable cities. In order to address a context of less complexity than cities, this thesis proposes an application on University Campuses. Like cities, university campuses are ecosystems composed of different entities that operate under a more centralized policy and legislative body, such as a smaller scale of a municipal government. In this project, two universities were chosen as cases for study. Both institutions aim to incorporate smartness and sustainability aspects in their campuses and mobility system: Federal University of Lavras (Brazil) and University of Paris-Saclay (France). This application is guided by a Design Science approach and presents a qualitative methodological character with an exploratory nature. Data collection was based on primary and secondary sources: academic literature, official documents, focus groups, and online surveys. Concerning analysis, content analyzes, descriptive qualitative analyzes, descriptive, and multivariate were performed. The qualitative analysis of the case studies will provide a holistic view of mobility systems. The different national contexts will high-light important aspects that can contribute to policy and managerial processes. Furthermore, communities can be supported to structure benchmarks as well as solution finding and decision-making processes appropriately, stimulating relevant and necessary discussions about a responsible urban mobility system. The proposed discussions are guided to highlight contextual insights, being relevant to the macro level of cities and other communities.
Keywords: Responsible Innovation. Quintuple Helix. Urban Mobility. University campuses. Smart cities' performance. Sustainable cities.

RESUMO GERAL

Há um reconhecimento global das cidades como sistemas cruciais para proporcionar um desenvolvimento humano sustentável. Como ambientes de inovação focados em melhores condições para o bem-estar coletivo, as cidades têm se caracterizado por uma alta densidade populacional e de atividades, gerando funções sociais, educacionais, culturais e de saúde que são desenvolvidas em um contexto frágil. Este cenário ressalta questões relacionadas à segurança, demanda habitacional, empregos, serviços básicos, aspectos de infraestrutura como sistemas de transporte adequados e bem conectados, e outros elementos que impactam a vida urbana. A mobilidade, como um dos sistemas urbanos, tem enfrentado novas demandas que chamam atenção para a integridade dos sistemas naturais, econômicos e sociais, exigindo um planejamento adequado e integrado. Para isso, é fundamental estruturar uma definição de governança que suporte as práticas e processos urbanos de autoridades reguladoras, empresas e sociedade em um aparato sistêmico. O objetivo deve ser o desenvolvimento de uma estrutura que seja mais integradora, prospectiva, responsiva, consciente dos impactos para as gerações futuras e capaz de criar, capturar e assimilar valor do cenário dinâmico. Para lidar com este contexto, propomos discussões baseadas no conceito de cidades e comunidades inteligentes e sustentáveis, hélice quíntupla (5H), e inovação responsável (IR). Os desafios são propostos de serem amenizados através do desenvolvimento de um sistema de desempenho responsivo baseado na análise dos fatores críticos de sucesso (FCSs). Neste sentido, o objetivo geral é identificar e discutir os fatores críticos para apoiar o desenvolvimento de um sistema de mobilidade urbana responsável como um elemento de cidades inteligentes e sustentáveis. A fim de abordar um contexto de menor complexidade do que as cidades, esta tese propõe uma aplicação em Campus Universitários. Como as cidades, os campuses universitários são ecossistemas compostos por diferentes entidades que operam sob uma política mais centralizada e um órgão legislativo, como por exemplo, uma escala menor de um governo municipal. Neste projeto, duas universidades foram escolhidas como casos de estudo. Ambas as instituições têm o objetivo de incorporar aspectos de inteligência e sustentabilidade em seus campi e em seu sistema de mobilidade: Universidade Federal de Lavras (Brasil) e Universidade de Paris-Saclay (França). Esta aplicação é guiada por uma abordagem de Design Science e apresenta um caráter metodológico qualitativo com caráter exploratório. A coleta de dados foi baseada em fontes primárias e secundárias: literatura acadêmica, documentos oficiais, grupos de discussão e pesquisas on-line. Com relação à análise, foram realizadas análises de conteúdo, análises qualitativas descritivas, descritivas e multivariadas. A análise qualitativa dos estudos de caso proporcionou uma visão holística dos sistemas de mobilidade. Os diferentes contextos nacionais destacaram aspectos importantes que podem contribuir para os processos políticos e gerenciais. Além disso, as comunidades podem ser apoiadas para estruturar benchmarks, bem como processos de busca de soluções e tomada de decisões de forma apropriada, estimulando discussões relevantes e necessárias sobre um sistema de mobilidade urbana responsável. As discussões propostas são orientadas para destacar insights contextuais, sendo relevantes para o nível macro das cidades e outras comunidades.
Palavras-Chave: Inovação responsável. Quíntupla Hélice. Mobilidade Urbana. Campus Universitários. Performance de cidades inteligentes. Cidades sustentáveis.

RÉSUMÉ GÉNÉRAL

Les villes se définissent comme des systèmes essentiels pour assurer un développement humain durable. En tant que lieux d'innovation axés sur l'amélioration des conditions de bien-être collectif, les villes se caractérisent à la fois par une forte densité de population et d'activités et des fonctions sociales, éducatives, culturelles et sanitaires qui se développent dans un contexte fragile. Cette évolution met en lumière des questions liées à la gestion des infrastructures publiques (avec notamment des systèmes de transport adaptés et bien connectés), à la sécurité, à la demande croissante de logements, aux emplois, aux services de base nécessaires dans un contexte urbain. Le système de mobilité, est un de ces systèmes urbains essentiels qui est confronté à de nouvelles exigences. Afin de prendre en compte l'intégrité des systèmes naturels, les enjeux économiques et sociaux, une planification adéquate et intégrée doit être assurée. Pour ce faire, il est fondamental de structurer une définition de la gouvernance qui soutienne les pratiques et processus urbains des autorités de régulation, des entreprises et de la société dans un dispositif systémique et durable. L'objectif doit être le développement d'un cadre plus intégratif, prospectif, responsable, conscient des impacts pour les générations futures, et capable de créer, de capturer et d'assimiler la valeur d'un scénario qui change et se développe en termes d'opportunités. Pour faire face à ce contexte, nous proposons dans cette thèse de mobiliser des réflexions basées sur le concept de villes et communautés intelligentes et durables, de quintuple hélice (5H), et d'innovation responsable (IR). Notre objectif est de développer un système de performance d'un territoire porteur d'un projet de mobilité basé sur l'analyse des facteurs critiques de succès (FCS). Ainsi, nous identifions et discutons des facteurs critiques pour soutenir le développement d'un système de mobilité urbaine responsable dans des villes intelligentes et durables. Afin d'aborder un contexte moins complexe que celui des villes, cette thèse propose une application territoriale sur des campus universitaires. Les campus sont en effet des écosystèmes composés de différentes entités qui sont coordonnés par un organe politique et législatif et sont centralisés. Dans ce projet, comme le contexte institutionnel et social est important, deux universités différentes ont été choisies comme cas d'études. De plus, ces deux institutions intègrent des préoccupations de promouvoir une mobilité connectée et durable : l'Université Fédérale de Lavras (Brésil) et l'Université de Paris-Saclay (France). Cette application est analysée au travers d'une approche de Design Science et présente un caractère méthodologique qualitatif de nature exploratoire. La collecte de données a été basée sur des sources primaires et secondaires : littérature académique, documents officiels, groupes de discussion et enquêtes en ligne. Concernant l'interprétation des informations, des analyses de contenu, des analyses qualitatives descriptives, descriptives et multivariées ont été réalisées. L'analyse qualitative des études de cas permet d'obtenir une vision holistique des systèmes de mobilité. Les conclusions de ces analyses portent sur des préconisations politiques et d'aide à la décision quant à la mise en œuvre des systèmes de mobilité urbaine responsables sur un campus universitaire.

Mots clés : Innovation responsable. Quintuple hélice. Mobilité Urbaine. Campus universitaire. Performance des smart cities. Villes durables.

SUMMARY

FIRST PART

"Science knows only one commandment — contribute to science."

(Bertolt Brecht)

1. GENERAL INTRODUCTION

The present study addresses the issue of the Urban Mobility using the lenses of Responsible Innovation, Quintuple Helix, and Governance. This introductory section presents the contextualization and motivation, the research question, the objectives, the justifications, and the structure of this doctoral thesis.

1.1 Research contextualization and motivation

A current snapshot of cities can be seen as a combination of urban growth and a prominent economic transformation. This scenario has been taken as a current problematic issue since it is related to trends of a growing population, high energy consumption levels, waste production, and greenhouse gas emissions. The abovementioned factors call attention to the integrity of natural, economic, and social systems, demanding adequate and integrated planning (GÜNERALP; SETO, 2008; KLOPP; PETRETTA, 2017; VERMA; RAGHUBANSHI, 2018).

The global population in 2020, according to the World Bank, was about 7,7 billion people and more than a half live in cities (THE WORLD BANK, n.d.a). The urban population's growth raised 4.5% between 2010 and 2020, a growth has a concentration in less developed regions of the world, which is expected to rise to 68% by 2050 (THE WORLD BANK, 2020; WORLD HEALTH ORGANIZATION [WHO], n.d.a).

Urban density is key to categorize, analyze and understand trends related to the city's system. However, analyzing density is not enough (GARAU; PAVAN, 2018). Effective data management needs holistic analyses that include the different urban systems (ABREU; MARCHIORI, 2018).

Cities can be seen as places of innovation where wealth and employment are created focusing on better conditions for collective well-being. At the same time, urban areas have been characterized by high population and activity density, infrastructure problems, social, educational, cultural, and health functions that are developed in a fragile environmental context (BEK et al., 2018). This panorama reflects many interactions that can negatively affect life inserted in the broad space between the land surface and the sky (CRUTZEN, 2004).

Over the years, aspects such as population growth and urbanization are bringing forward new issues related to safety, housing demand, jobs, basic services, and infrastructure aspects such as suitable and well-connected transport systems, and to other elements that impact urban life (CORWIN et al., 2019; BUTLER et al., 2020). Terrestrial transport has changed in several forms in the past 300 years, including traction, motors, and fuels. As a result, mobility systems also change (ITF, 2019).

Beyond getting from point A to point B, mobility can influence how people live, work, access services, goods, and leisure, impacting the quality of transport and economic activities (MIRANDA; SILVA, 2012; SURAKKA et al., 2018; WOLFF; CALDAS, 2018; ITF, 2019). Therefore, new demands for mobility in terms of efficiency, sustainability, and equitability of the transport system emerge (ITF, 2017, BIBRI and KROGSTIE, 2017; GARAU; PAVAN, 2018).

The current mobility model is based on ownership, individual mobility, and fossil fuels as the key resource, resulting in (or intensifying) problems such as climate change, air quality, congestion, social exclusion, and inequalities (NEMOTO et al., 2021). To cope with this context, two concepts emerged: "sustainable city" and "smart city" (RASCA; WAEBE, 2019). Despite the popularity, these concepts do not have a commonly agreed definition, causing difficulties in their application in scientific, political, and managerial terms (HUOVILA et al., 2019).

Closely related to Information and Communication Technologies (ICTs), the smart concept has become mainstream in debates on urban issues. However, researchers have discussed that technology facilitates other progress, but technology by itself is not enough. Therefore, there is a need to incorporate and emphasize the sustainable character into smart city models to provide better support for urban practices, processes, and definitions (BIBRI; KROGSTIE, 2017). As a result of such discussions, the approach of smart and sustainable cities emerged (GARAU; PAVAN, 2018).

Cities are places where opportunities and threats to sustainable development are combined (FOLTÝNOVÁA et al., 2020). Boarnet and Crane (2001) stated that a problem occurs if the system is not prepared to gather benefits while avoiding the negative outcomes. Transportation services can increase industrial activities, individual incomes, private well-being, and consumption. On the other hand, the contradictory effects of socio-economic policies, the unlimited needs of users, and the miscoordination of stakeholders in the mobility system can lead to unsustainable solutions and negative externalities, such as pollution, urban congestion, overuse of public spaces for parking, risk of death or serious injury, noise, and disruption of communities and ecosystems (BENEVOLO et al., 2016; ITF, 2017; KNUPFER et al., 2018).

Given the key position of cities in the global sustainability challenge, the United Nations 2030 Agenda for Sustainable Development proposed the Sustainable Development Objective (SDGs) dedicated to cities and communities one of the 17 thematic areas. The SDG 11 aims to support cities and communities' transformation towards contexts safe, resilient, inclusive, and sustainable (UNITED NATIONS, n.d.). In this sense, this goal elucidates the need for improving cooperation among different stakeholders in governance definitions (LEAL FILHO et al., 2017).

The current organization of urban mobility is characterized by an institutional fragmentation into policy jurisdiction, political authority, and public funding with low coordination to meet supply and demand. These aspects can impact on coordination of urban transport services, offers, and costs. To address the cities' challenges and take advantage of the possible advances, it is necessary to develop a governance framework of urban mobility considering a definition of integrative governance (GEOFFRON, 2017; CORWIN et al., 2019).

As new paths to the future of mobility begin to be revealed, regulators, companies, and society need to keep attention to plan actions in a systemic apparatus. In terms of governance, questions turn from the 'why' to 'how' to tackle challenges. A useful and promising framework that attempts to 'how' questions considering different points of view (multiplicity of stakeholders) is the Quintuple Helix Model (BACCARNE et al., 2016; MARUCCIA et al., 2020).

Based on the interaction of universities, government, industry, society, and sustainability, the Quintuple Helix (5H) model represents a system of synergy between knowledge, technology, innovation, ecology, society, economy, and democracy, developing a win-win situation (CARAYANNIS; CAMPBELL, 2010; CARAYANNIS et al., 2015). In a 5H perspective, all systems influence each other, stimulating new knowledge and innovation based on a transdisciplinary and interdisciplinary view (CARAYANNIS et al., 2017).

Nevertheless, developing an urban mobility system that embodies all stakeholders and elements for effectiveness is a challenge. Therefore, the aim must be the development of an integrative, prospective, and responsive framework capable of creating, capturing, and assimilating value from the scenario that changes, which is increasing in terms of opportunity (DITTA et al., 2016). Institutions must reflect on the consequences of their actions and consider the integrity of the future as an issue. This idea can be led by the Responsible Innovation (RI) concept (STILGOE et al., 2013).

In its broadest vision, responsible innovation includes questions of governance, objectives, motivations, stakeholders, and social and political constitutions. Von Schomberg (2013, p. 19) offers a definition of RI as:

> a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society).

In this sense, responsibility is related to an attitude to reflect about consequences in the present, seeking to anticipate future ones to act properly with values and norms of a given society, seeking to benefit a system as a whole. Therefore, a sense of responsibility offers the potential to manage uncertainties and allows reflection on purposes and the projects' planning to minimize negative effects (JONAS, 1984; STILGOE et al., 2013; LEGAULT et al., 2018). It represents effective innovation management that should lead to development considering its social, economic, and environmental impacts (PAVIE; CARTHY, 2015).

Aiming to include integration and sustainability in mobilities' projects, developing a plan encompassing social, economic, and environmental aspects (HANAFI et al., 2015), the 5H is considered useful to guide this doctoral thesis governance processes of the urban mobility oriented by responsible principles. Besides, as an operational approach, it is proposed that the related challenges can be eased by developing responsive indicator systems that include goals from all stakeholders, facilitating the development of solutions to specific contextual problems (VERMA; RAGHUBANSHI, 2018).

Urban mobility's evaluation and monitoring systems require a strategic, useful, available, actionable, assessable, and consistent definition to provide quality and reliability for governance over time (CHANG et al., 2018; KARJALAINEN; JUHOLA, 2021). Indicators are essential tools for providing information to guide governance decisions. Several initiatives have been developed to guide and monitor performances of the various urban systems (LÜTZKENDORF; BALOUKTSI, 2017; MERINO-SAUM et al., 2020), such as ISO 37120 (Sustainable Cities and Communities – indicators for city services and quality of life), which involves guidelines to promote social and economic growth while maintaining environmental awareness (MOSCHEN et al., 2019). However, as stated by Halla et al. (2022, p.10), "rather than simply offering facts, assessments aiming to serve governance should tell a 'story' that brings the indicators to life by discussing them in their context".

Therefore, this doctoral thesis is guided by the premise that a governance framework based on ethical, comprehensive, responsive, reflexive, and constructive interchanges between the stakeholders can offer positive results and solutions to environmental, social, and market issues. This definition requires considering an integrative and interactive arrangement, a collective vision, a critical view on the supply capacity, the urban characteristics (context-based), and the interrelated technical, social, and environmental aspects. Such a governance framework is proposed based on RI's premises and in the 5H model. In terms of operationalization, governance processes must consider CSFs to make better decisions. As a result, a responsible urban mobility system offers equitability, efficiency, eco-sustainability, and safety, guiding action plans towards smart and sustainable cities and communities.

1.2 Research question and objectives

The objectives of the changes in the urban mobility system must be questioned. It is important to reflect on the motivations and objectives of innovations. A range of innovations is often dedicated to creating economic value and short-term development. However, what about the globally long-term needs of society, the environmental impacts on society and ecosystems: are these been considered into mobility motivations? Building cities that "work" with mobility innovations requires policy coordination and investment decisions – and it is urgent (SILVA et al., 2008; SURAKKA et al., 2018; FOLTÝNOVÁ et al., 2020).

Considering this context, some questions have become provocative: What are the technological, political, economic, social, and environmental aspects involved in the urban mobility system? What are the possible impacts of the changes? How can different stakeholders be integrated into this context, and how can they support the decision-making processes of urban mobility systems?

Therefore, the research question that will guide this doctoral thesis is:

What are the critical elements to be considered by a governance system to develop a principle of responsible innovation in mobility systems of smart and sustainable cities?

In this sense, the general objective is:

To identify and discuss critical factors to support the development of a responsible urban mobility system as an element of smart and sustainable cities.

To achieve this objective, this doctoral thesis is subdivided into the following specific objectives, each one extrapolated to a scientific article, aiming to:

1) **Conceptually identify the principles of Responsible Innovation adaptable to a mobility system's governance.**
2) **Identify and define Critical Success Factors (CSFs) to support governance definitions of responsible urban mobility systems.**
3) **Based on the CSFs lens, characterize and discuss the selected indicators considering the context of university campuses in Brazil and France as a cutout of urban systems.**

The investigations of this thesis are based on the idea of smart and sustainable mobility as a system of smart and sustainable cities that need to be arranged and planned responsibly (RI), which requires a suitable integrative governance. In order to understand the structure of the mobility system and develop the governance definition, the stakeholders must be identified. In this sense, in this thesis, the actors, as well as their knowledge involved in the context of mobility systems will be discussed based on the Quintuple Helix (5H) model.

Thus, to achieve the general objective, this thesis is structured in the format of articles. Firstly, it is necessary to understand responsibility in the urban mobility system's context (paper 1). Besides, in terms of governance operationalization, it is important to examine the commonly known frameworks of mobility indicators and their relation to the main RI's premises (paper 2). To support a suitable governance, it is proposed papers 3 and 4. In paper 3, an assessment framework to support the governance of a responsible mobility system is developed. Finally, in paper 4, considering a CSFs lens, the indicators inserted in the assessment framework are verified based on users' perspectives considering universities' campuses (Brazil and France) as real contexts where responsibility-driven governance processes can be developed.

1.3 Research justifications

Cities are composed of demographical, economic, social, and geographic data with the objective of identifying strengths and weaknesses that guide the definition of projects to subsidize political improvements and actions for the development of environments healthier, more sustainable, and with a higher quality of life, promoting an increase in economic and social attractiveness (LÜTZKENDORF; BALOUKTSI, 2017; RIBEIRO et al., 2019). Urban density is key to categorizing urban trends. However, density alone is not enough (GARAU; PAVAN, 2018). An effective view of cities needs holistic analyses that include the different urban systems, such as mobility (ABREU; MARCHIORI, 2020).

Mobility innovations have presented challenges and opportunities at the same time. Transportation options such as carsharing, bike-sharing, ride-hailing, and e-scooters have been raised and expanded, impacting the existing transit systems. A design including the modal options integrated seems more appropriate, convenient, and affordable. However, to achieve the benefits it is required more than point solutions; integrated solutions must be developed considering particular contexts: physical infrastructure (e.g., roads and rails), modes of transport (e.g., public transit, cars, sharing concepts.), and transportation service providers (e.g., public transport system) (CORWIN et al., 2019).

To achieve the benefits from the emerging innovations, solving the problems, cities need a holistic and integrated system that enables value creation and greater performance, benefiting diverse stakeholders (DEE ANGEL, 1989; FREUDENDAL-PEDERSEN; KESSELRING, 2016; ATTIAS; MIRA-BONNARDEL, 2017). Kuhlmann et al. (2019) highlight the need for a more analytical governance attitude. A step of analysis is fundamental and must be developed considering the context targeted. It is necessary to analyze the context, objectives, visions, essential resources, related stakeholders and their roles, future expectations, and possible impacts of the changes. Thus, governance must be based on the integration of stakeholders, context-sensitive approach, and focused on being reflexive to anticipate adverse outcomes, adequately responsive, and developing solutions that negatively impact the market, society, and environment. In this sense, in order to ensure better results, the Responsible Innovation (RI) approach can be useful (STILGOE et al., 2013; PAVIE; CARTHY, 2015; NICOLAÏ; LE BOENNEC, 2018).

As Stilgoe et al. (2013, p. 1568) ponder, "the governance of emerging science and innovation is a major challenge for contemporary democracies". The emergent scenario in the urban mobility system is considered as complex as, besides other factors, it includes different actors. As stated by Souza, Cavazza et al. (2019), empirical studies are useful to verify the operation of the helix model in urban mobility innovation contexts. In this sense, this doctoral thesis can contribute to the governance of the urban mobility dynamics responsibly structured based on the 5H model.

This doctoral thesis covers some of RI's literature gaps. As stated by Macnaghten et al. (2015), as RI is a recent discussion, it requires to be inserted on contextual and practical debates, like those related to urban and economic development. Souza et al. (2020) emphasized some criticisms of the RI approach, such as the lack of practical orientation and the roots in the political issues of the Global North. A developing country's reality calls for a shift towards a more social focus in transportation planning to avoid exacerbating existing problems and creating new ones (CHAMSEDDINE; BOUBKR, 2020). These aspects can support theoretical improvements and the concept application, promoting the expected benefits to a larger number of possible scenarios.

In practical terms, by addressing issues related to the Sustainable Development Goals (SDGs) (UN, n.d), this doctoral thesis can promote insights to the development of inclusive, smart, and sustainable growth and innovation through policies and planning processes. To do so, as Verma and Raghubanshi (2018) and Karjalainen and Juhola (2021) emphasized, these must be structured based on trustworthy, comprehensive, and appropriate frameworks, tools, and indicators to assess data, support analysis, and monitor actions toward expected results.

Bibri and Krogstie (2017) highlight gaps in applied theoretical research on smart and sustainable cities that expose the difficulties of the field regarding, in general, urban forms and design concepts of smartness and sustainability. In-depth analyses are required on the existing relationship between several factors besides technology, such as density, diversity, modes, and users. This panorama demonstrates the need to study urban strategic development, monitoring, and planning that operate in an integrated and coordinated manner in terms of actors, functions, operations, and services.

For Sharifi (2019), future research can be directed to critically evaluate indicators, their content, focus, and structure. Nieminen and Hyytinen (2015) suggest that the development of evaluation mechanisms based on indicators must deeply incorporate systemic and dynamic approaches to better consider the wide range of complexities. Aligned with these points, a comprehensive assessment could be based on the RI approach.

Nemoto et al. (2021) highlighted that a proper combination of ICTs with sustainability policies and projects supported by appropriate assessment tools is fundamental to promoting positive mobility system changes. Israilidis et al. (2021) highlight the need for research that provides guidance that supports the achievement of smart sustainable cities and communities' goals based on well-defined and appropriate management frameworks. In the same vein, Cavazza et al. (2021) highlight the need for studies related to specific indicators to innovation in mobility to promote critical guidelines for governance.

In addition to the usually discussed urban challenges, since 2020, the global scenery has faced the unexpected challenge of the Covid-19 pandemic. The impact of such an event raises questions about problems in the short, medium, and long term. In the field of mobility, the urgent need for integrated, sustainable, affordable, flexible, and resilient infrastructure is even more prominent. This underscores the need for follow-up and monitoring mechanisms (ALOI et al., 2020; THOMBRE; AGARWAL, 2021).

By structuring the main discussions on the 5H model and RI approach, this doctoral thesis proposes a solution to questions and challenges of the urban mobility system and offers a theoretical alignment that can be fruitful to future works in different practical and contextual topics. Therefore, in this thesis, it is argued that governance, integration, and responsibility become crucial to offer the expected benefits to cities and communities from the innovations in urban mobility.

The universities University of Paris-Saclay (UPS, France) and Federal University of Lavras (UFLA, Brazil) were selected as cases for study as the Ph.D. project was developed in both institutions, which allowed the researcher to live in both contexts, experiencing the mobility system in loco. Besides, both institutions have projects related to smartness and sustainability aspects in their campuses and mobility system. The institutions represent two distinct countries in socio-economic and demographic terms, bringing relevant insights to understand how contextual characteristics can influence the mobility system.

In sum, the research justification for this doctoral thesis is guided by some key aspects:

- The urban mobility system must be understood considering contextual/urban specificities;
- Potential changes in urban mobility systems are related to a range of interactions and impacts. Governance has the role of maximizing benefits and responsibility can offer results with more positive impacts;
- Governance oriented by responsibility requires the involvement of different actors such as industry, government, society, and universities (4H);
- In terms of the 5H, previous studies (CARAYANNIS; CAMPBELL, 2010; GRUNDEL; DAHLSTRÖM, 2016; MINEIRO et al., 2018; CARAYANNIS; CAMPBELL, 2021) point out 'sustainability' helix, instead of an actor, the representation of a project (or contextualization) to guide the actions of the 4H.

This doctoral thesis can provide academic, managerial, political (public policies), and social contributions. As an academic contribution, the emergent concept of RI will be discussed and applied in the field of governance of urban mobility, also being related to the 5H model. The inclusion of the RI perspective to urban mobility governance is a novel proposition. It can highlight practical aspects that can subside theoretical improvements. In this sense, the contribution is extended by considering the inclusion of 5H to support the identification of perspectives. Such alignment of theories is also a theoretical innovation.

As a managerial contribution, by proposing a concept of a responsible system and seeking to identify and develop the conceptualization of CSFs, it is possible to draw insights for governance decision-making processes. Since this thesis starts from the integrative proposal for governance, such management contributions can also be applied to public policies, favoring the development of public actions that favor the development of adequate solutions for the mobility system. Thus, social impacts are addressed. Social contributions come from the insights highlighted to guide responsible planning of mobility systems. CSFs, when verified from users' perspectives, will favor addressing social issues in governance processes. By addressing different contexts (France and Brazil), the results of this thesis provide a basis for discussions at developed and developing country levels.

1.4 Doctoral thesis structure

This doctoral thesis is composed of two main parts, and it is structured in the form of scientific papers meeting the guidelines defined on the "Manual of standards and structure of academic works" from *Universidade Federal de Lavras*[1]. In addition to the fact that this is an agreed element between the universities for the cotutelle doctorate, the two-part format allows for an emphasis on the conceptual and methodological background (Part 1) of the papers that are developed to support the answer to the research question that guides this thesis (Part 2).

The **First Part** contemplates the Introduction, the Theoretical Background, the Methodology, the Conclusions, and the References. The Introduction is divided into the sections: "Research contextualization and motivation"; "Research question and objectives"; "Research justifications", and the "Doctoral thesis structure". The Theoretical Background presents the main concepts that support the research topic's development and understanding. The "Methodology" section specifies and describes the methodological structure defined to this doctoral thesis. The "Conclusions" presents a synthesis of results, limitations, and suggestions for future research. At last, the "References" are presented.

Part Two presents the scientific papers developed to support the general objective of this doctoral thesis. Each paper was presented with main details: authors, abstract, publication status, and the full version. The papers are presented in the standard formats required by the journals to which they will be submitted.

[1] Available at: < http://repositorio.ufla.br/jspui/bitstream/1/11017/5/NOVA%20VERSÃO%20DO%20MANUAL%20DE%20NORMALIZAÇÃO%20E%20ESTRUTURA%20DE%20TRABALHOS%20ACADÊMICOS.pdf> Accessed on October 9th, 2021.

2. THEORETICAL FOUNDATIONS

This topic introduces the main concepts that supported this doctoral thesis' development: urban mobility, smart and sustainable cities, and communities, mobility system governance, quintuple helix model, responsible innovation, and indicators for decision-making.

2.1 Urban mobility: a system of smart and sustainable cities

With the unprecedented growth of the urban population, the urbanization level, and the number of cities, both opportunities and challenges are posed to traditional forms of city management (OJO et al., 2015).

Mobility is one of the most complex urban systems to tackle in metropolitan areas. Transport has several negative impacts and problems for the quality of life in cities, such as pollution, poor traffic conditions, poor infrastructure, limited services, spatial disparities, high costs, new and increased transport needs, unequal access to services, and issues related to safety and security, social health, urban design, and transport system design (BENEVOLO et al., 2016; BIBRI; KROGSTIE, 2017).

The background of innovation in mobility emerges as based on a kind of technological revolutions. For Sperling (2018), there is a panorama of "three revolutions" for urban mobility: sharing, electrification, and automation. Given this, mobility is changing based on patterns of technical topics, as well as patterns of consumer, behavior, interests. Kuhnert et al. (2017) discuss that innovation in the car concept will change the mobility idea. Considering that the car will be **e**lectrified, **a**utonomous, **s**hared, **c**onnected, and **y**early updated, referred to as 'eascy', mobility will become easier, more personal, and flexible, being on-demand. According to Moeller et al. (2018), innovation in mobility brings up 'ACES trends': **a**utonomous driving, **c**onnected cars, **e**lectrification, and **s**mart mobility. However, a general fundamental question must be taken into account: "Will cities build integrated seamless mobility plans and, in the process, orchestrate ecosystems"? (MOELLER et al., 2018, p. 13). Will the plans consider these innovations interrelated to other fundamental elements?

A rethink is required towards a multidimensional approach to cities, considering social, economic, and environmental as indissociable domains (MORI; CHRISTODOULOU, 2012;

SHMELEV; SHMELEVA, 2018). In this context, it is worth understanding two concepts that emerged: "sustainable city" and "smart city" (RASCA; WAEBEN, 2019).

A sustainable city is a concept that combines environmental concerns, human capital development, and healthy living principles based on education, energy, transportation, buildings, waste management, natural resources as important elements (SODIQ et al., 2019). The smart city is dated to the 1990s. During the last decade, Smart Cities have gained great popularity as a new city format with technology and innovation as central elements. Definitions range from purely ecological to technological perspectives, from economic to organizational and social positions (LARA et al., 2016; CHANG et al., 2018). The essence can be identified without a common definition through two mainstream approaches: technology-oriented and people-oriented. Based on the premise to integrate key sectors, Smart City is a 'smart' combination of six characteristics: economy, people, governance, mobility, environment, and life. A Smart City is built of participative and conscientious citizens (GIFFINGER et al., 2007; GARAU; PAVAN, 2018; YIGITCANLAR et al., 2018; SHARIFI, 2019).

Smart Mobility is one of the most promising themes of the Smart City (NOY; GIVONI, 2018). Involving all paradigms of a Smart City, the approach is widely permeated by technological innovations aiming to support solutions towards quality, connectivity, security, and accessibility of mobility services (BENEVOLO et al., 2016; FULTON et al., 2017).

However, as Hollands (2008) argues, a city to be smart needs more than technological advancements. A better conceptualization must also include different stakeholders' voices and "take much greater risks with technology, devolve power, tackle inequalities and redefine what they mean by smart itself" (p.316). In this sense, the path must "incorporate sustainability in smart city approaches and smarten up sustainable city models" (BIBRI; KROGSTIE, 2017, p.186). Although the original idea of smart cities includes attention to sustainable development, there is criticism of neglect of sustainability goals (AHVENNIEMI; HUOVILA, 2021).

Thereby, widespread in the mid–the 2010s, a Smart and Sustainable Cities approach bends ICTs, human orientations, economic, social, and environmental aspects. This new approach to cities can support urban research, planning, policy, and politics towards the achievement of the desired efficient, reliable, and resilient outcomes for the whole urban system (DHINGRA; CHATTOPADHYAY, 2016). Although not always clearly presented with this new label, a Smart and Sustainable City focuses on economic, social, and environmental improvements to achieve desired outcomes (HÖJER; WANGEL, 2015; GARAU; PAVAN, 2018).

Therefore, the "new mobility" brings up innovation in "vehicles, mobility services, modal preferences, emissions, distances traveled, land-use, infrastructure, jobs, and employment markets, social equity, health, parking and dozens of other urban issues and parameters", which figures as the complexity that will be reflected in public infrastructure management, automotive sector, a wide spectrum of demands, and governance (GRUSH; NILES, 2018, p. 269).

Inserted in a broader spectrum, one characteristic of this new context of urban mobility is the creation of more convenient and affordable solutions that encompass the beginning and the end of a journey. As examples, we have modes like ride-hailing, carsharing, bicycle-sharing, integrated electronic fare payment, dynamic shuttles, and ride-hailing. These modes of transportation are based on-demand and can change the relations with the traditional mainstream of owning vehicles (DIXON et al., 2019), leading to an increase in multimodal behavior (CYGANSKI, 2016).

The 20th century can be characterized by the promotion of individual carbonized mobility as the 21st century is characterized by new discussions guiding to the trail for multimodal mobility (ATTIAS; MIRA-BONNARDEL, 2017). As stated by Van Audenhove et al. (2018, p. 9), "the solution for the future is an interconnected multimodal mobility system, with increased convenience and efficiency, tailored to the city's growth project and balancing economic development and well-being".

A system based on the urban multimodality changes the traditional dichotomy' private versus public' transportation towards a combination between different modals to obtain benefits and avoid possible failures (VAN NES, 2002). This scenario requires investments in infrastructure to promote cycling, walking, public transport, and services (FULTON et al., 2017). Hence, a multimodal orientation includes integration of physical, operational, technological, and fare aspects, offering readiness, security, and accessibility (DARIDO et al., 2018).

So, there is a novel feature of mobility: a value proposition guided by a focus on service rather than products – which guides to the Product-Service-System (PSS) paradigm. This concept discusses products deepening the question of a solution, that is, it stands out and promotes a larger extent of the point of view of the customers. Thus, PSS is based on experience and on-demands, aiming to increase the perceived value. Therefore, besides the strategic and economic benefits, PSS is potentially capable of changing consumption patterns to create more sustainable practices and promote more sustainable societies (KUIJKEN et al., 2016).

According to Dhawan et al. (2019), the developments will be as profound as those related to past radical changes such as 'horses-to-cars'. Mobility's changes are coming faster, including multiple dimensions. Radical improvements are expected to be more visible in terms of experience, convenience, cost-effectiveness, safety, and environmental impact. The context of smart and sustainable urban mobility systems aligned to the PSS paradigm include technical, technological, economic, social, sustainable, legal, and political changes.

The PSS concept has been applied to the mobility context: mobility-as-a-service (MaaS). The MaaS is a user-oriented concept aiming to offer travel services related to journey planning, accessibility, and payment. As a platform, the MaaS is designed as a single app grounded on the connection between user needs and different sources of travel services information, both public and private (VAN AUDENHOVE et al., 2018).

Given this prospect, Dixon *et al.* (2019) point out that the new mobility context offers the opportunity to reshape cities, economy, and society - which goes beyond locomotion from one point to another. However, as urban environments are complex and dynamic, achieving these objectives is not easy (LÜTZKENDORF; BALOUKTSI, 2017). The ever-expanding challenges require a shift towards innovative and more efficient urban management (SHARIFI, 2019).

The goals must be adapted based on reliability, scalability, accessibility, and resilience by using ICTs to promote economic growth, efficient services and infrastructure, quality of life and well-being, and effective regulatory and governance systems to ensure adequate policies (DHINGRA; CHATTOPADHYAY, 2016). Besides boosting development processes, it must also include examining, assessing, understanding, monitoring, and planning activities (BIBRI; KROGSTIE, 2017). Therefore, it is fundamental to define a governance model focused on a holistic approach, stakeholders' inclusivity, efficiency, long–term perspective, responsivity, and responsibility to achieve the expected benefits (CARAYANNIS; CAMPBELL, 2010; BACCARNE et al., 2016).

2.2 Urban Mobility System's Governance and the Quintuple Helix model

Population growth and urbanization are increasingly pressuring cities' management towards changes and adaptations considering emerging issues and their association with numerous social, environmental, and economic impacts (BIBRI; KROGSTIE, 2017).

Grounded on very specific characteristics, cities have faced - and will continue to face - complex and multi-sectorial challenges, placing them as a central aspect to be dealt with in the global sustainability challenge (ISO, 2017). Due to such centrality, the UN's Sustainable Development Goals (SDGs) devoted one of the 17 goals specifically to cities and communities (SDG 11: Make cities and human settlements inclusive, safe, resilient, and sustainable). The SDG 11 recognizes mobility as one of the central topics to sustainable development (UN, n.d).

Through multi-stakeholder involvement, the SDGs seek to identify and respond to important problems spanning the three foundations of sustainable development: economic prosperity, social well-being, and environmental protection. Such a scenario presents complexities that require adopting governance mechanisms that maximize synergies and deliberations considering stakeholders, seeking to define comprehensive approaches from a holistic view (KANIE et al., 2019).

The SDGs refer to actions designed in multi-sectoral and multilevel environments, which carries multiple factors that demand an adequate appropriation of available knowledge, adopting a reflexivity posture to aggregate long, medium, and short-term perspectives of the spheres that make up society (MEULEMAN; NIESTROY, 2015). Therefore, it is essential to define an appropriate definition of governance to achieve the SDGs. The SDGs present two main links with the governance aspect: governance presents itself as a crucial means to mobilize, implement and realize the SDGs, and governance also presents itself as a goal set by the SDGs (MONKELBAAN, 2019).

Governance is commonly taken as synonymous with government. It must be clear that it is a confusion, and it is possibly based on an international lack of a common word to hierarchy and government (WEISS, 2000; GRAHAM et al., 2003; MEULEMAN; NIESTROY, 2015). Governance in terms of government states governance's characteristics related to a national administration's system (WEISS, 2000). In front of this disarray, the need is, as stated by Finkelstein (1995, p. 368), "a conceptualization that enables us to penetrate and understand the government-like events that occur in the world of states even in the absence of government".

For Kuhlmann (2001), governance results from integrating the political system with the innovation system. For Gebhardt and Stanovnik (2016, p. 55), governance is related to "the processes of interaction and decision-making among the actors involved in a collective problem that lead to the creation, reinforcement, or reproduction of social norms and institutions". Kuhlmann et al. (2019, p. 1092) discuss that governance is the basis to legitimate agreements considering "dynamic interrelations of (mostly organized) actors, their resources, interests and power, fora for debate and arenas for negotiation between actors, rules of the game, and policy instruments".

Therefore, governance involves processes and structures, both public and private, through which interactions occur in different levels, being individuals or institutions, designed to embrace decisions (FINKELSTEIN, 1995; WORLD BANK REPORT, 2017). For this, a cooperative vein of action is necessary to manage interests and develop common directives and policies (COMMISSION ON GLOBAL GOVERNANCE, 1995; WEISS, 2000).

The collective action is, thus, a principle of the concept of governance. The literature has tended to focus on the governance system as a whole or on a framework that represents a process and its agreements, conventions, procedures, and policies. This focus can result from difficulty in observing processes. Governance must embrace more strategic aspects beyond indications of 'a route to go'. Governance must, therefore, include definitions on who (roles), what, and capacities (GRAHAM et al., 2003).

The World Bank Report (2017) introduces governance based on formal and informal rules that are constantly shaped by power, taking this as an ability of groups or individuals over desired outcomes, dependent on the context and its specificities. In addition, considering that governance takes place at different levels - from international to community bodies -, these dimensions can overlap and create a complex network of players and interests, highlighting different factors that can influence the governance structure (FINKELSTEIN, 1995; VEENEMAN et al., 2018).

Governance is opening a new intellectual space by providing a framework to address and discuss public issues as well as the possibility to see roles in a wider manner, considering that government and other groups also have strong influences (GRAHAM et al., 2003). So, faced with the trend of increased interaction, new governance standards are emerging to deal with complex projects. Governance's function, hereupon, has been becoming deeper in managing complexity to anticipate problems (GEBHARDT, 2013).

Kuhlmann, Stegmaier, and Konrad (2019) highlight that, considering the knowledge production process involved, the multiplicity of actors and interests, and the changes in markets and industrial sectors, a governance approach becomes crucial.

Innovation processes are becoming more systemic, with intense interactions between an increased range of actors, competencies, technologies, and institutions. It can be said that the current context is characterized by innovations shaped by societal requirements, institutional structures, and user's needs, a fact that requires adequate governance (WEBER, 2017, p. 100):

> The problems we are facing are not only more complicated than in the past, but show complex characteristics with unpredictable long-term consequences. Understanding and subsequently managing transitions is currently an important research topic that is still in its infancy (Kemp and Romans 2005) In parallel, confidence in the traditional top-down and linear approach to public policy-making and implementation has declined. New ways are required to deal with problems resulting from the development and use of technology, and to respond to the new demands for more transparent, accountable and participatory modes of policy-making. Currently, new models of governance mechanisms are being tested in many areas touching on innovation and new technology.

Taking the idea of good governance, in terms of governance of innovation, a good result requires an emplacement in which stakeholders are integrated and to provide systemic and holistic views of the innovation system, allowing to effectively and efficiently use the competencies (MEISSNER et al., 2013; WEBER, 2017).

In the mobility context, as the future begins to be revealed, regulators, companies, and society need to keep attention to manage the changes that will influence services, behaviors, and the activities of the different players that are inside in this 'drive game', such as manufacturers, energy companies, scientists, public authorities, and users (ATTIAS; MIRA-BONNARDEL, 2017). As stated by Fournier (2017, p. 42):

> The value chain and value propositions of mobility solutions will therefore be deeply impacted in the future: new raw materials, components, vehicles and services will arise; new players will reshape the value chain and challenge traditional OEM's with new product and services; through customer centric approach the new shapers can seize customer's interests and contact, and thus capture more value; customer will even be part of the value chain and become prosumer, being either consumer or producer as the case may be.

According to the theory of innovation system, actors, such as different organizations, universities, society, and government, have different logics and can perform roles, individually and collectively, to develop innovation and technology (SCERRI, 2017; ETZKOWITZ; ZHOU, 2018; ZANG et al., 2018). Such actors are interrelated to produce, diffuse, and adjust technological knowledge (SMITH; LEYDESDORFF, 2014).

Innovation systems can be characterized in national, regional, technological, or sectoral based on its definitions (HILLMAN et al., 2011). Besides, innovation systems settle their elements to facilitate the flow of technology and information among the actors. However, an opening to a broader focus, overlapping the boundaries of institutional spheres, enables a more flexible and productive innovation model, that is, beyond the structured network of innovation systems, founded on interactions from where different spheres can operate with complementary roles. The Triple Helix Model (3H) can expand such an interaction view.

The 3H model is a framework developed to guide the analysis of knowledge-based innovation systems (ETZKOWITZ; ZHOU, 2018) considering that exists "multiple and reciprocal relationships between the three main agencies in the process of knowledge creation and capitalization: universities, industry and government" (LOMBARDI et al., 2012, p. 139). The 3H considers such actors as sources to knowledge production and innovation application towards problem-solving. Thus, transdisciplinarity, knowledge heterogeneity, and reflexivity become keys, enabling the consideration of the empirical context that emerged from innovation systems (CARAYANNIS; RAKHMATULLIN, 2014; SMITH; LEYDESDORFF, 2014; ROSENLUND et al., 2017).

In a current panorama, society is increasingly facing new and complex challenges in a global way, representing the coevolution of economy, society, and democracy based on knowledge. Given that, it becomes necessary to include more stakeholders in the 3H, considering knowledge and resources to establish the right solutions. The 3H was, thus, expanded with a fourth helix. The Quadruple Helix (4H) proposes society as a valuable source of knowledge, explaining democracy as fundamental to innovation (CARAYANNIS; CAMPBELL, 2009).

Given the changes and demands in socio-ecological systems, a new helix emerges seeking such a "human-centered" orientation: the natural environment, that is, as social aspects, source of innovation (CARAYANNIS et al., 2015). From an interdisciplinary and transdisciplinary approach, the Quintuple Helix (5H) represents a system of synergy between knowledge, technology, innovation, ecology, society, economy, and democracy considering the five societal subsystems: educational/research, economic, civil society, political and the natural environment (CARAYANNIS et al., 2012; BACCARNE et al., 2016). The premise is that business models operate beyond the pursuit of economic profit while also offering social and environmental solutions. In other words, it is necessary to promote a healthy equilibrium between economy and societies' development (CARAYANNIS et al., 2015).

All 5H systems perform essential functions and influence each other. By focusing on increasing value through investments in knowledge and sustainability, 5H promotes new and crucial impulses for societal advancements (CARAYANNIS; CAMPBELL, 2019).

Considering the premise of actors leading the deployment of an ecosystem guided to be sustainable, smart, inclusive, and participatory (CARAYANNIS et al., 2017), sustainability as a fifth helix could not be a real actor. The fifth helix emerges as a driver to the innovation process in response to ecological issues in a broader socio-ecological perspective (GRUNDEL; DAHLSTROM, 2016).

As "innovation and knowledge function are twin drivers in urban development", taking the context of the innovations in the urban mobility system, these need to be explored considering its human-environment systems. A rapid evolution influences social, physical, economic, and ecological systems, a panorama that pushes cities to look for new ways to manage. It is fundamental to set definitions based on flexibility and transparency considering the interaction between the different stakeholders, such as citizens, enterprises, universities, government, and non-governmental organizations (HANAFI et al., 2015, p. 45).

Therefore, there are different decision-making levels, a scenario which requires a suitable governance model to deal with the emerging challenges, as discussed by Attias (2017, p. 15)

> Stakeholders are increasingly numerous and diverse, regulations are put into question, and local authorities are confronted with new modes of transport that oblige them to reorganize the way that their territory is managed. Urban policies are challenged and obliged to redefine their investment choices and set up incentive measures or usage restrictions in urban areas.

Dixon et al. (2019, p. 4) highlight a "lack of integration, coordination, and effective governance among transportation regulators and providers between the city and the suburbs, and between public and private bodies". For the authors, this scenario with different regulatory providers suppresses an efficiently functioning and integrated transportation system, which could be improved by a coordinated integration of stakeholders. Therefore, "public and private players need to find ways to move people and goods in ways that maximize the use of space and minimize such social costs" (p. 5), which means developing suitable and sustainable solutions.

In this sense, in this thesis, the 5H model is useful to understand and analyze the knowledge inherent to cities (BACCARNE et al., 2016). By encompassing economic, social, and environmental aspects, the 5H model can promote urban development from enhanced planning to overcome existing challenges (CARAYANNIS et al., 2012; YIGITCANLAR; LÖNNQVIST, 2013; HANAFI et al., 2015).

Therefore, governance has the role of maximizing benefits while giving simultaneous attention to factors related to "why (the public policy function), what (the rules of the game), who (the networks of actors and their position, power, and objectives) and how (the manner in which the public is involved and accountability and transparency are maintained)" (DOCHERTY et al., 2018, pp. 117-118).

A clear and comprehensive set of goals for the urban mobility system is required grounded on the commitment to promote not only innovations and economic development but also fundamentally of social and environmental values. Such intent can be underlined by a Responsible Innovation (RI) approach.

2.3 Responsible Innovation

Amidst the continuous increase in population rate, urbanization, technology, and the attention to environmental concerns, mobility settles down as critical to the whole urban ecosystem (OJO et al., 2015). The negative effects of transport highlight the need for innovative solutions related to safety and security, social health, urban design, and transport system design (BIBRI; KROGSTIE, 2017).

Related to dynamic environments and constant changes presenting new threats, new technologies, new markets, and new regulatory frameworks, innovation is seen as a challenge as it is a moving target (BESSANT, 2013).

As a concept, innovation is multifaceted and brings a wide possibility of delivering something substantially new, original, or improved, generating values, being conceived from incremental improvements to radical changes (GRINBAUM; GROUVES, 2013). In a more generic and philosophical term, innovation is a process that is based on exploitation activities and the conversion of ideas into marketable outcomes. In other words, the general premise is the combination of intellectual and practical creativity as a potential future creator (PANSERA; SHANKER, 2014).

The concept goes back to Schumpeter's seminal work in which the author discussed innovation, highlighting it as crucial to creating competitive advantages to firms' surviving in a capitalist system. The fundamental idea is that innovation, when inserted in the market, generates a 'creative destruction' (FAGERBERG et al., 2013; PANSERA; SHANKER, 2014). From this point, different disciplines have improved, enhanced, encouraged, and diffused innovation (JIMENEZ; ZHENG, 2017).

Fagerberg et al. (2013, p. 1) highlighted an important aspect to be included in discussions about innovation:

> Innovation is increasingly recognized as a vitally important social and economic phenomenon worthy of serious research study. Firms are concerned about their innovation ability, particularly relative to their competitors, because they believe their future may depend on it. Politicians care about innovation, too, because of its presumed importance for growth, welfare, and employment. However, to recognize that innovation is desirable because of its assumed beneficial effects is not sufficient in itself. What is required is systematic and reliable knowledge about how best to influence innovation and exploit its effects to the full. Gaining such knowledge is the aim of innovation studies.

According to Soete (2013), the focus should be on outcomes and their impacts, as well as consideration of the parties involved. In this sense, as Schumpeter proposed, innovation should be oriented - creative destruction - rather than a destructive creation. This means that, rather than a focus only on benefits that can be seen as narrow, such as economic, an innovation project is desirable in creating improvements while taking care of outcomes and impacts.

Even if proposing to offer benefits, it is not guaranteed that all innovations have results essentially good. A well-known example is the pesticide DDT. DDT was initially applauded as an innovation that revolutionized the field of pesticides. However, significant negative impacts came to light. Nuclear energy and the development of "wonder" drugs can be cited as other examples. Such examples emphasize the need to consider the innovation process in a reflective manner (BESSANT, 2013).

As an appropriate guidance to address technological impacts, the principle of responsibility treated by Jonas (1984) discusses the technology and its effects, considering that responsibility enlarges beyond relations between interhuman and between humans and the biosphere. For the author, responsibility terms are imperative, indicating that the actions related to technology must consider the impacts on human conditions. Thus, governance must be reflexive and precautious to recognize and incorporate long-term effects.

For Kuhlmann et al. (2019), considering that uncertainties are inherent to emergent technology and innovation, governance must include aspects of: *reflection* as a way to address alternatives and contingencies; *anticipation* to develop possible future paths; adaptive as a capability to seek a better outcome; *experimentalism* to include flexibility, dynamism, openness, learning capacity and reversibility in a target; *distribution* to involve more participation in decision-making processes; mixed in terms of coordination; and *exploration* to connect governance and innovation.

Responsibility in innovation implies an attention to the future in terms of the innovations' outcomes, emerging as the concept of responsible innovation (RI) (GRINBAUM; GROUVES, 2013). RI originates from the concept of Responsible Research and Innovation (RRI), an important statement in the European Union program "Horizon 2020", translating ideas related to innovation and technological research (VON SCHOMBERG, 2013; KOOPS, 2015). The RRI concept can be taken as an umbrella that represents questions about "what can be done in order to ensure that science, research, technology, and innovation has positive, socially acceptable and desirable outcomes" (STAHL et al., 2014, p.76).

In order to provide a common conceptual treatment, beyond academic and policy rationalities, in this thesis, there is a cut in the broader concept of RRI, considering specifically the RI concept. According to Legault et al. (2018, p. 531), RI "has been proposed as a broad theme where theoretical and practical analysis on how to make innovation responsible converge by taking into account the possible impacts of the innovation on individuals, institutions and society". RI's idea focuses deeply on engagements with innovation systems to offer greater possibilities for systemic transformations based on co-creation and co-production of results aligned with stakeholders' values, needs, and expectations (STILGOE et al., 2013; PAREDES-FRIGOLETT et al., 2015; OWEN; PANSERA, 2019).

Conceptually there is no commonly held definition for RI (VON SCHOMBERG, 2013). According to Koops (2015), the roots of RI can be found, separately and in combination, in science, technology, and social studies considering technological assessment and value-sensitive design, applied ethics, and governance and regulation topics. Owen et al. (2013) highlight the collective intent and a responsive administration, which means a commitment to the present and an awareness about the future. Stahl et al. (2014) discuss the concept of RI as a process that focuses on socially desirable results based on ways of identifying problems that can emerge and structuring solutions for these. Meissner et al. (2017) advocates that innovation is recognized as a driver of growth and a provider of economic value, being an approach that emphasizes the environmental and socio-economic benefits. According to Pavie and Carthy (2015), RI is the process of the development of new products and services that associate performance, growth, and responsibility. Besides, for the authors, RI is "an evolution or modernization of the sustainable development theory, since it incorporates the emerging issues within the socio-economic and political landscape of the 21st century" (p. 1042). In the same vein, Blok and Lemmens (2015) discuss RI as a new approach to innovation.

In sum, RI is considered as useful to guide the aim of anticipating risks and resistances, being based on transparency and interaction of innovative actors considering the changing environment, the mutual responsibility, the acceptability, sustainability, and social suitability (VON SCHOMBERG, 2011; MEISSNER et al., 2017).

The RI discourse has been the subject of criticisms related to a lack of amplitude (Stahl et al., 2015), a strict relation to north global political issues (STILGOE et al., 2013; GENUS; ISKANDAROVA, 2018), and a lack of a guide to practical approaches (OWEN et al., 2012; STAHL et al., 2014, WODZISZ, 2015). For Owen and Pansera (2019), the most significant is the negligence in critically and normatively connecting RI with political skills. In this regard, van Oudheusden (2014), RI should be more political in including the attention to the real needs of deliberation in terms of power dynamics, indicating a strategical position. For Martinuzzi et al. (2018) and Brand and Blok (2019), RI is mainly implemented in the context of public research sponsored, lacking a critical exam of deliberative engagement suitability for the industry given the questioning of transparency versus competitive advantage. In the same sense, Lubberink et al. (2017) highlight an emphasis in science and technological advancements, failing to address innovation life cycle stages, such as commercialization.

There is not an agreement on directives to implement RI. For Von Schomberg (2013), five mechanisms can guide the application of RI premises: technological assessment and technological foresight; the precautionary principle; innovation's governance; normative principles; and public engagement. Technological assessment and technological foresight, a possible basis for anticipatory governance, are proposed to reduce human errors by the activity to anticipate positive and negative impacts, as a way to set which these are socially desirable. To avoid the negative ones, the precautionary principle seems applicable. "The precautionary principle works as an incentive to make safe and sustainable products and allows governmental bodies to intervene with risk management decisions (such as temporary licensing, case by case decision making etc.) whenever necessary" (VON SCHOMBERG, 2013, p. 22). In terms of innovation governance, for a RI purpose, the inclusion in the innovation process of stakeholders should be stimulated. The idea is that there is an advantage to expanding the focus from particular aspects to a wider panorama of the innovation process. To avoid future unexpected responsibilities, the normative principles can be introduced as orientations that can take the form of standards, regulations, certification requirements, and codes of conduct to design new technologies. Finally, the idea of public engagement and public debate is that it should lead to a situation of mutual responsibility, which means that actors surpass their traditional roles – what is needed for legitimacy.

However, even with these recommendations, the wide range of innovation focuses and its goals, the nature of responsibility presents conceptual and practical difficulties, appears as obstacles to a successful practical framework of RI (GRINBAUM; GROUVES, 2013). In this sense, Pavie and Carthy (2015) proposed a practical approach based on a design thinking model.

Since RI involves forms of knowledge, practices, various actors, and the address of uncertainty as a handle for creativity throughout the innovation process, the proposal of the design thinking model to operationalize the RI approach is "to develop specific solutions to address complex issues" (PAVIE; CARTHY, 2015, p. 1043).

Considering that innovation encompasses understanding people's needs and preferences, through direct observation, design thinking operationalizes innovation activities with a human-centered design character. With this intent, the designer's sensibility and methods combine people's needs with feasible and viable technology to deliver benefits to society (BROWN, 2008).

According to Pavie and Carthy (2015, p. 1043), design thinking in the context of RI has five main objectives:

> the opening up of the innovation process to include customers, stakeholders and experts capable of providing guidance with regards to potential impacts; the improved understanding of customer needs and expectations, by involving these throughout the process; the full use and management of new distribution channels through the cross-disciplinary work; the reduction of risks posed by innovations by making an impact monitoring system central to the innovation process and the redefined role of organizations as actors actively shaping the future of society.

So, in the context of RI, by combining scientific and technical rigor, promoting the comprehension of society's needs, clarifying economic imperatives, design thinking can help monitor a project in terms of environmental impacts. In a practical manner, a framework for developing a RI process comprises five stages - understand; co-create; design; co-evaluate, and develop - based on a multidisciplinary group (PAVIE; CARTHY, 2015).

RI encompasses uncertainties, motivations, purposes, social and political structures, paths, and directions of innovation. Defined based on collective values, ethics, flexibility, adaptation, inter and trans-disciplinary approach, integrated stakeholders' visions, transparency, commitment to the present, and future awareness (OWEN et al., 2013; VAN OUDHEUSDEN, 2014), the RI approach adjust questions from 'why' to 'how' to tackle challenges, assuming a role for governance approaches (VON SCHOMBERG 2013).

In this sense, Stilgoe et al. (2013) proposed a governance framework composed of four dimensions: anticipation, reflexivity, inclusion, and responsiveness. Considering that outcomes can be economic, social, and environmental, RI must embrace an anticipation character, which means both 'what can happen' and 'what is desirable to happen' must be known. The anticipation character does not aim to predict; the idea is to take issues into account and explore possible implications and impacts that could be uncovered. So, anticipation is also useful to ground the reflective character on the purposes and capacities of innovation. Reflexivity is associated with risks and uncertainties, uncovered areas, hypotheses, questions, and dilemmas. Inclusion has a deliberative character. The idea is to introduce a wider range of perspectives to discuss issues and to lead to legitimacy. The objective is to open the process looking for acceptable solutions. So, this collective activity can extend and expand the dialogue and, consequently, the solutions. Finally, responsiveness means to respond to new knowledge, new perspectives, new views, and new norms. So, the process must be situated. It is fundamental to reshape or redirect objectives considering stakeholders' values in a dynamic environment (OWEN; PANSERA, 2019).

RI elucidates science, technology, and innovation, through policies, processes, and institutions embedded by competencies of anticipation, inclusive deliberation, reflexivity, and responsiveness. This requires as key features the abilities of adaptation, iteration, flexibility, and a strong inter and trans-disciplinary approach to developing a process of co-creation and shared learning (OWEN et al., 2012).

In sum, RI seeks to gather different ideas and traditions and put them into the process of innovation, considering interactions that emerge in a context of complex processes and transactions considering its future impacts.

Considering the context of the urban mobility system as composed by multiple stakeholders, in order to discuss and respond to questions and challenges, the concept of RI is considered in this thesis as a broad and relevant approach applicable to the governance of innovation in mobility system considering this as a complexity composed by institutions, social practices, regulations, and technology, elements that represent the systems of the 5H Model.

The topicality of the issues in mobility, the attention to responsible principles, as well as the applicability and complexity of governance's concept suggest that it is important to treat measurements. According to Kaufmann and Kraay (2008), there are different indicators that, sole or in combination, can clarify the dimensions of governance.

2.4 Indicators for decision-making

Given the key position of cities in the global sustainability challenge, several initiatives have been developed to guide and monitor the performances of the urban systems (LÜTZKENDORF; BALOUKTSI, 2017; MERINO-SAUM et al., 2020). The Sustainable Development Objective 11 (SDG11) and ISO 37120 (Sustainable Cities and Communities – indicators for city services and quality of life) are best-known examples. Both instruments involve guidelines to promote social and economic growth while maintaining environmental awareness (MOSCHEN et al., 2019).

Leal Filho et al. (2017) discuss that the SDGs elucidate the need for improving cooperation among different stakeholders in governance definitions to achieve the delimited goals. This requires aspects' observation and monitoring.

Nemoto et al. (2021) highlighted a proper combination of ICTs with sustainability policies and projects to promote positive mobility system changes. Appropriate assessments tools must support such a combination. To this end, as discussed by Docherty et al. (2018) and Ahvenniemi and Huovila (2021), it is important to define a governance model that supports the implementation of solutions considering the network of actors, their goals, and roles.

Data, indicators, and analysis, when combined, can support contextual understandings and, consequently, the conversion of assumptions into facts, subsiding decision-making processes toward improvements, effective solutions, and long-term definitions (WOLK et al., 2009).

To understand indicators for decision-making, it is worth comprehending the concept of Critical Success Factors (CSFs), a concept firstly elaborated by Rockart (1979). CSFs represent selected topics that, with satisfactory results, ensure successful better performance for a project, an organization, or a department. The idea is that these topics are fundamental to generating adequate outcomes resulting from efforts towards goals. So, basic questions should be referred to: what areas should receive more attention? Which ones should be more strategically arranged? (BULLEN; ROCKART, 1981).

CSFs are essential elements to be achieved as a source of competitiveness. In this sense, these are actions or processes - not goals – internal or external, that must be managed (GRUNERT; ELLEGAARD; 1992; BROTHERTON; SHAW; 1996; BROTHERTON, 2004). Monteiro (2012) discuss that, in a broader view, rather than strictly related to firms, CSFs can conduct to better performance to diverse projects if aligned to strategy and operations.

CSFs have been applied to different perspectives and contexts, such as total quality management, small enterprises, building industry, knowledge management, systems implementation, e-commerce, supply chain, among others (MONTEIRO, 2012). Examples of CSFs related to such areas are:

- Total Quality Management: customer focus, leadership, engagement of people, process approach, improvement, evidence-based decision-making, and relationship management (WANG; MECKL, 2020).
- Small enterprises: organizational strategy, resource, training and education, management and leadership, processes, performance measurement, motivation (SCHAEFER et al., 2020); improvement, products' positioning, customers' perception,

relationships, sales, learning, environmental awareness, culture and firm philosophy (ALONSO; KOK, 2020).

- Building industry: past performance, contractor's experience, contractor's reputation, response to instructions, quality of past projects (AL-SALAHI et al., 2020); managing stakeholders with social responsibilities (economic, legal, environmental, and ethical), exploring stakeholders' needs and constraints to projects, communicating with and engaging stakeholders properly and frequently, understanding the area of stakeholders' interests, identifying stakeholders properly (YANG et al., 2009).
- Knowledge management: according to Sensuse et al. (2018), knowledge management's CSFs are categorized into five categories: technical or technology, strategy, organizational culture, personal success factor, senior management support and leadership, and regulation or policy. Some examples are: training programs, knowledge architecture, the network of experts, knowledge sharing, and transparency (AKHAVAN et al., 2006).
- Systems implementation: Singh et al. (2019), focusing on product lifecycle management (PLM) systems, identified CSFs related to business processes and practices, people, and technology. Exemplifying CSFs to traceability Systems in Supply Chain Management, Khan et al. (2018) cited: Training of Employees, Efficient and Effective Communication, Dedicated IT Infrastructure, Top Management Support, etc.

- E-commerce: system quality, information quality, service quality, use, user satisfaction, and net benefits (ALI et al., 2017).
- Supply chain: supplier relationship, process management, quality management, strategic planning; knowledge management (LIN et al., 2013); collaborative partnership, information technology, human resource, and top management support (TALIB; HAMID, 2014).

OECD (n.d) defined transportation's CSFs as indicators covering freight, container and passenger transport, car registrations, road deaths, and spending on infrastructure. World Economic Forum (WEF, 2018) presents indicators related to transport infrastructure to measure roads, railroads, air transport, and water transport infrastructure.

Cavazza et al. (2021) proposed CSFs to develop an innovation radar to implement autonomous vehicles (AVs) in a country. The findings are expressed based on four key dimensions: technology and innovation, social and political environment, consumer and market, and infrastructure and patterns. The CSFs related to “technology and innovation” are technological capability, IT standards, data management, and security. “Social and political environment” presents as CSFs: law and liability, public policies, and ethics and moral. CSFs of “consumer and market” are consumer behavior, macroeconomic environment, and stakeholders’ relationship. The dimension “Infrastructure and patterns” presents the CSFs: roads’ infrastructure, cities’ infrastructure, and mobility and transport planning.

CSFs are, therefore, useful to identify aspects to be prioritized, to develop metrics, identify key information, knowledge, and main characteristics of the field in consideration. These benefits can support fundamental definitions (ROCKART, 1979, CARALLI et al., 2004; COLAUTO et al., 2004). Remus and Wiener (2010) highlight the importance of considering the context and situation in which the CSF is inserted. Analysis of CSFs offers management inferences that must be taken as suggestions rather than normative guidelines. As sources for decision-making processes, indicators can support the analysis and discussions of CSFs (BULLEN; ROCKART, 1981).

In general terms, indicators are symbolic representations of specific objectives. In other words, these are related to analysis and settings to support the target's achievement (HIREMATH et al., 2013; LÜTZKENDORF; BALOUKTSI, 2017). As multifaceted constructs, these are composed of a label (or title), a definition, a detailed unit of measurement (qualitative, quantitative, or descriptive), basic data, a reference point to these data (e.g., a target or an orientation), and a clear link to the associated context. The latter is especially relevant as it sustains the indicator's contribution and the set of indicators, articulating a given topic (MERINO-SAUM et al., 2020). Indicators’ analysis can support the transformation of assumptions into facts, boosting effective resolutions (WOLK et al., 2009).

OECD (2008) developed a handbook to guide a quantitative construction and the use of indicators for policymakers, the media, academics, and other interested parties. Useful to compare countries’ performance, the composite indicators (CIs), as labeled by the OECD team, can provide an easier illustration of the complexity and of the issues in different fields. In this sense, CIs “must be seen as a means of initiating discussion and stimulating public interest. Their relevance should be gauged with respect to constituencies affected by the composite index" (OECD, p. 13), and the information must be well interpreted.

According to Kuhlmann et al. (2019), governance requires analytical activities and has the designing measures as a challenge. An appropriate governance measure needs to be developed for a particular problem or target. Therefore, a degree of flexibility is important to be considered into its indicators, and, for this, it must be studied to understand how to employ flexibility in order to ensure, at the same time, a sufficient stability level.

2.5 Theoretical key constructs

The key ideas are presented synthetically in Figure 1.

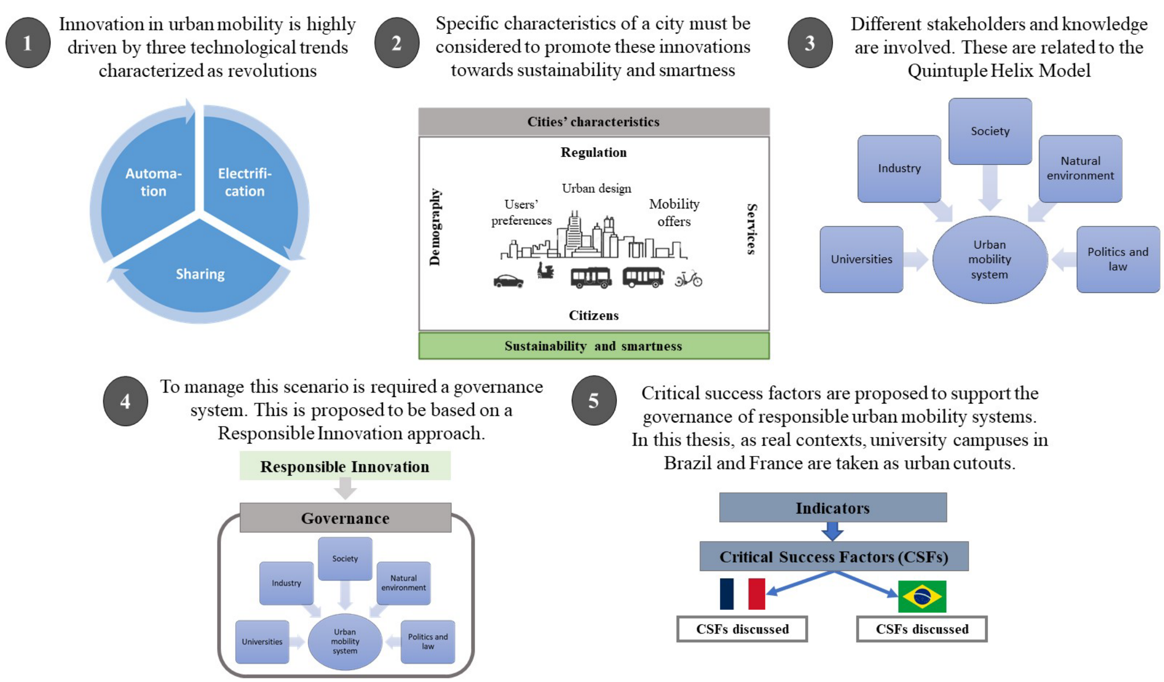

Figure 1: Synthesis of the thesis' ideas
Source: Prepared by the author.

As a real background, we consider urban mobility and related innovations. Although presented in the literature as mainly technological, focusing on electrification, automation, and sharing, innovation in mobility goes beyond bringing out the context as complex and challenging (KUHNERT et al., 2017; MOELLER et al., 2018; SPERLING, 2018).

As a snapshot, the current mobility has a greater focus on the car as the most used transportation modal (MATTIOLI et al., 2020). With the innovation trends, the expectation is to improve the transport system, changing from a focus on delivering transport to delivering solutions (VAN NES, 2002; KARIM, 2017). For this, specific characteristics of a city must be considered to promote innovations towards sustainability and smartness (ITF, 2021).

Different stakeholders, perspectives, and knowledge are involved in such a scenario. In this thesis, these are related to the Quintuple Helix Model (CARAYANNIS; CAMPBELL, 2010). At this point, some questions are posed: how can different stakeholders be integrated into this context? How can they support the decision-making process related to a responsible mobility system? The questions turn from the 'why' to 'how' to tackle challenges (BACCARNE et al., 2016). To manage this scenario is required a governance system. This is proposed based on a responsible innovation approach (STILGOE et al., 2013).

Such ideas and the general objective of this doctoral thesis are supported by key constructs related to the main theories approached in this thesis. These are presented in Figure 2.

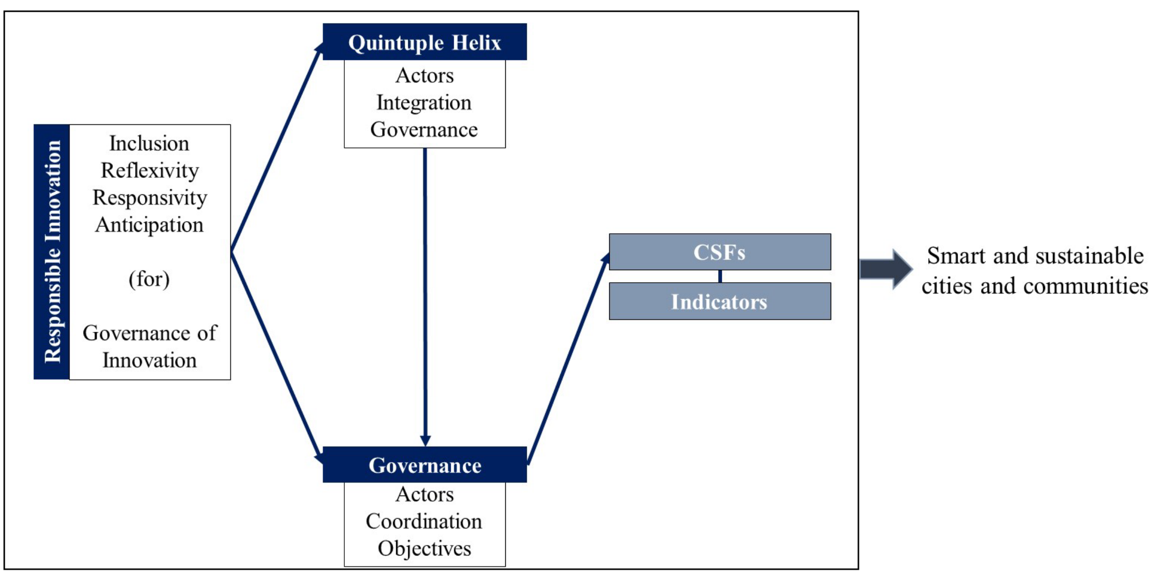

Figure 2: Theoretical approach
Source: Prepared by the author.

The RI is emphasized as an approach to governance based on four dimensions designed to care for the future of generations through innovations. The related constructs are linked to 5H and governance constructs. Considering such links, it is possible to identify CSFs and transform them into indicators to support the results' evaluation. Consequently, it can establish more comprehensive and responsible decision-making processes towards developing sustainable and smart cities and communities.

3. METHODOLOGY

This section describes the main methodological definitions and the methodological procedures that will guide each paper of this thesis.

3.1. Methodological Definitions

This project is guided by a Design Science approach and presents a qualitative methodological character with an exploratory nature. Data collection was based on primary and secondary sources: academic literature, official documents, focus groups, and online surveys. For the qualitative methods, content analyses, descriptive, and multivariate analyses were performed.

Although the RI's practical orientation is related to the Design Thinking model, the Design Science approach was selected in this thesis. Design Science and Design Thinking focus on problem-solving (DOLAK et al., 2013). Design thinking intends to satisfy human needs through technological practicable and viable outputs. For this, designers' sensibility and methods are applied to develop desirable and needed solutions. The focus enfolds creating and evaluating artifacts that can solve problems (BROWN, 2008).

Design Thinking receives criticisms about its lack of rigor (DOLAK et al., 2013) that can be explained by the lack of a clear definition and methodological guidelines (JOHANSSON-SKOLDBERG et al., 2013).

It can be understood that design thinking proposal have focused more on applications in the business field, not providing practical guidance to non-designers regarding the appropriate ways to select, adapt, and use tools and techniques as a projective and useful focus to different contexts and situations (LAURSEN; HAASE, 2019).

Whereas the general objective of this thesis is to create knowledge to support the development of responsible solutions to the mobility system (relevance), which means a close link to specific contexts, there is a great requirement of rigor. Besides, instead of evaluating artifacts in terms of their design process, this thesis's objectives are guided to the proposition, application, and discussion of proposed critical success factors (usefulness). Therefore, Design Science fits better to guide the methodological procedures.

Design Science ponders artificial systems, such as technologies, products, organizations, and social aspects, need to be well-considered and analyzed mainly because these are constantly changing. The emerging changes are issues that must be contemplated in actions plans, and, in this context, the solutions are proposed as artifacts (SIMON, 1996; VAN AKEN, 2004; 2005).

The general premise is that organizational, social, and technological issues can be managed to achieve better and more accurate outcomes. For this, situations must be taken as particular, systemic, and referred to specific perspectives, needs, and purposes that can be interfered (ROMME, 2003).

Research guided by Design Science is founded by relevance and rigor as main premises. Relevance is related to the societies' demands that can be referred to as organizations, social systems, or technology development. Rigor is regarded to the creation of applicable knowledge based on concepts, theories, and methodologies. As a result, the artifact is developed by a design cycle that couples rigor and relevance to generate a better and suitable outcome in practical or theoretical terms (ROMME, 2003; HEVNER et al., 2004).

Besides rigor and relevance, Design Science research focuses on quality, utility, adequacy, and efficacy (HEVNER et al., 2004; PEFFERS et al., 2007). For this, important stages to research are: problem identification and motivation; definitions of the solutions' objectives; design and development (creation of the artifact); demonstration; evaluation; and communication (PEFFERS et al., 2007).

The qualitative character is related to the qualitative data used to support holistically understanding a phenomenon (the context of an urban multimodal mobility system) and its complexity. This means considering processes and meanings that are natural to its environments as well as social actors' meanings to understand the complexity. This structure supports the explorative approach (DENZIN; LINCOLN, 1994).

The exploratory character focuses on developing, clarifying, and addressing concepts and ideas that are useful for discussing problems, solutions, and hypotheses, looking for new insights, new knowledge, new meaning, or new comprehension (BRINK; WOOD, 1998; STEBBINS, 2001; STEVENS et al., 2012). The exploratory character is flexible and useful to generic themes, debates with experts, situations requiring clarification, and delimitation that can be developed through literature review and other trials. The result brings a panorama more enlightened that can be further explored with systematic procedures (BRINK; WOOD, 1998; STEBBINS, 2001; GIL, 2008).

In this project, the components of the mobility system are explored to support the development of an integrative governance approach based on the 5H model and in the RI. So, the exploratory nature is justified by the search for determining or influential factors to the phenomena that emerge during the data collection and are relevant to the research question. A valuable way to develop this character is through the analysis of selected cases (STEVENS et al., 2012).

Such methodological definitions (qualitative and exploratory) are linked to the first stage of a research-oriented by design science approach - problem identification and motivation – and will base the definition of the objectives for a solution and the artifact's creation.

Considering the ‘how’ and ‘why’ questions inserted in the objectives of this thesis, as well as the indication of a demonstration's stage from the Design Science, the method used to conduct this exploratory character is the case study considering the nature and complexity of the urban mobility system that is emerging (MYERS, 2009; YIN, 2009).

The case study provides an analysis of real events and their holistic and empirical characteristics (SCHELL, 1992). In this thesis, the case study will occur with multiple cases. According to Yin (2009), it offers more robust evidence as well as useful information for comparisons, enriching the research.

The selection criteria for the universities Paris-Saclay (France) and UFLA (Brazil) as cases for the study were:

- The Ph.D. project was developed in both institutions, which allowed the researcher to live in both contexts, experiencing the mobility system in loco;
- Both institutions have projects related to smartness and sustainability aspects in their campuses and mobility system;
- The institutions represent two distinct countries in socio-economic and demographic terms, which can bring relevant insights to understand how contextual characteristics can influence the mobility system.

Further discussions in terms of the cases will be presented in topic 3.3.

This thesis was conducted since March 2018 until February 2022, being conducted at the Federal University of Lavras (Brazil) and CentraleSupélec, University of Paris-Saclay (France).

3.2. Methodological Procedures

The methodological design carried out is illustrated in Figure 3. In order to achieve the general objective, this doctoral thesis is composed of three specific objectives and four papers. Each paper is related to a specific objective and has a specific methodology.

Both Paper 1 and 3 are developed based on an integrative literature review. Aiming to provide synthesis and critical examination of studies relevant to a given topic, integrative literature reviews focus on bias reduction, transparency, reproducibility, validity, and rigor in the processes of articles selection and analysis. As a type of systematic review, it is developed to the reviewing and summarizing of representative literature topics through rigorous search steps, allowing cross-analysis, perspectives' identification, and insights' highlighting, enabling significant and value-added contributions (WHITTEMORE; KNAFL, 2005; TORRACO, 2016; SNYDER, 2019). To this end, it starts from a defined research question, develops the search and selection of documents based on strategic and explicitly presented criteria, and uses clear inclusion and exclusion protocols (BERRANG-FORD et al., 2015). Such methodological procedure supported: a) for Paper 1, the selection of relevant articles that provided a background for the development of the concept of responsible urban mobility systems, and b) for Paper 3, the understanding of urban mobility systems' CSFs by the indicators' identification and conceptualization

Considering the objective of Paper 2, the data collection method selected as appropriate was documentary research. This method is based on the study of existing documents, that is, documents that were not developed for the purpose of the research in question. The documents are then studied in order to collect information relevant to the research objective (BAILEY, 1994; PAYNE; PAYNE, 2004; MOGALAKWE, 2006).

The analyses of the documents were performed based on qualitative content analysis. The chosen methodological technique guides an objective, systematic and reliable review and interpretation of selected documents (HAYES; KRIPPENDORFF, 2007; KRIPPENDORFF, 2018). Content analysis, thus, allowed the test and theoretical verification, enhancing and improving the data understanding (ELO; KYNGÄS, 2008).

Unlike a narrow quantitative focus on word counts, the qualitative process of content analysis allowed the process of extraction, synthesis, examination, and interpretation of the texts looking for meanings, themes, and patterns (HSIEH; SHANNON, 2005; PRASAD, 2019). Themes can be identified through two directions: inductive or deductive approaches. The main differences are related to the categories' source. In the inductive approach, categories emerge from the data. It is usually appropriate in cases of limited existing related theory or literature. As previous knowledge was used to structure the analysis' operationalization, the content analysis was performed as a deductive technique (HSIEH; SHANNON, 2005; ELO; KYNGÄS, 2008). Specific predetermined RI premises (SOUZA et al., 2020), were used to identify passages of interest.

In Paper 4, the first data collection is developed through focus groups. According to Malhotra (2020), the technique is valued by the unexpected results that come from free-flowing discussions. Focus groups allow the gathering of insights from a group of people selected due to their involvement in the practical context (in the case of this research) to be addressed. The technique involves the development of discussions based on problematization, critical visions, and creativity with the presence of a moderator who has the role of conducting the dynamics considering central topics of interest to the research (NYUMBA et al., 2017). For this paper, the purpose of the focus group is, considering the CSFs proposed by Souza *et al.* (Paper 3), to gather insights to verify the experts' view on the indicators and refine their contents.

The second data collection is based on questionnaires. Built from questions about demographic characteristics, lifestyles, preferences, opinions, behaviors, expectations, or motivations of a group of respondents that meet the research objectives, questionnaires should consider the appropriateness of language, writing, logical, number of questions, delivery format, and layout in order to increase response rates and quality. One of the main benefits is the relative ease of coding, analysis, and interpretation of the data (MARSHALL, 2005; MALHOTRA, 2020).

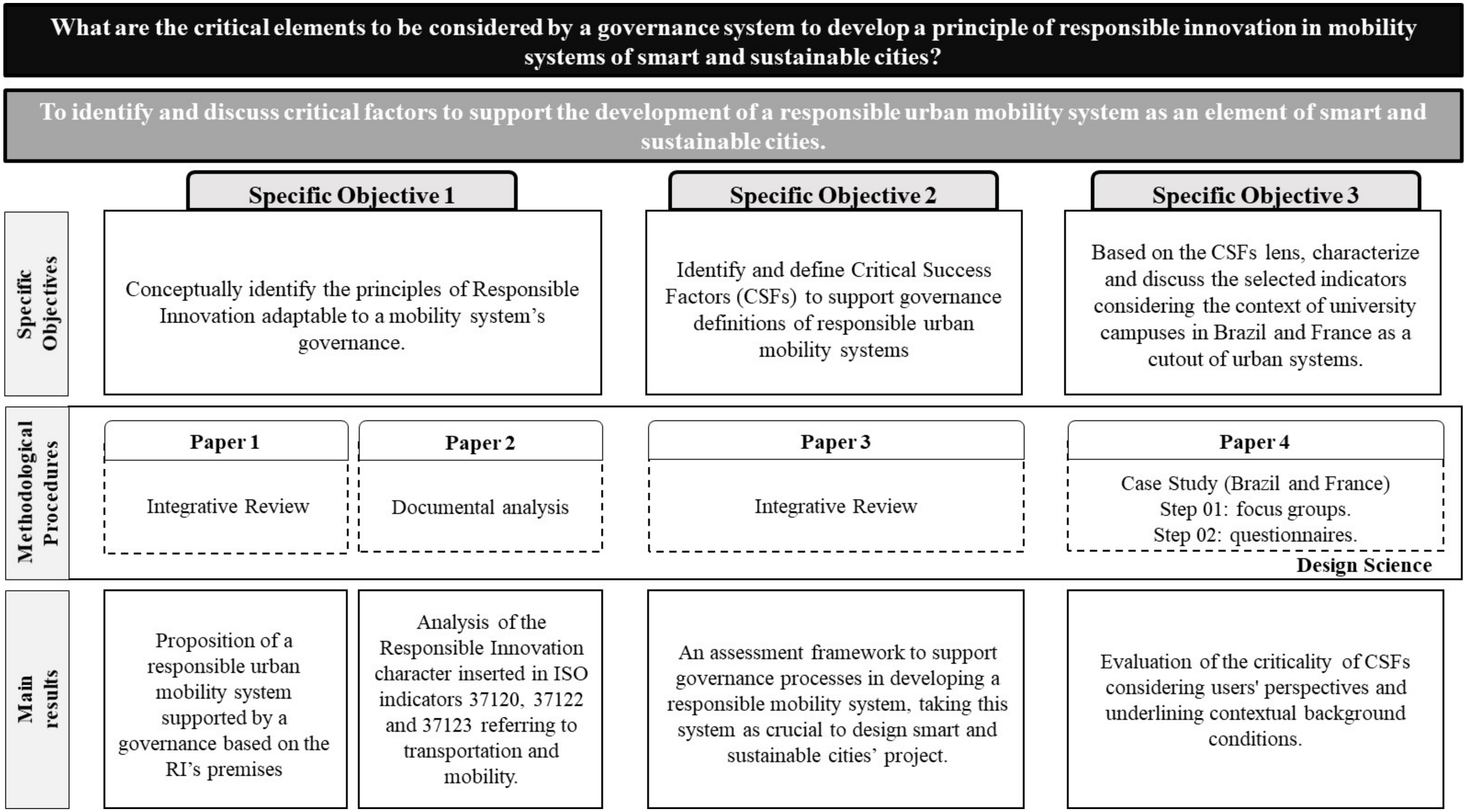

Figure 3: Summary of the methodological design
Source: Prepared by the author

3.3. Cases studies

The universities Paris-Saclay (France) and UFLA (Brazil) portray characteristics of both countries that, in comparison, are relevant for understanding the mobility system.

In demographic terms (based on the year 2020), according to the World Development Indicators database, the data are as follows: total population in France: 67.39 million, while in Brazil it was 212.56; population density (persons/km²) in France was 123.1 and in Brazil 25.4; the annual percentage of population growth are closer in France and Brazil: 0.2 and 0.7, respectively; the annual growth of urban population in Brazil was twice as high (1.0%) as in France (0.5%) (THE WORLD BANK, n.d.b).

What distinguishes countries in terms of income also distinguishes them in terms of road traffic fatality rates. According to the World Health Organization (WHO, 2018), the highest road traffic death rates per 100,000 population in 2016 occurred in low- and middle-income countries, while in high-income countries, these figures are on average 3 and 2 times lower, respectively. These numbers globally represent approximately 1.3 million deaths each year, which generate costs to countries of, on average, 3% of their gross domestic product (GDP). In France, 3477 road traffic deaths were reported in 2016, while in Brazil, there were 38651. This resulted in total health expenditures representing 11.54 % of France's GDP and 9.21% of Brazil's (The World Bank, 2022). Such data was ranked globally (266 countries based on deaths per 100,000 population), ranking Brazil 155th and France 240th position (THE WORLD BANK, n.d.b). Among the top 10 causes of death in Brazil in 2019 (both sexes, all ages), road accidents rank 8th. In France, on the other hand, such injury is not among the top 10 causes (WHO, n.d.b).

In terms of accident involvement profiles, worldwide data shows road traffic crashes as the leading cause of death for people between 5 and 29. Deaths from traffic accidents can be studied based on the type of road user (WHO, 2018). Data for France and Brazil from 2016 are shown in Figure 4.

Type of road user	France	Brazil
4-wheeled drivers/passengers	54.4	23.2
Motorized 2-3-wheel drivers/passengers	21.1	31.4
Cyclists	4.7	3.4
Pedestrians	16,1	18,1
Other/unspecific	3.8	24

Figure 4: Distribution of road traffic deaths by type of road user (%)
Source: Adapted by the authors from WHO (2020)

São Paulo is the most populous city in Brazil, the city with the highest congestion level in the country, and the 24th in the world, generating 52 hours of traffic jams. In France, the most populated city is also the one with the highest congestion level. Paris is the 6th most congested city in the world, with 88 hours lost in traffic (INRIX, 2021). The latest data from Brazil about the number of registered vehicles is related to 2016, with 93,867,016 vehicles, while in France, this number is of 2015 with 42,363,000 registered. These statistics, besides the already mentioned accident issues, cause environmental problems. In Brazil, CO2 emissions in 2018 were 2.0 metric tons per capita, while in France, it was 4.6 tons (THE WORLD BANK, n.d.d; WHO, n.d.c).

According to KPMG's survey (2018), in terms of infrastructure, France has excellent road conditions and good road infrastructure, and Brazil ranks penultimate in road quality (Russia is ranked last). In technological terms, France and Brazil have a low density of electric recharge stations, while, considering coverage of 4G, Brazil presents a good level, differently from France.

In Brazil, Law No. 12,587, dated January 3, 2012, establishes guidelines for the National Policy on Urban Mobility (BRAZIL, 2012). The essence is the integration of modes of transport in order to improve the accessibility and mobility of people and cargo at the municipal level. The central objective is based on the planning and democratic management of the National Urban Mobility System, considering it as a set of transport modes, services, and infrastructures, thus dealing with urban transport and urban mobility infrastructures. It also contributes to the mitigation of environmental, social, and economic costs, prioritizing collective public transport projects that integrate urban development (BRAZIL, 2012).

France bases its guidelines on Law No. 2019-1428 on mobilities considering the period 2019 to 2037, which directs directives on the transport code (in vigor since December 2010). The objectives described in the law are directed to the role of transport to: i) reduce territorial inequalities by improving accessibility; ii) to address the daily supply of travel with attention to quality, safety, sustainability, and social connection in terms of areas; iii) to reduce emissions of pollutants as well as congestion and accelerate the energy transition by working, to this end, on promoting behavioral changes for more sustainable choices; and iv) to improve the competitiveness of territories from the sustainable strengthening of the freight transport system (LÉGIFRANCE, 2019).

Accordingly, the mobility code focuses on satisfying users' needs, taking into account their special needs concerning their displacement and the choice of means to do so. To this end, the code designates the need to consider the most advantageous social, economic, and environmental conditions (LÉGIFRANCE, 2021).

Such contextualization reflects challenges and opportunities at the national levels. The Automotive Business platform promoted in April 2018, in the Brazilian context, an Automotive Industry Forum where professionals from the automotive and mobility industry met in a session - AB Lab Inovação - to reflect and debate on the future of transportation. As result, it was pointed out as Brazil's main challenge the lack of infrastructure for technologies to be implemented. On the other hand, we have opportunities to improve competitiveness, the aggregation of value to products, the development of local technologies for solutions in the digital area, and focus on global market trends. Thus, as ways to innovate, we must go beyond engineering and R & D; in the search for connectivity, creativity must focus on developing services, customization, and the humanized treatment of technology with a focus on the consumer (AUTOMOTIVE BUSINESS, 2018).

Data from KPMG (2018) point out that France stands out in working technology and innovation and establishing public-private partnerships. However, there are still questions and doubts about how to harness potential and mitigate obstacles in both developed and developing countries. For example, Brazil is ranked in the last position (of 20 countries) in terms of policy and legislation. According to Makhtar Diop, Vice President for Infrastructure at the World Bank, technological aspects are not enough to experience the full impact of mobility. It is necessary to find solutions adapted to the specific realities, deal with the technical knowledge, understand the basic system, and identify needs that refer mainly to infrastructure issues.

In the next topics, the real contexts taken as cases to study are presented. For the development of the research, official documents made available by digital means open to public consultation were consulted, as well as specific documents of the projects made available by the responsible project's sectors.

3.3.1. Federal University of Lavras (Brazil)

Strategically located between Brazil's main centers (230 km from Belo Horizonte, 370 km from São Paulo, and 420 km from Rio de Janeiro), the Federal University of Lavras (UFLA), situated in the city of Lavras (State of Minas Gerais), has an area of approximately 600 km² divided into green areas and 74 buildings, these being laboratories, classrooms, area-specific departments, 1 university restaurant, cafeterias, 1 central library, 1 student residence, rectory, and administration, among other properties. The most current UFLA demographics numbers (2019) are: 11,100 undergraduate students, 1,850 graduate students, 766 teaching personnel, and 581 staff. The current structure results from a historical trajectory that highlights it as one of the main institutions of higher education in Brazil (UFLA, 2022d; 2022e).

Beginning in 1908 with the creation of the Lavras Agricultural School by Presbyterian missionaries, the history goes through the transformation into the Lavras Superior School of Agriculture (ESAL) in 1938. In 1994, it was then transformed into its current structure as UFLA. Over time, the story unfolds efficiently in the role of teaching, research, and extension, expanding into the provision of services and product development aligned with environmental issues (UFLA, 2021e; 2022d). UFLA offers 32 undergraduate courses, 32 master's and doctoral academic programs, and 9 professional master's programs (UFLA, 2022a; 2022c).

The result of UFLA's development has been consolidated with the recognition of UFLA as one of the most important Brazilian institutions of higher education, reflecting in achievements such as: i) with a top rating for the twelfth consecutive year in 2019, UFLA is positioned among the top 10 universities in Brazil in the General Index of Courses (IGC) of the Ministry of Education (UFLA, 2019); ii) for seven consecutive years present in the UI GreenMetric World University Ranking (2016, 2020), being in 2016 the most sustainable higher education institution in Latin America and the 38th in the general ranking, rising to 30th position 2020; iii) positioned in the Times Higher Education (2021) Latin America ranking in 44th position in 2018, 34th in 2019, 24th position in 2020, being the 21st in 2021.

As a public institution, UFLA bases its strategic definitions on State legislation. In this sense, based on the Normative Instruction No. 24, March 18, 2020, of the Ministry of Economy, in a manner aligned with the Pluriannual Plan of the Union (PPA 2020-2023, Law No. 13.971, December 27, 2019), as well as based on Decree No. 10. 531, of October 26, 2020, that defines the

Federal Development Strategy for Brazil (EFD) in the period 2020 to 2031, UFLA carried out the elaboration of the institutional strategic planning (PDI 2021- 2025) where are considered as basic elements the economic, institutional, infrastructure, environmental and social axis (UFLA, 2021a).

The strategic objectives of PDI-UFLA 2021-2025 are presented in an organized way in the Strategic Map, which is structured in three dimensions that support the balanced definition of indicators and targets: "Results and Society", "Governance, Learning and Resources", and "Internal Processes". Regarding the objectives of "Results and Society" dimension, these are expanded considering the quality of education, economic sustainability, and social and environmental responsibility. Thus, the expected results aim to fulfill the Institutional Mission in a sustainable way, generating value for society (UFLA, 2021c).

By focusing on cost reduction and resource consumption, economic sustainability considers the definition of ICT use and Smart Campus concepts (Strategic Objective 3.2.3). The target is to implement 15 Smart Campus projects in order to improve "the efficiency in the provision of services available to the academic community and in capturing information that assists the university management team in decision making". For this, this strategic goal has an estimated budget for investment of R$ 1,160,000.00. The responsible department is the Infrastructure and Logistics Directorate (PROINFRA) through the Technological Development Coordination, focused on the Intelligent Campus projects. Among the strategies, there is the focus on "improving mobility within the campus"; "intelligent security solutions and physical access control"; "prospect partnerships with the private sector, which enable projects related to intelligent campus" (UFLA, 2021c, p. 51).

Related to the PDU, dealing specifically with strategic and tactical information technology planning, was instituted the Master Plan of Information and Communication Technology (PDTIC) 2021-2025. With annual revision, the PDTIC includes a definition of a Goals and Actions Plan based on an inventory of needs (Projects/Processes) (UFLA, 2021d).

The need N.62, Intelligent Solutions for Security, Mobility, and Transit on Campus, goal M62.1, related to the strategic objective 3.2.3 of UFLA's PDI 2021 - 2025 focuses on meeting the total demand for "physical access control and automation solutions, according to the prioritization of the Technology Coordination and Intelligent Campus, and according to the institutional budget availability and PROPLAG's [Pro-Rectory of Planning and Management] authorization" (UFLA, 2021b, p. 145). Moreover, M.62.3 deals with actions related to the monitoring of institutional and external buses, seeking to provide panels at the bus stops with information about schedules and routes (UFLA, 2021b).

Aiming to broaden the understanding about actions, favoring the achievement of goals, the PDTIC has a Plan of a direction about Risk Management. Specifically, about N.62, there are three risk events: "lack of accessibility in mobility within the campus"; "threat to the physical integrity of people within the UFLA campuses"; and "vehicle congestion and lack of parking areas". The causes identified are, respectively, the "lack of signaling, infrastructure and technological solutions that promote accessibility in transportation and locomotion of people with special needs inside the campus"; the "lack of security monitoring systems inside the campus"; and the "non-implementation of flow analysis of people and vehicles inside the campus". The consequences are related to the dissatisfaction of users with special needs, accidents, and lack of support for the creation of mobility policies (UFLA, 2021b, p. 168).

The PDI 2021-2025 is unfolded, also, in-unit development plans (UFLA, 2021d). Specifically, PROINFRA's PDU delimits the sector's objectives, goals, result indicators, and actions. In this document, dealing specifically with the Smart Campus project, the Coordination of Technological Development and Smart Campus (CCI) is presented. Created by the Rector's Office Ordinance No. 719, of JUNE 16, 2020 (Electronic Memorandum No. 163, of 06/09/2020), the CCI is responsible for applying innovative techniques, such as assistive technologies and the Internet of Things, in order to improve processes, services, and results, thus favoring the responsiveness to the needs of the campus community.

In an attempt to support the achievement of goal 3.2.3 of the PDI, using Information and Communication Technology based on the Smart Campus proposals to reduce costs and resource consumption, among the strategic objectives of PROINFRA's PDU are:

- Goal 3.2.3.3: "develop a web portal that presents the initiatives related to the smart campus". Goal: "deploy Proinfra's institutional website with information from 17 smart campus projects developed by PROINFRA's directorates and coordinators by 2025".
- Objective 3.2.3.4: "help improve mobility on campus". Goals: "Provide 14 bus stops at UFLA with led screens with monitoring panels of the institutional bus routes and external bus schedules"; "Keep the total number of parking spaces on campus updated" (PDU, 2021, p. 25-26).

- Goal 3.2.3.5: "Intelligent security solutions and physical access control". Goal: "meet 100% of the demand for video security solutions, according to the DSL's prioritization and institutional budget availability and PROPLAG's authorization". (UFLA, 2021d, p. 27).
- Objective 3.2.3.6: "present calls for proposals that encourage members of the academic community to develop projects related to the intelligent campus". (UFLA, 2021d, p. 29).
- Objective 3.2.3.8: "prospect partnerships with the private sector, which enable projects related to smart campus". Goal: "accomplish 1 annual partnership with the private initiative, which enable projects related to smart campus" (UFLA, 2021d, p. 33).

Furthermore, contemplating a larger spectrum of sustainable actions, it is important to highlight the goal of PDI 3.3.1, which seeks to strengthen actions towards the development of UFLA's Environmental Sustainability. Thus, PROINFRA has as a strategic objective the review and update of the institutional Sustainable Logistic Plan in line with the Sustainable Development Goals and the premises of the 2030 agenda (UFLA, 2021d).

3.3.2. University Paris-Saclay (France)

Seeking international influence from the integration of institutions, knowledge and training policies, research, and open innovation, the University of Paris-Saclay (UPS), from January 1, 2020, replaces the University of Paris-Sud and the Community of Universities, adding as component institutions (continuation of legal personality and statutes), the Institute of Life Sciences and Industries and Environment (AgroParisTech, 2021), CentraleSupélec, the Paris-Saclay Superior Normal School and the Institut d'Optique Graduate School. In addition to these, the Institut des Hautes Études Scientifiques is also included as a partnership. In an effort to transform France's research and higher education landscape, UPS's plans also include a short-term (2025) merger with the Université de Versailles-Saint-Quentin-en-Yvelines (UVSQ) and the Université d'Évry-Val-d'Essonne (UEVE), which are currently associated institutions (UNIVERSITÉ PARIS-SACLAY, 2019; 2022b).

The UPS campus is located on the Moulon plateau, at the southern end of the Saclay plateau, a region south of Paris, with a territorial extension that reaches Orsay, Évry, and Versailles. Thus, its position is considered geographically and socioeconomically strategic, bringing numerous benefits to the university and the region (UNIVERSITÉ PARIS-SACLAY, 2019; 2021a).

Considered one of France's leading institutions, UPS currently has 48,000 students, 9,000 researchers and professors, and 11,000 technical and administrative staff. Representing 13% of France's research potential, UPS has 7 undergraduate programs with different courses, 67 master's programs (research master's and professional master's), and 20 doctoral programs, supported by 371 laboratories divided among the related institutions (UNIVERSITÉ PARIS-SACLAY, 2021b; 2022c).

The efforts in territorial expansion, area coverage, and quality of training have resulted in relevant positions worldwide. In 2021 UPS was ranked 13th in the world's best universities based on the Academic Ranking of World Universities (ARWU), up to one position from the 2020 ranking. Moreover, the University, for the second consecutive year, is ranked #1 in the world in Mathematics (UNIVERSITÉ PARIS-SACLAY, 2021a)

In addition to research and training efforts, strengthening the strive to enhance the intellectual capital of institutions and the region, UPS is linked to the Paris-Saclay Agglomeration Community. Created on January 1, 2016, the Community includes 27 municipalities, has a population of more than 300,000 inhabitants, more than 180,000 jobs, and 25,500 business performances, hosting 15% of the French research structure (UNIVERSITÉ PARIS-SACLAY, 2022c).

The Agglomeration has focus areas of activity: economic and employment development hub, business concentration, world-class science center, Paris-Saclay university center. In terms of governance, it has a Development Council supported by participatory democracy, including members of civil society (UNIVERSITÉ PARIS-SACLAY, 2022b).

To expand and strengthen the strategic decisions and benefits, one of the pillars of the Agglomeration is the territorial project supported by a network of multimodal transport infrastructure that allows the flow of people, making accessibility an additional aspect of attractiveness (PARIS-SACLAY, 2022a).

The physical connectivity with Paris and other regions is structured by public transport lines (RER lines and 74 bus lines), soft modes (100 km of bicycle paths, and an extensive network of pedestrian sidewalks) (Paris-Saclay, 2022b). The physical structure of the Agglomeration supports the infrastructure for living on the UPS campus. The UPS has 63 public transportation stops, 73 parking areas, and 9 university residences (UNIVERSITÉ PARIS-SACLAY, 2022a).

The focus on the development of the territory expands with the adoption of the Climate Plan 2019 - 2024 proposed by the Agglomeration. Among the lines of action, there is the focus directed towards the development of the mobility system to facilitate user travel are the ambitions of the "mobility" policy of the agglomeration's community. To this end, the projects are based on proposals for intermodality and digital solutions that impact the reduction of individual car use, the quality of life, and the economic attractiveness of the region. The objectives are developed in actions to: i) support the arrival of structuring transportation networks; ii) optimize the urban and interurban transportation network; iii) develop intermodality to facilitate access to structuring transportation networks, iv) implement alternative modes of mobility; and v) make road traffic routes and junctions more fluid (PARIS-SACLAY, 2022d).

A proposed project of action to improve the user mobility experience (work, study and/or housing) and animate the innovation community was carried out from 2018 to 2021: the Move In Saclay platform. The project was supported by institutional partners (public actors related to mobility issues, such as the national government, governments of the Île-de-France region, Île-de-France Mobilités, the Department of Essonne, among others), industrial partners (such as Nokia Bell Labs France and Transdev) service partners (such as Ouihop, Klaxit, Karos, Arvey, RATP, Transdev, and Moov'hub), and the scientific and ethical council (CentraleSupélec, École Nationale des Ponts et Chaussées, Telecom ParisTech, Inria, CEA List, System X, Vedecom, Ile de France mobilités, and UPS). These partners worked on fronts related to territory and financing, implementation, research and development, service provisioning, and early adopters (FABRIQUE DES MOBILITÉS, 2022).

The project was structured based on collaborative workshops open to all territory actors with the focus on identifying and defining the main challenges and possible solutions related to mobility, such as new mobilities, transportation infrastructures, and autonomous vehicles, dealing with discussions of development and experimentation. The program's premise was based on the understanding that the search for improved and efficient mobility depends on a broad understanding of the user experience, with proposed solutions that go beyond technology, because first of all, it is supported by the collaboration between actors in the territory (Fabrique des Mobilités, 2022). The service provider partners were focused on extra practical value to the project, exemplifying solution innovation actions: OuiHop, Karos, and Klaxit work with carpooling, Arvey (transportation on-demand organization), and Moov'Hub with shared parking (FABRIQUE DES MOBILITÉS, 2022).

4. CONCLUSION

The conclusion, general considerations, research limitations, and suggestions for future studies are presented in this topic.

This doctoral thesis was composed of four scientific papers to support the achievement of the general objective: to discuss critical factors to be considered on governance processes to support the development of a responsible urban mobility system as an element of smart and sustainable cities. The first paper was meant to develop the main concept to support the third and the fourth papers. The second paper was related to indicators and traditional commercial frameworks to support a critical view of the academic literature indicators. Figure 5 shows the link between the papers, as well as the relationship to the Design Science development stages.

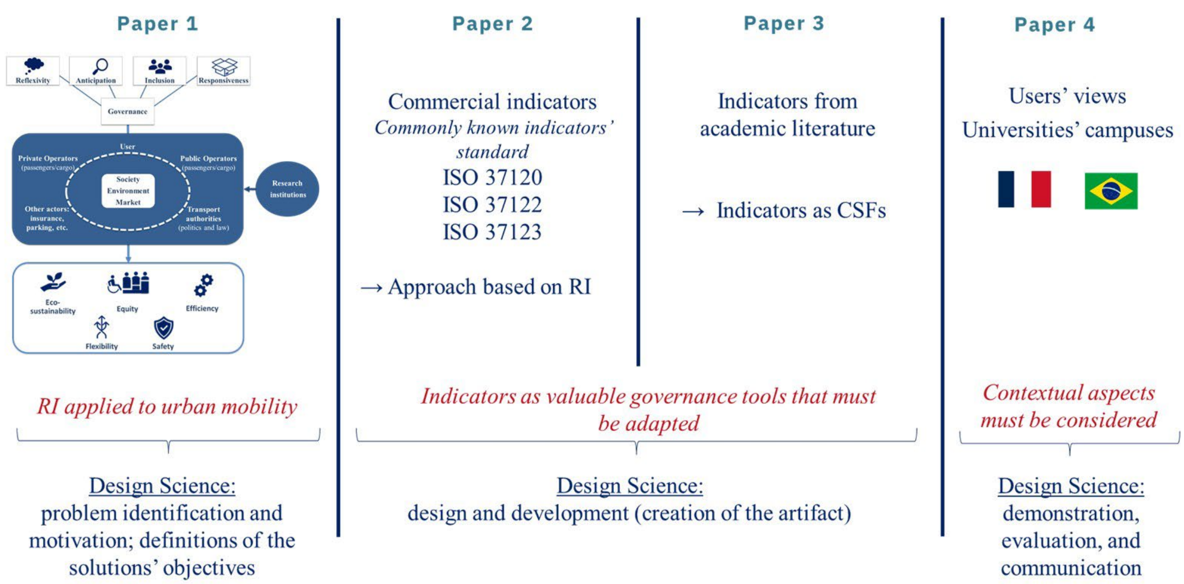

Figure 5: Developed Papers
Source: Prepared by the author

In terms of results, the first paper brings the concept of a responsible urban mobility system supported by a governance based on the premises of RI. The second paper develops an analysis of the RI character inserted in the ISO 37120, 37122, and 37123 indicators related to transportation and mobility. Paper 3 lists indicators related to the responsible mobility system, considering these indicators as representations of CSFs. Finally, Paper 4 verifies in real contexts of universities in Brazil and France (UFLA and UPS) the criticality of such indicators by the view of users, thus highlighting their importance for governance decisions.

From the development of this thesis, the alignment of the theories and approaches employed regarding the core ideas is remarkable. It can be said that the mainstream of this thesis is on the RI premises applied in the field of urban mobility. Due to its still recent development, the RI literature does not bring in-depth application contributions in the mobility field. In this sense, the proposal is to deal with innovations in mobility in a way that ethics supports them, long-term vision as to results and impacts, holistic and inclusive vision as to stakeholders' perspectives, attention to demands and needs with a focus on responsive actions, consideration of the context as part of the innovation process - and not a background, and treatment of environmental, social, and economic aspects as integrated aspects. In this way, a Responsible Urban Mobility System (RUMS) delivers eco-sustainable, equitable, flexible, safe, and efficient solutions.

Considering these RUMS solutions, the CSFs are proposed as guiding topics for governance actions that should be based on the particularities of the context. This reinforces one of the main arguments of this thesis: governance with the integration of perspectives is necessary. At this point lies the 5H literature.

Aggregating several discussions in different fields, the 5H model, derived from other helix theories (3H and 4H), is grounded on the knowledge economy proposal, which portrays multi-stakeholder cooperation as fundamental. This is geared towards the co-creation of innovative (innovation-driven) user-oriented solutions. Considering the 5H aligned with RI proposals, this thesis highlights the need to monitor and evaluate smart and sustainable urban projects from the perspective of all key stakeholder groups - government, researchers, industry, and citizens. Thus, the condition for better management and use of resources is improved, generating collective contributions that can support the achievement of better results.

The theme of urban mobility is seen as rooted in discussions about smart cities and sustainable cities with solutions targeting multimodality and MaaS. As discussed in Paper 2, efforts have been widespread to develop indicator frameworks to support such definitions. However, treating the development and analysis of smart and sustainable urban projects in a linear and generalized way is not appropriate since aspects related to learning and the sharing of the wider environments within which the projects are active can be neglected. This is how the RI premises fit into the indicators. As the most well-known framework, taking the ISO's indicators related to cities as examples for analysis, the RI is thus proposed as theoretical background to be inserted in cities' indicators to support analysis beyond statistical, economic, and technical aspects.

Thus, one has that governance, as a model based on integrative social dynamics, from the RI and 5H proposals can overcome barriers that hamper cooperation and association of perspectives. In this way, as a systemic, open, and human-centered governance apparatus, knowledge is processed in all phases of the innovation journey, thus allowing it to be converted into solutions with better chances of generating more positive impacts on the social, economic, and environmental spheres.

In this thesis, seeking to address a smaller urban context (communities), two university campuses were studied, one in Brazil and one in France. Although aware of the differences in culture, politics, structure, and mobility consumption habits, the contexts can be considered as rich for the developed discussions. Based on these differences, it was possible to verify the importance of developing projects, actions, and analysis processes adequate to the context. Moreover, the different perceptions of users highlight the importance of including them in the proposal development processes and the governance decisions - and not only in the acceptance test stage, as is commonly done. Also, the differences highlighted the importance of critical consideration of pre-established analysis frameworks by different institutions. While highlighting important aspects, since mobility is context-sensitive, indicators must reflect contextual particularities to efficiently support decision-making processes. At this point, the analysis supported by CSFs is underlined.

The discussions in this thesis were possible to be developed due to the methodological choices. The integrative reviews allowed a systematized deepening in the related theories. It was possible to make new propositions considering other authors' theoretical framework already developed. In this way, we contributed to the literature and practice by proposing feasible results to be applied in real practical contexts. The documental analysis developed by content analysis supported the verification of existing frameworks developed by non-academic institutions. The commercial documents bring practical lenses that were also important to be analyzed to support the achievement of the expected goals. Following this logic of analyzing academic and market propositions, the case studies developed from the application of questionnaires allowed the inclusion of the social perspective from the collection of users' perceptions about CSFs.

Seeking to develop responsible mobility solutions, this paper builds on the definition of governance based on the RI and 5H premises. The intent was to take a step forward in discussions about urban mobility governance. Many discussions have been held both in academia and in the market about the existing challenges regarding governance, especially in terms of a misalignment of objectives among stakeholders. Moreover, the discussions have brought to light the importance of structuring collaborative governance arrangements involving different actors. The challenges are, in fact, existing, and the collaborative structure is a way to solve them. This is where the RI premises fit in. In order to achieve the best results by overcoming obstacles, collaboration must be developed along with a culture of anticipation, reflexivity, inclusiveness, and responsiveness. In operational terms, it is discussed that CSFs should guide actions toward proposing solutions as a way to direct efforts toward more positive impacts. Thus, the approach of categories and indicators as analysis support to address CSFs was adequate. Moreover, this approach was original in the field.

What is at stake is the rationale for innovative solutions to create new solutions or improvements in traditional mobility options. This leads to new challenges for cities, demanding a critical review of governance processes considering the real dynamics. Along these lines, this thesis was proposed to identify and understand the critical factors that can support governance in the development of a responsible urban mobility system, this being important support for smart and sustainable cities and communities. As a result, the critical factors are:

- Incentives for the use of "greener" routes and modes
- Reduction of GHG Emissions
- Noise pollution reduction
- Electrical technologies
- Reduce fossil fuel dependency
- Coverage (origins and destinations)
- Parking area
- Cleanliness
- Infrastructure
- Comfort (of modals)

- Information availability (real-time information about services)
- Frequency
- Congestion
- Governance of mobility
- Transport management system (real-time information about the mobility system)
- Transparency and responsibility in decisions
- Resilience
- Reliability
- Affordability
- Citizens' participation in decisions
- Inclusion (special needs)
- Actions to promote mobility with social equity
- Access in a given radius - time and space (stations/modals)
- Easiness
- Multimodal system (physical connectivity)
- Infrastructure for micro mobility
- Infrastructure for active mobility
- Shared Mobility
- Friendly-user tools for trip customization
- Service integration
- Accidents’ prevention
- Personal data protection
- Security against robberies/thieves
- Safe and secure structure
- Personal safety

Based on the RI and 5H premises, these CSFs were considered comprehensive and capable of supporting decisions to overcome mobility challenges, providing direction for positive impacts in the short, medium, and long term. In this sense, smart and sustainable city initiatives rely on a responsible approach that enables the development of a culture of learning, collaboration, and active stakeholder participation throughout the project process, rather than the analysis of perspectives being merely a final process.

The development of a Responsible Mobility System (RMS), considering the proposition presented in Paper 1, can be understood as presented in Figure 6. First, it is necessary to map the stakeholders: who are the actors? What are their roles? What are their expectations and goals regarding mobility? A second step is the alignment of these stakeholders (common roles, expectations, and objectives). Thus, it is possible to define an integrative governance composed of 4H representatives, including the environmental perspective, thus being a definition based on the 5H model. At this point, the need to deepen the understanding of user perceptions is highlighted. This grounds an analysis on how CSFs are defined in terms of criticality also based on context.

The previous steps underpin the decision-making step. This step develops the analysis and planning processes. As a result, one has the definition of mobility planning, which should include a monitoring and evaluation plan. As the innovation and mobility field are dynamic, it is necessary to include reviews about the existence of new technologies, new demands, new behaviors, new stakeholders, new legal parameters, among other aspects.

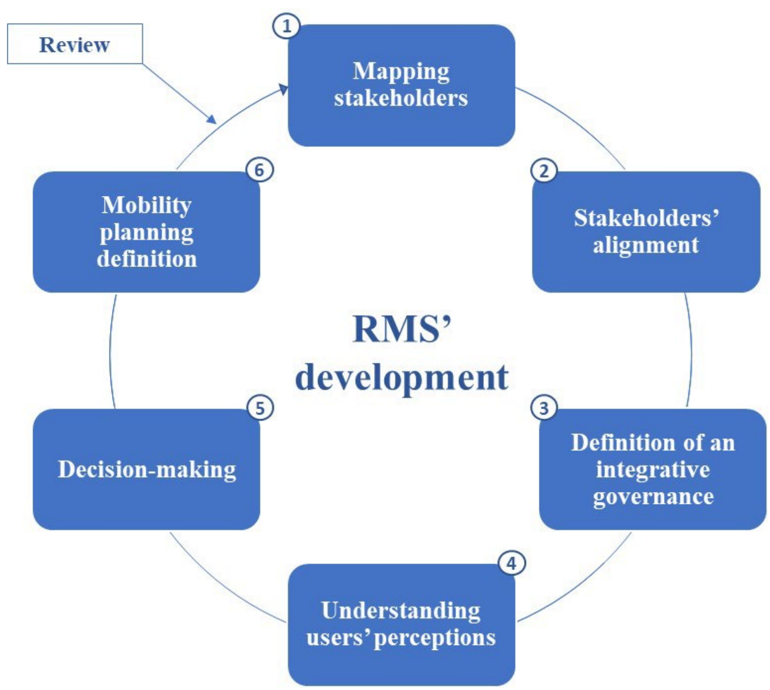

Figure 6: The RMS' development

Source: Prepared by the author

The focus on CSFs can support better definitions and implementations of more effective and beneficial proposals to the mobility system's users. In this sense, some highlights could be outlined from the results and analysis of the papers that compose this thesis:

- Some aspects are highlighted as critical regardless of the users' socioeconomic status: increase in distances and, consequently, in the travel duration and number of trips; attention to costs, health, and safety;
- The users' behaviors of the mobility system are directly related to their needs and real-context considering several factors such as the trip objective, time, cost, safety, and comfort;
- Users welcome incentives to promote alternative modals, but these must be appropriate to the needs and be well structured in order to provide comfort and safety, especially. Thus, it is essential to know the real mobility needs;
- For this, it is necessary to create a friendly infrastructure for pedestrians and bicycles, which requires infrastructure improvements in paths/roads, including aspects such as road conditions, signage, parking, and lighting;
- Short distances can be encouraged to be traveled through alternative mobility. For this, it is necessary to create a connected transport network infrastructure considering topographical conditions and climate changes;
- On the other hand, it is necessary to optimize the supply of public transportation services in order to create a connected mobility network for longer distances with attention also to frequency and timetables. This can also be improved through multi-modal schemes;
- Improvements regarding information to the users are important: signs, location maps, customizable trip applications that include payment services, displays with timetable information at the stops and stations, among others;
- Creation of a system of benefits for users who use modes of transport other than private cars in an individualized way, i.e., in the case of universities, those who give rides can also benefit from different incentives: discounts at restaurants and other services on campus. To this end, an interesting proposal is to create an application and other integrated systems internally to universities for registration, recording, and cataloging of transportation choices and benefits;
- As highlighted by Dehghanmongabadi and Hoşkara (2018), Transportation Demand Management (TDM) strategies can direct transportation system projects;

• Collaborative efforts should be undertaken between the institutions, the private sector, public authorities, and users to define mobility services improvements. To this end, creating an integrative institution, such as an Interdisciplinary Committee for Smart and Sustainable Communities (ICSC), can ensure the consideration of heterogeneity of interests, expectations, and roles.

Such highlights can support decision-making processes considering an integrative structure of stakeholders involved in urban mobility, thus underpinning the design of action plans. Although this paper proposes application in university campus contexts, the CSFs can also be considered on a broader scale, such as cities.

Among the CSFs, resilience stands out. Taking the example of the Covid-19 pandemic, one can infer how the criticality factors must be constantly revisited and analyzed to make the mobility system a source of solutions for cities and communities. Since 2020 the pandemic has been impacting urban mobility in several ways. Its emergence, impacts, and duration were (and still are) unexpected, highlighting the question about cities' resilience. While it is impossible to predict such events, the proposal to include IR in governance can support a broader consideration of solutions by adding perspectives.

A survey conducted by BCG in April 2020 in the US, China, and Western Europe (France, Germany, Italy, Spain, and the UK) sought to understand people's travel priorities and pandemic times. As expected, the physical distance between people and cleanliness were highlighted as new safety and reliability measures. However, transportation choices are related to price as a value proposition. Thus, over time, even though safety perceptions are predominant, economic and social issues may re-direct choices (Bert et al., 2020). The resilience of mobility and cities in the face of the pandemic clarifies the need for governance adjustments focusing even more on human, environmental and social aspects.

This thesis presents some limitations as it deals with the alignment of theories and approaches that are still recent. In the first paper, there was the need to include new parameters for the integrative review precisely because of the reduced number of articles relating the RI and mobility. In the second paper, there was a methodological cutout to analyze the indicators related to transportation. Although it is the category with the most number of indicators, it is interesting to conduct an RI analysis regarding the other aspects of the ISO standards. Furthermore, new applications in other indicator frameworks are appropriate.

Although it provides the study of several articles and indicators, the methodological approach of the third article presents limitations about the possible bias of researchers to carry out the summarization and organization of indicators. Article 4, on the other hand, has limitations regarding the definitions for the correlation analysis. All statistically significant correlations at 1% were evaluated considering the possibility of deepening in meanings for analysis and discussion.

Future studies can deepen empirical analyses of the framework proposals presented in this thesis based on the development of an RMS (Figure 5). Regarding the responsible urban mobility system framework (Paper 1), it is possible to focus on stage 1 and propose discussions about roles, expectations, objectives, and possible contributions. Furthermore, studies can verify the challenges for stages 2 and 3, considering the governance proposal based on the RI premises. Stage 4 (CSFs) can be verified in other contexts, such as other universities, comparisons of cities, communities, as well as national contexts. Future studies may also verify the practice of real cases regarding steps 5 and 6, identifying challenges and proposing possible solutions based on the discussions proposed in this thesis. It is also important to emphasize the potential contributions of new studies regarding the review questions. Given the dynamics of societies and markets, it is fundamental to bring up-to-date in the various spheres. Thus, it is possible to provide more support for policy and project improvements.

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PART TWO

“The goal of science is to make the beautiful and complex, understandable and simple - but no less wonderful."

(Hebert A. Simon)

ARTICLE 1: Can urban mobility be responsible? A governance perspective.

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Can urban mobility be responsible? A governance perspective.

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Abstract: Transport and mobility systems are historically deeply influenced by the context, including legislation, operation arrangements, decision-making process, users' behaviors, and travel modals. With a great expectation to change what is known, mobility innovations aim to offer a better arrangement towards a more sustainable, efficient, safer, and economical, technological, and spatial accessible. A suitable definition of governance processes is required to achieve positive results. In this sense, based on the responsible innovation (RI) approach, this paper aims to propose a responsible urban mobility system. The applied methodology is based on an integrative review supported by content analysis. As a result, a concept of a responsible urban mobility system is proposed based on governance definitions sustained by RI's premises, which results in solutions with less negative impacts for the society, the market, and the environment.
Keywords: Governance; Responsible Innovation; Urban mobility; New mobility.

1. Introduction

Even if emerging mainly based on technological concepts (Kuhnert, Stürmer, and Koster, 2017; Moeller *et al.*, 2018; Sperling, 2018), mobility innovations must also be considered in a wider perspective, beyond technology (Dee Angel, 1989; Freudendal-Pedersen and Kesselring, 2016; Attias and Mira-Bonnardel, 2017).

The mobility structure, encompassing business, politics, technology, environment, and energy, builds up a complex scenario where it is unlikely for one to precise innovations' consequences (Timmermans, 2017). The different waves of innovations have presented positive and negative impacts. It is urgently needed to understand and organize transport routes, road sharing, impacts on inter-city travel, short trips, inequalities between territories, the inclusion of vulnerable populations, digital gap, and other factors. In this sense, an appropriate setting of urban mobility plans must support anticipated considerations of potential negative outcomes' sources and ensure a sustainable approach, which means governance with anticipatory, integrative, and participatory capacities, aware of balancing stakeholders' roles, interests, values, and purposes (Smith, Stirling, and Berkhout, 2005; Gebhardt and Stanovnik, 2016; Ludwig and Macnaghten, 2020). In this paper, it is proposed to be done through a responsible innovation (RI) approach (Von Schomberg, 2013).

Pondering traditional innovation approaches as neglecting societal values and needs, as well as environmental issues, the RI concept has emerged rooted in the European Commission's definitions of Responsible Research and Innovation (RRI) (van Oudheusden, 2014). The main idea is to address socio-ecological issues based on ethics, collective values, and stakeholders' integration, focusing on creating a desirable future through an innovation process based on suitable and responsive governance systems (Stilgoe, Owen, and Macnaghten, 2013).

The RI literature has expanded fast over the last decade, but its operationalization is still less understood (Koops, 2015; Timmermans, 2017; Fraaije and Flipse, 2020). The gap between practice and theory hampers the translation of RI premises into practice considering “real world” conditions to innovation (Rivard and Lehoux, 2020). In the same vein, for Carrier and Gartzlaff (2020), there is a need for context-sensitive considerations. The wide variety of industries, knowledge, and objectives also challenges the RI operationalization, given the difficulties related to stakeholder management regarding their goals, expectations, and values (Long *et al.*, 2020). Owen and Pansera (2019) stated that the RI's research field needs interrelated discussions with innovation systems considering different structures, such as national, regional, technological or sectoral. It is necessary to develop discussions besides competitive advantage's results by considering deeper problems emerging in society globally. In this sense, this paper takes the urban mobility system as a practical context.

In this optics, this paper aims to propose a concept of an urban mobility system based on a governance perspective based on the RI approach. Such definition is important to help appropriate governance efforts towards more sustainable results. RI concepts guide the proposition of solutions and less negative impacts to society, the market, and the environment.

The main discussion of this paper is directed to propose that the urban mobility system should be implemented in a responsible way. From this introduction, a background of innovations in the urban mobility system is presented and a theoretical approach of the context of RI and governance. Through an integrative literature review, this work demonstrates that a governance approach to the urban mobility system could be an option to ensure the implementation of a responsible mobility system. Finally, we propose a governance structure with its relevant characteristics that it is proposed as appropriate.

2. Innovations in urban mobility

Transport and mobility systems are historically deeply influenced by the context, which includes legislation, operation arrangements, decision-making process, users' behaviors, and travel modals. As such, mobility has been an inflection point. Current circumstances demand new reflections (Dixon, Bornstein, and Pankratz, 2020).

Many authors have great expectations from innovations in mobility since new arrangements can dramatically change the way people move, work, and especially how cities are designed. (Fournier, Hinderer, and Baumann, 2012; Golbabaei, Yigitcanlar, and Bunker, 2020). Such innovations are mainly related to a series of changes based on automation and artificial intelligence that are strengthened with information and communication technologies (ICTs) (Schade, Krail, and Kühn, 2014; Lenz and Fraedrich, 2016).

For Kuhnert, Stürmer, and Koster (2017), one of the main changes emerge with innovations in the car concept as it will be **e**lectrified, **a**utonomous, **s**hared, **c**onnected, and **y**early updated ('eascy' trend). Moeller *et al.* (2018) discuss mobility's innovation related to 'ACES trends': **a**utonomous driving, **c**onnected cars, **e**lectrification, and **s**mart mobility. According to Sperling (2018), sharing, electrification, and automation are the main revolutions for urban mobility.

Aiming to deliver improvements to users' experience, convenience, cost-effectiveness, safety, and environmental impact, these innovations are assigning complexity to the system since it includes new dimensions, resulting in challenges to technical, technological, economic, social, sustainable, institutional, legal, and political arrangements (Kuhnert, Stürmer, and Koster, 2017; Dhawan *et al.*, 2019). Besides, the patterns of consumption, needs, interests, and behavior, in general, are also changing (Sperling, 2018). In this context, the concepts related to disruptive innovation, as discussed by Christensen (2013), can support deeper investigations embracing discussions on how these innovations could disrupt market structures and induce changes in behavior.

The need is to develop science and technology aware of societal and environmental dimensions in order to be able to better deal with the potentially harmful effects (Jonas, 1979). A balance must be established between economic and socio-environmental objectives. On the one hand, there is the need to generate incentives for innovation to respond quickly to problems while remaining economically competitive in the short term. On the other hand, there is the need to consider the long-term implications, sustainability, and social appropriateness of innovation. Accordingly, economic and ecological goals must be complemented with long-term perspectives, a viewpoint that has been questionable for some time in innovation processes (Jonas, 1984).

New technologies and knowledge topics have been increasingly challenging and transformative, triggering impacts that urge for a collaborative-based innovation approach, including society's participation towards beneficial outcomes to all involved (Doezema *et al.*, 2019). From this point of view, in this paper, it is proposed to define what responsibility structure the case of the urban mobility system must incorporate.

3. Responsible innovation

Innovation is closely linked to social, environmental, and political arrangements, facing dilemmas, risks, and uncertainties that occur in different degrees, requiring knowledge in a future perspective. As an appropriate guidance to address such innovation's aspects, the principle of responsibility treated by Hans Jonas (1984) discusses the technology and its effects, considering that responsibility enlarges beyond relations between interhuman and between humans and the biosphere. For the author, responsibility terms are imperative, indicating that the actions related to technology must consider the impacts on human conditions. Thus, actions must be reflected and precautious to recognize and incorporate long-term effects.

Academic literature, policy, and projects documents have been increasingly calling for the idea of Responsible Innovation (RI) (Fraaije and Flipse, 2020). RI is portrayed as rooted in the Responsible Research and Innovation (RRI) concept. Emerged from European Commission, RRI is a policy-driven discourse with objectives related to a call for a relation between society, research, and innovation towards positive impacts (von Schomberg, 2013).

RI was proposed as a concept with academic foundations, dismembering the close relationship of the RRI with European origin (Owen and Pansera, 2019). Besides, RI can cover wider goals and processes, surpassing and broadening the context of technology and science-driven that embodies research and innovation (van Oudheusden, 2014).

Despite the lack of a standard concept, the discourse on including responsibility in innovation processes has common principles associated with the need to address socio-ecological issues, which the stakeholders' interactive engagement must do with attention to potential problems and suitable solutions based on ethics and values, creating a system of responsive governance (Von Schomberg, 2013; Wickson and Carew, 2014). The aim is to provide a socially desirable innovative future grounded on collective actions in the present (Owen, Macnaghten, and Stilgoe, 2012).

The idea that underlies the RI concept is that the common/traditional ways of innovating through science and technology are failing as there is a lack of attention to societal values and needs and environmental concerns (van Oudheusden, 2014). RI "firstly asks what kind of future we want innovation to create, and secondly, given that the future is inherently uncertain and unpredictable, how we should proceed under conditions of ignorance, ambiguity and uncertainty" (Owen and Pansera, 2019, p. 29).

RI's concepts have been projected to align social and public values with related institutions and practices, resulting in not only economical, but also societal value (Fisher, 2020). Stilgoe, Owen, and Macnaghten (2013) proposed the foundational ideas as a framework that elucidates science, technology, and innovation, through policies, processes, and institutions. Such a governance framework highlights RI's dimensions: anticipation, inclusive deliberation, reflexivity, and responsiveness. Directed to develop a process of co-creation and shared learning towards desirable outcomes, the responsible definition requires adaptation, iteration, flexibility, and a strong inter and trans-disciplinary approach.

4. Governance of urban mobility system

The emergent mobility context offers opportunities to reshape cities, economies, and society. However, this challenges infrastructures, modals, needs, expectations, and business models, merging into a system with already legally and socially accepted structures. The changes converge to demands beyond traditional structures. To ensure desirable results, an appropriate governance system should be structured (Smith, Stirling, and Berkhout, 2005; Gebhardt and Stanovnik, 2016).

Usually mistaken as a synonym of the State, governance goes beyond. The focus surpasses ideological, institutional, structural, and instrumental State issues. Governance includes a feedback system based on communication, knowledge, and resources, representing a system of collective actions, standards, rules, and practices that aim to make decisions and implement action plans. It is considered a social phenomenon since it encompasses different interacting actors, creating a context of negotiation processes and power relations (Stoker, 1998). Such diversity of actors is explained by various interests and resources, reflecting a sense of interdependence and complementarity focused on a common objective of transformation (or maintenance) in a system. Appropriate coordination and articulation, both in procedural and contextual terms, are conditional elements of successful outcomes (Smith, Stirling, and Berkhout, 2005).

Changes in governance definitions have been proposed to enable and foster a reflective attitude of the system. Restricted, departmentalized, and fragmented relationships no longer meet the needs of the context. The demand is for the ability to analyze and adapt structures and processes, developing a posture of exploration and exploitation. The changing movement moves toward an expanded vision, encompassing integrative and holistic visions (Edler, Kuhlmann, and Smits, 2003).

As discussed by Pangbourne *et al.* (2020), the current mobility system still focuses on the operator, a scenario that requires a change to user orientation. For the authors, the challenge of governance in mobility consists of rethinking structural and technological determinism, adopting a reflexive posture on the complexity of changes and results, encompassing inclusive thinking in social, structural, and environmental issues. Therefore, governance needs to define the collective goal to then outline processes and means to achieve them. For this, it is essential to consider stakeholders' particularities and contexts' specificities (Peters, 2014; Salvia and Morello, 2020).

In order to characterize the governance of an urban mobility system and identify the relevant stakeholders considering their knowledge, stakes, and expectations, this work's main analysis was conducted based on a systematic literature review.

5. Methodological definitions

The methodological definition is based on the objective of creating and developing new knowledge on responsible innovation in urban mobility. To this end, it is essential to review, synthesize, integrate, and critically analyze the relevant related literature. Thus, the integrative review is used as the systematized methodological procedure (Whittemore and Knafl, 2005;

Torraco, 2016). In order to support the analysis of the selected articles, the content analysis' definitions were chosen.

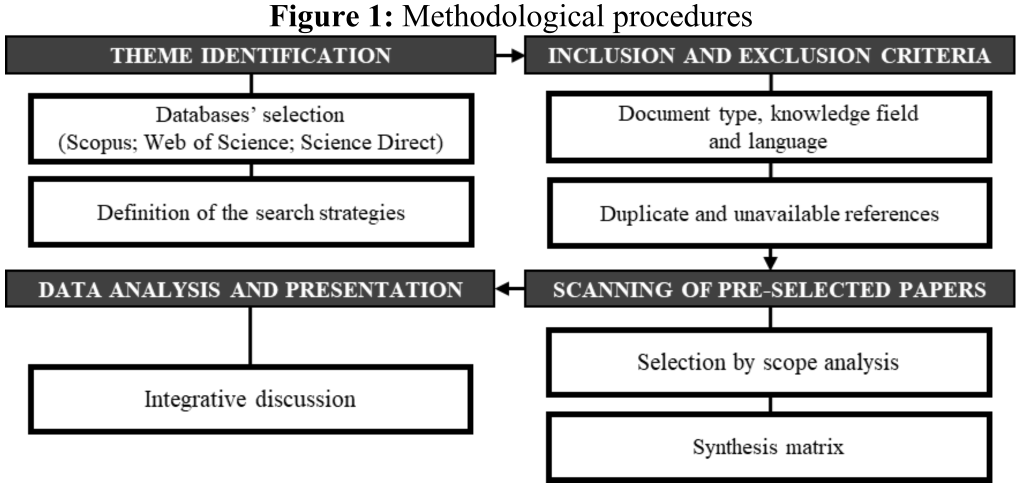
This methodological choice is pertinent since the urban mobility field is dynamic, and has been influenced and challenged by technology, demanding new knowledge. Besides, the RI's field is emergent, still lacking new theoretical and practical approaches. Thus, the integrative review is useful for developing a comprehensive review by bringing together both literature with a critical cross-analysis, enabling identifying perspectives and highlighting significant insights. Aiming a new proposal relating both literature, this methodological definition, and its rigorous steps underpin the delivery of a substantial and value-added contribution.

Based on Whittemore and Knafl (2005) and Torraco (2016), the stages of the review were defined as theme identification, the definition of inclusion and exclusion criteria, scanning of pre-selected papers, data analysis, and presentation (the aforementioned integrative effort).

Methodological details are presented:

• **Stage 1 – Theme identification**. The databases used for searching articles were Scopus, Web of Science (WoS), and Science Direct. As search strategies, considering the period referring to "all years", the search was performed based on "topic" (article title, abstract, keywords) in the WoS and Scopus databases and, as there is no such option, in Science Direct there was a general search ("Find articles with these terms"). The terms used were: "responsible_innovation" and "mobilit*". In order to ensure reliability and amplitude in the search and to refine the results, the boolean operator underlined (_), the asterisk (*), and quotes ("") were used. The methodological design is described in Figure 1.

Figure 1: Methodological procedures



Source: Prepared by the authors

As a result of this step, 2 articles were found at Scopus, 2 in WoS and 54 in Science Direct.

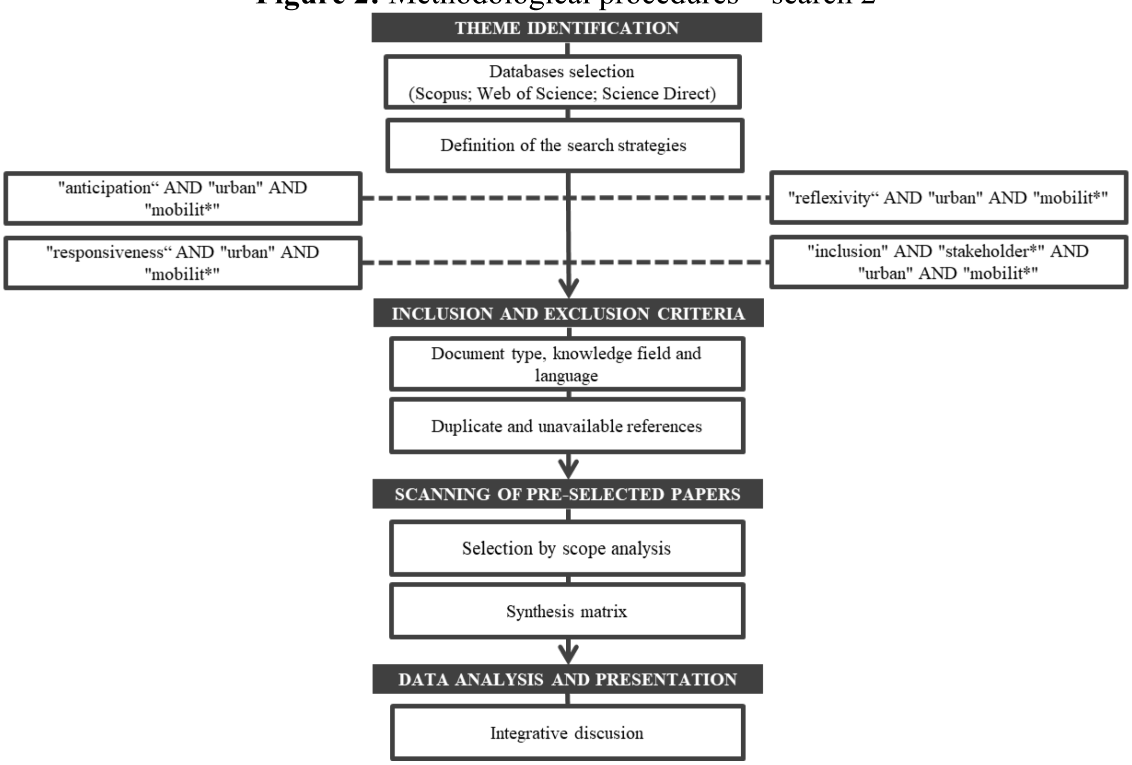
• **Stage 2 – Inclusion and exclusion criteria**. The first criterion used was the selection of "articles" type documents in English. Additionally, these were filtered by area: 'business, management, and accounting' in Science Direct and Scopus, and 'economy', 'business', 'management' and 'public administration' in WoS. There was no exclusion due to the unavailability of text. In terms of duplicity, 1 article was excluded.

• Stage 3 - Scanning of pre-selected papers. To filter the scope of the research, all the titles and abstracts of 46 papers were read. Two papers resulted from the Scopus' search, and forty-one from Science Direct were excluded as they were out of scope. Thus, just 3 papers were selected for data analysis (Appendix 1). Their data were allocated in a synthesis matrix containing definitions that support the papers' analysis: title, author, publication year, central background (project or technology), related country, specificities, challenges and solutions to urban mobility systems, gaps, and limitations.

In the face of this small number of selected papers, the authors decided to design and perform new search strategies. Following is presented the first three stages of the search 2.

• **Stage 1 – Search 2: theme identification**. In order to search for other useful papers for the discussion of responsibility in urban mobility, it was determined as a parameter the search for papers that cited the RI's premises. Thus, using the same databases and time cutting, the RI theory was approached by the lens of its premises: anticipation, reflexivity, responsiveness, and inclusion (Stilgoe, Owen, and Macnaghten, 2013). Therefore, the second stage of search was composed of 4 stages: i) "anticipation" and "urban" and "mobilit*"; ii) "reflexivity" and "urban" and "mobilit*"; iii) "responsiveness" and "urban" and "mobilit*"; iv) "inclusion" and "stakeholder*" and "urban" and "mobilit*". The additional term (stakeholder) is justified in the search for "inclusion" as a means of improvement, aligning the searches to the premise's concept. Asterisks (*) and quotation marks ("") were also used to refine the results. Figure 2 presents the methodological design of the second search.

Figure 2: Methodological procedures – search 2



Source: Prepared by the authors

As results were found:

i) Anticipation: 14 papers from Scopus, 6 from WoS, and 4 from Science Direct = 25 papers;
ii) Reflexivity: 13 papers from Scopus, 8 from WoS, and 0 from Science Direct = 21 papers;

iii) Responsiveness: 19 papers from Scopus, 15 from WoS, and 32 from Science Direct = 66 papers;
iv) Inclusion: 10 papers from Scopus, 8 from WoS, and 3 from Science Direct = 21 papers.

• **Stage 2 – Search 2: inclusion and exclusion criteria**. The same definitions used in search 1 (articles, English, areas related to business and management) were applied in this stage. No articles were discarded due to the unavailability of text. There were 5 duplicate articles excluded.

• Stage 3 – Search 2: scanning of pre-selected papers. The articles' scopes were analyzed according to the objective of this research. For this purpose, from the reading of all the titles and abstracts of 69 articles, *were selected*:

i) Anticipation: 1 paper from Scopus, 0 from WoS, and 1 from Science Direct = 2 papers;
ii) Reflexivity: 2 papers from Scopus, 0 from WoS, and 0 from Science Direct = 2 papers;
iii) Responsiveness: 1 paper from Scopus, 0 from WoS, and 16 from Science Direct = 17 papers;
iv) Inclusion: 0 papers from Scopus, 1 from WoS, and 2 from Science Direct = 3 papers.

Thus, 24 papers (Appendix 2) were selected for data analysis and were also allocated in the synthesis matrix.

• **Stage 4 Data analysis and presentation**. In this stage was performed the data analysis of the 27 articles selected in searches 1 and 2. The contexts (countries), technologies, problems, and solutions related to urban mobility were identified and analyzed as categories and other relevant topics for discussion. In order to address the research problem, it was necessary to understand the field that permeates urban mobility. At this stage, content analysis was used to systematically group the common problems within the urban mobility system and solutions cited in the selected studies (Hayes and Krippendorff, 2007; Krippendorff, 2018). Thus, from reading, it was possible to identify repetitions and similarities, organizing and relating them as categories that emerged as a synthesis of the content itself.

6. Analysis and discussions

6.1. General overview

The 27 articles analyzed were published in 23 different journals between 1989 and 2021: (1) 2006, (1) 2012, (1) 2014, (3) 2015, (2) 2016, (3) 2017, (3) 2018, (4) 2019, (7) 2020, and (1) 2021. Such bibliometric panorama can be explained by some facts that can be highlighted: main publications on RI in 2013 (Stilgoe, 2013; Von Schomberg, 2013); creation of the journal dedicated to RI discussions in 2014 (Guston *et al.*, 2014); increase in publications from 2017 on autonomous vehicles as a potential urban mobility-related technology (Golbabaei, Yigitcanlar, and Bunker, 2020) and on smart mobility (Francini *et al.*, 2021); and rapidly increasing interest in Mobility-as-a-Service (MaaS) as an important urban mobility-related topic from 2018 (Butler, Yigitcanlar, and Paz, 2021).

The related countries were Poland (1), Belgium (1), Netherlands (1), Malta (1), Jordan (1), Georgia (1), Philippines (1), Kazakhstan (1), Spain (1), Hungary (1), Greece (1), UK (2), France (2), Ghana (2), USA (3); Italy (4); and Finland (4). The most cited countries bring interesting actions in the mobility field. In Italy, there are studies on: i) incentive projects for sustainable operators in order to change a traditional performance in the field of logistics and, consequently, in the way they interfere in the urban mobility system (Marciania and Cossu, 2014); ii) project focused on developing technologies to support practices directed to the sharing of urban mobility means ("sharing city") supporting behavior changes in the use of the mobility system (Salvia and

Morello, 2020); iii) project to offer flexible transport services on demand in urban areas facing the criticism on the inefficiency of the public transport system and the behavior still focused on the use of private cars (Giuffrida *et al.*, 2021); iv) innovative Demand Responsive Transport (DRT) service already tested (Inturri *et al.*, 2019).

In the Finnish context, the main actions are associated with Kutsuplus, the Helsinki Capital Region. Mainly related to the primary uses of the MaaS term, Finland brings out discussions highlighting the actors involved in MaaS' plans (Pangbourne *et al.*, 2020). Following these service ideas, the flexible micro transport services (FMTS) pilot (also referred to as automated demand-responsive transport service) widespread in Finland provides lessons on different perspectives as it aims to offer transport alternatives and then it includes different stakeholders (Weckström *et al.,* 2018; Haglund *et al.*, 2019; Jokinen, Sihvola, and Mladenovic, 2019).

From the analyzed papers, it was possible to categorize the problems of the urban mobility system highlighting the backgrounds (project or technology) addressed (Figure 3).

Figure 3: Urban mobility issues

Category	Urban mobility issues	Backgrounds (project or technology)	Authors
Capacity and quality of the transport supply	Scarce transport supply	Demand Responsive Transport (DRT)	Oteng-Ababio & Agyemang (2015) Inturri et al. (2019) Giuffrida et al. (2021)
	Problems related to last mile connections	Demand Responsive Transport (DRT)	Inturri et al. (2019)
	Public transport is questioned in terms of reliability, agility and costs	Demand Responsive Transport (DRT) Sustainable Urban Mobility Plan (SUMP)	Oteng-Ababio & Agyemang (2015) Przybyłowski (2018) Weckström et al. (2018)
Cities' particularities	Contextual diversity; specific geo-demographic characteristics and mobility framework	Demand Responsive Transport (DRT)	Finn (2012) Attard, Camilleri & Muscat (2020)
Environmental issues	Transport sector resulting in a wide range of environmental externalities, such as carbon emissions (air quality)	Demand Responsive Transport (DRT) Eco-Mobility projects Decision-support tools	Finn (2012) Nicolaï & Faucheux (2015) Navarro-Ligero & Valenzuela-Montes (2016) Franco, Johnston & McCormick (2020)
Institutional Relations	Conflict with the authorities (authorization and legalization)	Demand Responsive Transport (DRT)	Finn (2012)
Management issues	Inefficiencies posed to the different actors in terms of regulations, costs and operating issues	Demand Responsive Transport (DRT) Mobility as a Service (MaaS)	Marciania & Cossu (2014) Lyons, Hammond & Mackay (2020) Pangbourne et al. (2020)
	Strategic transport modelling tools neglecting possible integrations between public transport services and private on demand mobility services (also shared)	Demand Responsive Transport (DRT)	Franco, Johnston & McCormick (2020)
	Parking resources	Parkings	Weckström et al. (2018) Rosenblum, Hudson & Joseph (2020)
	Traffic	Demand Responsive Transport (DRT) Urban traffic control strategies	Franco, Johnston & McCormick (2020) Dinopoulou, Diakaki & Papageorgiou (2006)
	Growing number of taxi trips (problems with distribution and utilization of vacant taxis)	Taxis	Ramezani & Nourinejad (2018)

Figure 3: Urban mobility issues (continuation)

Category	Urban mobility issues	Backgrounds (project or technology)	Authors
Modal patterns and behaviors	Car dominancy as transport modal (private cars); modal imbalance	Demand Responsive Transport (DRT) Sustainable Urban Mobility Plan (SUMP)	Przybyłowski (2018) Jokinen, Sihvola & Mladenovic (2019) Giuffrida et al. (2021)
	Citizens' interests and capacities to adopt sharing services into daily practice is not in accordance to the pace of technological innovations	Collective participation and shared mobility's model	Salvia & Morello (2020)
Social function of the system	Social exclusion (transport accessibility)	Demand Responsive Transport (DRT)	Finn (2012) Oteng-Ababio & Agyemang (2015) Weckström et al. (2018) Giuffrida et al. (2021)
	Congestion affecting the liveability in the city	Demand Responsive Transport (DRT) Urban traffic control strategies	Franco, Johnston & McCormick (2020) Dinopoulou, Diakaki & Papageorgiou (2006)
Traffic conditions	Congestion	Demand Responsive Transport (DRT) Urban traffic control strategies Sustainable Urban Mobility Plan (SUMP) Taxis	Dinopoulou, Diakaki & Papageorgiou (2006) Finn (2012) Farhi et al. (2015) Przybyłowski (2018) Ramezani & Nourinejad (2018)
Urbanization processes	Suburbanisation processes	Sustainable Urban Mobility Plan (SUMP)	Przybyłowski (2018)
	Parking scarcity	Demand Responsive Transport (DRT)	Weckström et al. (2018) Rosenblum, Hudson & Joseph (2020)
	Growing population	Shared Autonomous Electric Vehicle (SAEV) Services Demand Responsive Transport (DRT)	Franco, Johnston & McCormick (2020) Vosooghi, Puchinger, Bischoff, Jankovic, Vouillon (2020)

Source: Elaborated by the authors based on selected papers

These categorized issues must be understood as a compound rather than isolated elements. As cities are particular contexts, both in social, demographic, and political structure, urbanization processes and characteristics are distinct. A negative panorama can arise from the lack of addressing and processing specific matters. An immediate result lies in the transport supply's capacity and quality, and, as a cycle, resulting in poor traffic conditions, generating environmental and social issues. Besides, the differences reflect on institutional relationships and, consequently, on their management.

Solutions could also be categorized from the papers (Figure 4).

Figure 4: Solutions for urban mobility

Solutions		Authors
Efficient governance (including citizens' participation)	Sustainable model for decision-making processes (including analysis, planning, financing, and operations) towards strategic definitions guided by participation, coordination of different actors, factors and elements (such as demands and capacities), dynamic interactions, debate, synergy, deliberation, and iterative learning, aiming to cover gaps avoiding undesired effects, and proposing solutions considering context's particularities and the different structures and cultures	Dinopoulou, Diakaki & Papageorgiou (2006) Marciani & Cossu (2014) Freudendal-Pedersen & Kesselring (2016) Narayan, Cats, van Oort, Hoogendoorn (2017) Sayarshad & Chow (2017) Szigeti, Csiszár & Földes (2017) Weckström *et al.* (2018) Haglund *et al.* (2019) Inturri *et al.* (2019) Pangbourne et al. (2020) Rosenblum, Hudson & Joseph (2020) Salvia & Morello (2020)
Traffic management strategies	Traffic issues impact on the overall system's performance that must meet demands, responding efficiently and rapidly the needs	Farhi *et al.* (2015) Ramezani & Nourinejad (2018) Franco, Johnston & McCormick (2020)
Eco-mobility / eco-sustainable system	New transport concepts aiming to solve transport problems while meeting climate commitments, providing cleaner and more sustainable solution	Finn (2012) Marciani & Cossu (2014) Navarro-Ligero & Valenzuela-Montes (2016) Przybyłowski (2018) Attard, Camilleri & Muscat (2020)
Modal shift	Rationalisation of private car use by understanding the different needs, offering and improving accessibility, increasing the efficiency, providing flexibility, aware of costs, quality, and of the differences between urban contexts	Finn (2012) Przybyłowski (2018) Jokinen, Sihvola & Mladenovic (2019) Haglund *et al.* (2019) Attard, Camilleri & Muscat (2020) Lyons, Hammond & Mackay (2020) Pangbourne *et al.* (2020) Giuffrida *et al.* (2021)
Appropriate infrastructure	Transport modals' specifications and configurations require suitable infrastructure to positivelly impact the system's capacity and performance	Vosooghi et al. (2020)

Source: Elaborated by the authors based on selected papers

A wide range of environmental externalities and bad traffic conditions (congestion) were the issues more discussed in the papers. Such academic focus can also be seen through the practical backgrounds most cited: “Demand Responsive Transport”, “Urban traffic control strategies” and “Sustainable Urban Mobility Plan (SUMP)”.

DRT, also referred to as Shared Demand Responsive Transport (DRST), flexible micro-transit services (FMTS), on-demand mobility service, and automated demand-responsive transport service, is presented in all categories identified. “Urban traffic control strategies” and “SUMP” were related to issues of congestion, traffic, car dominancy, modal imbalance, and public transport's performance. These backgrounds represent a significant emphasis on advances towards sustainable mobility through mobility-on-demand, sharing models, and mobility-as-a-service approaches. Regarding solutions, "efficient governance and modal shift" and "appropriate infrastructure" were the most frequently mentioned.

Such an approach to problems, practical projects, and solutions presents an important alignment to be discussed. In this paper, it is reasoned that the urban mobility elements must be identified, understood, and integrated in order to provide responsible solutions and results. This requires a suitable governance definition, and it is proposed as a result of responsible urban mobility.

6.2. Responsible urban mobility systems and their governance

Even if not included as a specific global Sustainable Development Goal (SDG), transportation, as the mobility representation, is essential to its achievements and support economic and social development. This is reflected in different SDGs' categories: Good Health and Wellbeing; Affordable and Clean Energy; Industry, Innovation, and Infrastructure; Sustainable Cities and Communities; Responsible Consumption and Production; Climate Action; and Partnerships for the Goals (Mohieldin and Vandycke, 2017; Sustainable Mobility for All, 2017).

In 1989 the author Dee Angel reported the mobility sector's demands: traffic congestion, parking scarcities, air quality, and other local regulations attempting to avoid intensifying issues. The referred context raised challenges referred to the following 20 or 30 years from different perspectives such as infrastructure, individual motorists' needs, fixed-route public transportation, improvements for high-occupancy vehicles, demand management (Dee Angel, 1989).

Confirming this vision, solutions highlighted from the papers were somehow proposed as technology-driven (Figure 4). However, as already warned years ago also by Dee Angel (1989, p. 554), "technology alone cannot solve our transportation problems. To be effective tools in achieving solutions (…), technological advances must be accompanied by appropriate transport management strategies.".

Thus, the future of cities and mobilities, beyond a technocentric approach, need to be developed through social cohesion and integration, based on a link between society and transport (Freudendal-Pedersen and Kesselring, 2016; Le Boennec and Nicolaï, 2018). Then, socio-economic and urban changes typify trends related to increasing personal mobility expectative, needs, and behaviors; metropolitan areas structured as spatial networks; cities characterized as alive and active; and new work and life patterns (Finn, 2012). This results in service trends related to demand profiles oriented by the integration of transport modes (Haglund *et al.*, 2019; Franco, Johnston, and McCormick, 2020). As stated by Haglund et al. (2019, p. 2):

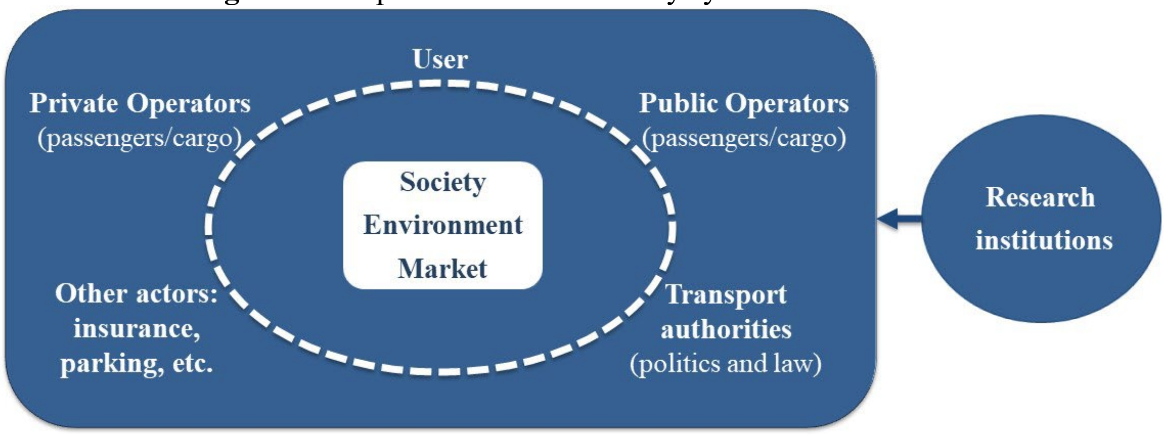
> "(…) further service development still has to pay attention to a range of potential barriers, including fleet properties, institutional and regulative frameworks, financing schemes and operating costs, as well as operator and community culture."

A new perspective must include environmental and social aspects, being climate-responsive, offering equity, accessibility (in several ways, such as economical, technological, and spatial), flexibility, efficiency, and safety (Oteng-Ababio and Agyemang, 2015; Mohieldin and Vandycke, 2017; Szigeti, Csiszár, and Földes, 2017; Weckström *et al.*, 2018). However, the current situation seems unaligned with this. The transport sector is resulting in economic and social inequalities, increasing fossil fuel use, air and noise pollution, and greenhouse gas emissions (Oteng-Ababio and Agyemang, 2015; Mohieldin and Vandycke, 2017).

One of the main challenges to urban decision-makers is how to include sustainable goals into the urban fabric. It requires significant stakeholders' engagement to establish a comprehensive planning process aware of the future (Przybyłowski, 2018).

As an element of the urban context, mobility is also a complex system. Composed by specific infrastructures, actors, transport modes, users' demands, this has been usually managed through unsystematic policies, negatively impacting the urban areas in different aspects (Marciani and Cossu, 2014). Iterative and integrative processes outline the path towards a desirable, socially accepted, and legitimated future (Oteng-Ababio and Agyemang, 2015; Freudendal-Pedersen and Kesselring, 2016; Haglund *et al.*, 2019). Figure 5 illustrates the arrangement of urban mobility stakeholders guided by the RI's premises.

Figure 5: Responsible urban mobility systems' stakeholders



Source: Elaborated by the authors

Thus, mobility can no longer be seen as a fragmented system. This results in vague, insufficient, and unsuitable objectives and results (Mohieldin and Vandycke, 2017). The call is for a consistent, synergic, and sustained system based on cooperation and coordination, setting a room for a dynamic of knowledge and resources' exchanges between stakeholders (Marciani and Cossu, 2014; Oteng-Ababio and Agyemang, 2015; Pangbourne *et al.*, 2020; Van Mierlo, Beers and Hoes, 2020). Sustainable mobility planning must be based on appropriate regulations to offer better systems solutions (Dee Angel, 1989; Finn, 2012; Marciani and Cossu, 2014; Franco, Johnston, and McCormick, 2020).

Innovative solutions and effective decisions came from suitable governance (Nicolaï and Faucheux, 2015; Oteng-Ababio and Agyemang, 2015). It can be achieved in a definition based on the premises of responsible innovation (Stilgoe, Owen, and Macnaghten, 2013), as represented in Figure 6.

Figure 6: Governance principles based on the RI approach

Source: Elaborated by the authors based on Stilgoe, Owen, and Macnaghten (2013)

In this sense, the premises of reflexivity, anticipation, inclusion, and responsiveness will underpin innovative results that offer better solutions to the mobility system.

Reflexivity translates the objective of avoiding an uncritical attitude in decisions, aiming at developing plans for the desired future results aligned with ethical values (Pangbourne *et al.*, 2020). This opens possibilities, benefiting long-term adaptive visions, promoting greener, socially, and economically desirable contexts for mobility across generations. The critical point is to identify risks, barriers and restrictions, and opportunities, developing robust decision-making (governance) capable of dealing with uncertainties that come with technological changes (Freudendal-Pedersen and Kesselring, 2016). This posture is useful for mobility systems as it examines and supports the reformulation of practices, processes, and arrangements in the light of changes (Navarro-Ligero and Valenzuela-Montes, 2016). It analyses, for example, what would be the potential challenges and problems; which results are desirable and which are undesirable; and what knowledge and institutional relationships are attached to technologies. Reflexivity, then, initiates a process of finding solutions (van der Vleuten, 2019). Thus, reflexivity is closely tied to anticipation.

Also related to the effort to identify issues and trends, anticipation can support the recognition of future opportunities by searching for alternative options. New trends require new policies and actions. Anticipation can support the achievement of desired mobility results by clarifying the challenges in urban mobility systems, facilitating the projects' processes of observation, identification, analysis, and monitoring (Dee Angel, 1989; Rosenblum, Hudson, and Joseph, 2020; Nicolai and Faucheux, 2015; Pangbourne *et al.*, 2020). For example, anticipation supports the identification of bottlenecks related to new technologies and services' insertion in the mobility system and their acceptance by users.

Even if closely conceptually related to demand-responsive technologies, responsiveness, as a mobility attitude, goes beyond (Haglund *et al*., 2019; Vosooghi *et al.*, 2020). As a responsible feature, responsiveness represents the tasks of translating attention into action, seeking to develop the mobility systems as solutions' sources (Giuffrida *et al*., 2021; Narayan *et al.*, 2017). To this end, contextualization is key as it impacts consumer behaviors, economic, environmental, structural, and political arrangements (Oteng-Ababio and Agyemang, 2015).

Considering the highlighted mobility issues, responsiveness means paying attention to responding to environmental and traffic issues, matching supply and demand needs (demand-pull and technology push), and supporting a modal shift towards an eco-sustainable and equitable future (Nicolai and Faucheux, 2015; Haglund *et al*., 2019). The actions can be figured as political, operational, or structural (Oteng-Ababio and Agyemang, 2015; Navarro-Ligero and Valenzuela-Montes, 2016; Vosooghi *et al.*, 2020). Responsiveness can result in support processes to modal shift, breaking the car dependency, as well as other aspects such as those related to mobility users' needs, such as costs, safety, and accessibility, besides responding to bottlenecks and barriers with suitable solutions (Weckström *et al.*, 2018; Haglund *et al*., 2019; Narayan *et al.*, 2017; Farhi *et al.*, 2015; Attard, Camilleri, and Muscat, 2020).

Inclusion is related to stakeholder integration and cooperation. The concept is mainly built by ideas of deliberation, participation, learning process, knowledge management, and collective objectives focused on win-win situations for all stakeholders and, consequently, the system. It is essential to identify urban mobility stakeholders and understand their roles (Marciania and Cossu, 2014; Nicolai and Faucheux, 2015; Lyons, Hammond, and Mackay, 2020). It is pointed out that, among the stakeholders, it is necessary to consider the citizens (Przybyłowski, 2018; Pangbourne *et al.*, 2020; Salvia and Morello, 2020). The diversity of interests is seen as knowledge sources, characterized as 'inputs' to the governance system. However, this can also pose difficulties that should be envisaged and managed by the governance system through effective and adequate tools and mechanisms (Freudendal-Pedersen and Kesselring, 2016).

The inclusion aims to take the wide point of view and interests, enrich debates, and make decisions to better support the reflexive, anticipatory, and responsive processes.

Emergent mobility innovations are posing challenges that require perspectives beyond market and financial terms (Mohieldin and Vandycke, 2017; Jokinen, Sihvola, and Mladenovic, 2019). By considering the wide range of related interdependent factors, mobility governance must also include users (behaviors, needs, and preferences), environmental and social aspects in its definition (Nicolaï and Faucheux, 2015; Pangbourne *et al.*, 2020). Exemplifying through AVs in mobility systems, the stakeholders' range can include industrial actors (original equipment manufacturers - OEMs), societal (users), legislative, and operational (service suppliers, both public and private) representatives. Inclusion can outline better strategies to mobility systems' outcomes, resulting in definitions towards growth, well-being, and health for cities.

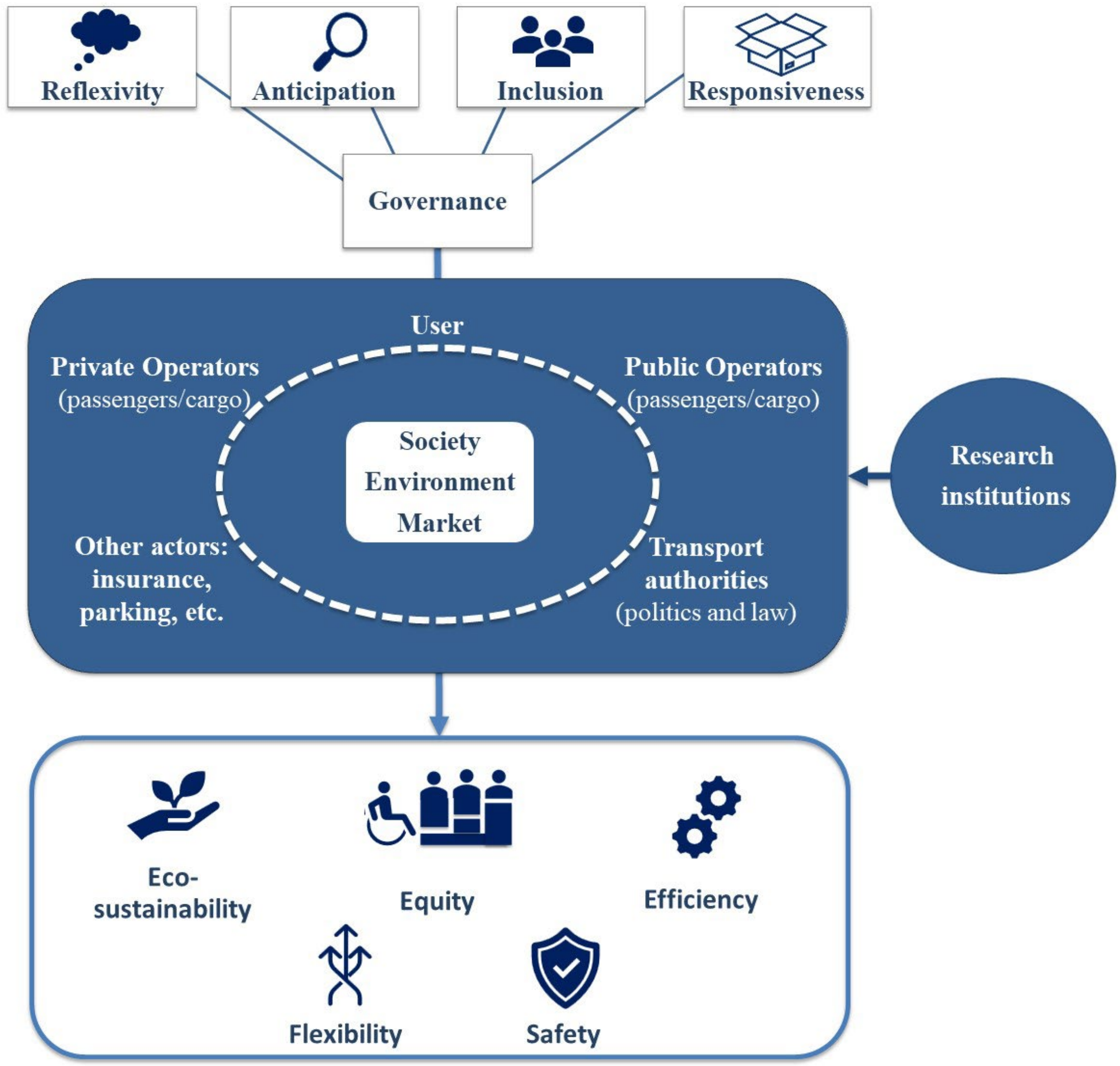
The context requires an anticipatory feature for governance to set an interactive dynamic where actors from different natures work collectively in societal, technical, economic, and environmental issues. This stands out the need for a deliberative mechanisms' definition to determine, promote and improve mutual learning processes in a reflexive way (Lehoux, Miller, and Williams-Jones, 2020).

Thus, governance frameworks need to be arranged as a combination of top-down and bottom-up initiatives for planning, financing, and operational settings. Besides the system' actors, partnerships with research institutes are important as knowledge is their main resource and expertise.

In this sense, the direction moves away from the discourse of unintentional and unanticipated consequences to embrace the awareness of the need for a focus on collective efforts towards a reflexivity vision about possible consequences, pointing out a responsible attitude (Oteng-Ababio and Agyemang, 2015; Pangbourne *et al.*, 2020).

In sum, a responsible mobility system's governance must consider: a systematized and interactive format (networked); a collective vision on objectives, solutions, and consequences; the different stakeholders integrated and a constructive dialogue between them; the issues in a critical and reflexive manner; the demand's features to develop an adequate supply capacity; the urban particularities; social, technical and environmental aspects as a compound. As a result, a responsible mobility system is created (Figure 7).

Figure 7: Responsible urban mobility system



Source: Elaborated by the authors

Although fruitful, the proposal of a responsible urban mobility system presents some bottlenecks that, even though analyzed under reflection, can only be overcome in practice in a specific and contextualized manner (mobility within the urban system).

Defining governance for an urban mobility system guided by the responsible innovation approach means defining collective actions, processes, practices, and rules based on aligned objectives and purposes. Such definitions can facilitate the deliberation process, enabling the co-creation process. For this, it is necessary to consider power structures and asymmetries to delineate a cohesive and robust structure, a forum for debate, effectively transforming democracy as a force, delivering values for all stakeholders. Appropriate terms and mechanisms for participatory deliberation must be defined based on the value creation and delivery model that attracts and supports their participation. Such a strategy is better supported when there is participation from the very beginning of the governance definition. This way, the objectives will be aligned and defined based on the actors' goals and interests, ensuring that the roles and participation are collectively defined based on their independent positions. Therefore, a suitable solution is creating an intermediate structure that articulates the governance system in an integrative way from the project's launch. Thus, firstly, it is necessary to identify the stakeholders involved and their purposes.

The differences in knowledge and experiences will base practices and procedures definition, offering efficient means to promote participation and deliberation (democracy). As a result, governance becomes a favorable arena for identifying and addressing opportunities and solutions for responsible innovations in the urban mobility system.

7. Final remarks

Even though it aims to produce benefits, innovation remains closely tied to the market and economic outcomes, often being questioned about failures in including societal and environmental issues as part of projects' definitions. Besides this negligence, innovations can exacerbate some problems. This is the main criticism that underlies the RI proposal (Owen and Pansera, 2019).

Focusing on responsible solutions to mobility systems, this paper proposes as necessary a reflexive attitude to support anticipatory efforts concerning undesirable and negative impacts. This definition can generate responsive actions to the related problems and demands in the most positive way. It can be achieved through an integration of stakeholders' views.

Rather than a determined process, RI is proposed as an approach to a governance model of urban mobility systems. The aim is to guide and support settings definitions rather than define steps as a methodological intent. Responsibility in urban mobility systems comes from a governance system founded on new ways of planning, coordination, and management of complexities and uncertainties, taking cities as particular contexts.

Reflecting urban specificities and including these in the governance frame, a responsible urban mobility system is responsive to social, environmental, and market issues, using these as the basis for ethical definitions, offering positive solutions and results for all the system. Hence, responsible innovation in mobility is founded by technical and non-technical principles in a contextualized manner, resulting in eco-sustainability, equity, efficiency, flexibility, and safety.

Eco-sustainability refers to mobility solutions that generate the least possible negative impact on the environment. Equity is translated into definitions of mobility system services and infrastructure that promote fair accessibility for different population groups. Efficiency refers to the operational means that improve or maintain the quality level of the mobility and transportation system (performance). Flexibility refers to proposals fundamentally based on multimodality (public, shared and on-demand transportation, non-motorized modes) and modal shift. Safety is the factor that deals with the safe use and experience of spaces in the transport and mobility system.

Although not indicated in the selected papers, it is important to point out that tools can support the translation of RI's dimensions into practice, as stated by Stilgoe, Owen, and Macnaghten (2013). To promote ‘anticipation’, technology assessment, scenarios, horizon scanning, vision assessment, or socio-literary techniques can be useful if well developed, keeping attention not exacerbating technological determinism. Reflexivity can be supported by mechanisms such as laboratories' experiences, moratoriums, and codes of conduct. For ‘inclusion’, open innovation, user-centric design, focus groups, deliberative mapping, and pooling can endorse a participatory approach. ‘Responsiveness’ can be achieved through attention to regulations and standards, underpinning actions by niche management and value-sensitive design. It is important to point out that these must be used according to the need, taking into account the field's contextual specificity and other particularities. Therefore, even not including such discussions, this paper offers a fundamental step to support translating RI's dimensions into practice by offering a contextual representation of the main concepts and premises.

Given the bottlenecks mentioned above to the responsible mobility system's practical context, future studies can explore real cases to understand how the power asymmetry is considered towards inclusion and deliberation. For this, it is necessary to consider the stakeholders' natures, purposes, roles, and particular goals. This proposal can be mainly focused on private operators given the possible competitive field where they come from.

Further research can also examine how to offer responsibility to the system considering its products and services.

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Appendix 1

Selected papers – search 1

Database	Title	Authors
WoS	Business models and the diffusion of eco-innovations in the eco-mobility sector	Nicolaï & Faucheux (2015)
SD	Questioning mobility as a service: Unanticipated implications for society and governance	Pangbourne, Mladenović, Stead & Milakis (2020)
SD	Reprint of: The importance of user perspective in the evolution of MaaS	Lyons, Hammond & Mackay (2020)

Appendix 2

Selected papers – search 2

Data base	Premisse	Title	Authors
WoS	Inclusion	Sustainable urban mobility planning: Gdynia city case study	Przybyłowski (2018)
SD	Inclusion	How the URBeLOG project will enable a new governance model for city logistics in Italian metropolitan areas	Marciania & Cossu (2014)
SD	Inclusion	Sharing cities and citizens sharing: Perceptions and practices in Milan	Salvia & Morello (2020)
SD	Responsiveness	Addressing the public transport ridership/coverage dilemma in small cities: A spatial approach	Giuffridaa, Le Pira, Inturri, Ignaccolo (2021)
SD	Responsiveness	Applications of the urban traffic control strategy TUC	Dinopoulou, Diakaki & Papageorgiou (2006)
SD	Responsiveness	A semi-decentralized control strategy for urban traffic	Farhi, Van Phu, Amir, Haj-Salem, Lebacque (2015)
SD	Responsiveness	A Tool for the Assessment of Urban Mobility Scenarios in Climate Change Mitigation: an Application to the Granada's LRT Project	Navarro-Ligero & Valenzuela-Montes (2016)
SD	Responsiveness	Demand responsive transport: Generation of activity patterns from mobile phone network data to support the operation of new mobility services	Franco, Johnston & McCormick (2020)
SD	Responsiveness	Dynamic modeling and control of taxi services in large-scale urban networks: A macroscopic approach	Ramezani & Nourinejad (2018)
SD	Responsiveness	Information Management of Demand-Responsive Mobility Service Based on Autonomous Vehicles	Szigeti, Csiszár & Földes (2017)
SD	Responsiveness	Multi-agent simulation for planning and designing new shared mobility services	Inturri, Le Pira, Giuffrida, Ignaccolo, Pluchino, Rapisarda, D'Angelo (2019)
SD	Responsiveness	Non-myopic relocation of idle mobility-on-demand vehicles as a dynamic location-allocation-queueing problem	Sayarshad & Chow (2017)
SD	Responsiveness	Performance assessment of fixed and flexible public transport in a multi agent simulation framework	Narayan, Cats, van Oort, Hoogendoorn (2017)
SD	Responsiveness	Policy lessons from the flexible transport service pilot Kutsuplus in the Helsinki Capital Region	Jokinen, Sihvola & Mladenovic (2019)
SD	Responsiveness	Shared autonomous electric vehicle service performance: Assessing the impact of charging infrastructure	Vosooghi Puchinger, Bischoff, Jankovic, Vouillon (2020)
SD	Responsiveness	The technology behind a shared demand responsive transport system for a university campus	Attard, Camilleri & Muscat (2020)
SD	Responsiveness	Towards large-scale flexible transport services: A practical perspective from the domain of paratransit	Finn (2012)
SD	Responsiveness	User perspectives on emerging mobility services: Ex post analysis of Kutsuplus pilot	Weckström, Mladenović, Ullah, Nelson, Givoni, Bussman (2018)
SD	Responsiveness	Where did Kutsuplus drive us? Ex post evaluation of on-demand microtransit pilot in the Helsinki capital region	Haglund, Mladenović, Kujala, Weckström, Saramäki (2019)
Scopus	Responsiveness	The Okada War in Urban Ghana: A polemic issue or policy mismatch?	Oteng-Ababio & Agyemang (2015)
Scopus	Anticipation	Mobility Futures: An Overview	Dee Angell (1989)
SD	Anticipation	Parking futures: An international review of trends and speculation	Rosenblum, Hudson & Joseph (2020)
Scopus	Reflexivity	Mobilities, Futures & the City: repositioning discourses – changing perspectives – rethinking policies	Freudendal-Pedersen & Kesselring (2016)
Scopus	Reflexivity	Radical change and deep transitions: Lessons from Europe's infrastructure transition 1815–2015	van der Vleuten (2019)

ARTICLE 2: Monitoring smart cities performance: A perspective from responsible innovation focusing on transport indicators.

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Monitoring smart cities performance:

A perspective from responsible innovation focusing on transport indicators

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Abstract: The city is at the crossroads of a multitude of innovation, and societal needs and uses, bringing forward social, environmental, urban, and technological challenges that impact the choices and habits related to transportation, thus, impacting daily lives. At a time of increasing urbanization and climate and digital transition, the issues of resilience and sustainability are at the heart of the responses to challenges. This paper discusses issues of resilient and smart cities from the perspective of Responsible Innovation. To do so, this paper analyzes whether ISO standards related to transportation of sustainable, smart, and resilient cities (ISO 37120, 37122, and 37123) present a responsible orientation. The methodological design is based on deductive content analysis dedicated to smart cities' performance. Based on the analyses, the discussions focus on presenting how the inclusion of responsibility premises can benefit ISO adaptations, which is proposed based on adequate definitions of governance supported by attitudes of anticipation, reflexivity, inclusion, and responsiveness.
Keywords: ISO 37120. ISO 37122. ISO 37123. Sustainable cities. Smart cities. Resilient cities. Responsible Innovation. Transport indicators. Performance.

1. Introduction

The growing urbanization, the increasing needs to be met in connection with the population explosion, the climate change, the decrease in resources, housing, and mobility issues, as well as growing socioeconomic inequalities, show a very high level of urban vulnerability with numerous social, environmental, and economic impacts (Bibri and Krogstie, 2017). In the face of these vulnerabilities, innovation in all its forms must be at the citizens' service to make the city a sustainable place to live, capable of adapting quickly to social and environmental changes. While digitalization is an innovation allowing the city to be more sustainable and resilient, it also has significant negative consequences (privacy risks, widening inequalities, growing carbon footprint). In line with the imperative outlined by the un through the UN's SDG 11 (Make cities and human settlements inclusive, safe, resilient, and sustainable), the city of the future will be defined as sustainable and resilient (Moschen et al., 2019; United Nations, n.d.).

A sustainable city is a concept that combines environmental concerns, human capital development, and healthy living principles based on education, energy, transportation, buildings, waste management, natural resources as essential elements (Sodiq et al., 2019). A sustainable city controls its internal impacts related to the city's metabolism, such as ecological inequalities and its external impacts linked to ecological footprint and intra-generational solidarity (Kennedy and Hoornweg, 2012). Inspired by ecological resilience, urban resilience is defined as the amount of disruption an ecosystem can absorb while maintaining its functions. A resilient city can cope with multiple crises. Therefore, these cities must be diverse, complex, and constitutive of a shared integrated ecosystem, interconnected, open to change, flexible, and resistant (Folke et al., 2002; Klein et al., 2004).

Therefore, the city of the future is a territory where services are built to meet the basic needs of its inhabitants and their quest for well-being, aware of sustainable aspects. Car-sharing, multimodal mobility, decentralized energies, urban public spaces of conviviality, public health, a better quality of life, mass education online, open spaces for culture, art, and leisure, and participatory democracy are just a few examples of the aspects that will make the city of tomorrow as a smart city. The main ideas are under definitions of open governance systems, collaborative information networks, local economy, and infrastructures.

The OECD (2020, p. 03) defines smart cities as "cities that leverage digitalization and engage stakeholders to improve people's well-being and build more inclusive, sustainable and resilient societies". However, it is not a standard definition. The essence of a smart city can be identified through two mainstream approaches: technology-oriented and people-oriented (Garau and Pavan, 2018; Yigitcanlar et al., 2018; Sharifi, 2019). This paper follows the orientation toward human issues and technological ones. In this sense, taking an interest in a smart city also means taking an interest in the city's complexity: its identity, cultural tradition, and the increasingly intense demands of its citizens concerning governance (Sepasgozar et al., 2019).

Facing such characteristics of complexity, measuring the performance of a smart city is essential to ensure its efficiency. The performance management framework of a smart city must fulfill five objectives according to OECD (2020): (i) generate expected multi-sector outcomes from digital innovation in cities; (ii) create initiatives that benefit all stakeholders - not selected groups; (iii) engage stakeholders; (iv) be useful for national and local considerations; and (v) monitor and measure evolution over time and spaces.

Indicators are essential tools for providing information to guide governance decisions. Several initiatives have been developed to guide and monitor performances of the various urban systems (Lützkendorf and Balouktsi, 2017; Merino-Saum et al., 2020), such as ISO 37120 (Sustainable Cities and Communities – indicators for city services and quality of life), which involves guidelines to promote social and economic growth while maintaining environmental awareness (Moschen et al., 2019). As one of the most globally known and used indicators' standards, ISO 37120 includes a composition of two critical elements for the current urban context: ISO 37122 (smart cities) and 37123 (resilient cities) (ISO, 2018). However, as noted by Berman and Orttung (2020), the ISO management system for smart and sustainable cities lacks an explicit theoretical foundation. Such a focus would provide comprehensive guidance on selecting appropriate indicators. In addition, theoretical concepts can underpin a broad view of city performance, making it possible to analyze results beyond purely statistical data, supporting the better performance of sustainable, smart, and resilient cities.

Nevertheless, the theoretical framework to evaluate indicators, their contents, focus, and structure is based on the hypothesis that the drivers of eco-innovation are classified as "market pull," "technology push," and "institutional factors and policy measures" (Horbach et al., 2012). As Nieminen and Hyytinen (2015) suggest, the development of evaluation mechanisms must deeply incorporate systemic and dynamic approaches to better consider the wide range of complexities and contributions to societal challenges. The theoretical framework needs to evolve to strengthen the links between sustainable and smart cities by focusing on social and environmental long-term equity to the human being (Bibri and Krogstie, 2017; Moschen et al., 2019).

Aligned with these points, a comprehensive assessment could be based on the responsible innovation (RI) approach. Grounded on governance definitions, it promises a more direct and coherent response to the complexities of a smart and sustainable city and could ensure its efficiency. RI is an oriented framework to ethically respond to issues, interests, and values considering inclusive integration of stakeholders. The incorporation of such principles into the ISOs related to urban contexts (37120, 37122, and 37123) can generate guidance towards policies and practices more socially, economically, and technically balanced, resulting in socially and environmentally desirable outcomes (Stilgoe et al., 2013; Macnaghten et al., 2014).

Given the context of emerging innovations, complexity management challenges, and possible improvements through theoretical approaches, it is proposed to evaluate the reference framework for measuring a smart city in light of the ethical considerations raised by the responsible innovation framework. So, the main question is: is there a responsible orientation in ISO standards management related to sustainable cities and communities (ISO 37120, 37122, and 37123)?

This paper first considers the responsible innovation framework to answer the research question, analyzing whether such ISO standards present an RI orientation. Secondly, the number of indicators inserted in the ISO standards is analyzed, focusing on determining the best approach to perform a deep and coherent deductive content analysis (Hsieh and Shannon, 2005; Elo and Kyngäs, 2008; Krippendorff, 2018). After defining the appropriate methodological strategy, the RI analysis framework is conceptualized to offer a reading of the ISO indicators under the prism of the responsible innovation framework.

This paper is structured by the discussion on indicators for cities and communities, presentation of ISO indicators (ISO 37120, 37122, and 37123), and the theoretical construct of RI is presented. Following are the methodological definitions and the proposed discussion on responsibility and ISO indicators. Finally, conclusions are presented.

2. Theoretical background

2.1. Measuring performance of cities and communities

The performance of cities is assessed based on economic, social, and geographic data to identify strengths and weaknesses of projects to subsidize policy actions for the development of healthier, more sustainable environments with a better quality of life, promoting increased economic and social attractiveness (Lützkendorf and Balouktsi, 2017; Ribeiro et al., 2019). Performance measurement requires adequate and integrated planning to draw attention to natural, economic, and social systems (Klopp and Petretta, 2017; Verma and Raghubanshi, 2018). Urban density allows for the categorization, analysis, and understanding of trends related to the city system. However, density analysis is not enough (Garau and Pavan, 2018). Effective data management requires holistic analyses that include different urban systems (Abreu and Marchiori, 2020) in the performance evaluation framework.

According to ISO 15392:2019 (ISO, 2019c), indicators are sources of analysis that can be quantitative, qualitative, or descriptive. According to Hiremath et al. (2013) and Lützkendorf and Balouktsi (2017), indicators refer to the analysis, evaluations, and definitions of mechanisms for achieving objectives. Indicators are rarely defined and employed independently and must be designed within a holistic framework. In the case of a city, indicators can subsume the analysis of complementary city subsystems, assessing the performance and progress of each (Kitchin et al., 2015). With this in mind, a relevant measurement framework for a smart city will consider different components:

- Various types of indicators: OECD framework (2020) recommends the consideration of three type categories of indicators: input/output/outcome; static/dynamic; quantitative/qualitative;
- Various scales of analysis: geographic focus; the scale of institutional analysis, primary target audience (city authorities, investors) (Sharifi, 2019);
- Various dimensions: from three dimensions for U4SSC (2020) to six categories for Petrova-Antonova and Ilieva (2018).

Many indicators have emerged because critical concepts are not commonly defined, interpreted, and used (Bibri and Krogstie, 2017). The SDGs generalization reflects this growing recognition, including SDG 11 dedicated to transforming cities and human communities into safe, resilient, inclusive, and sustainable contexts. However, to consider the impacts of a city more broadly, a complete review of all the SDGs is required.

Alongside the growing recognition of sustainable development, policy, business, and academic initiatives have proposed alternative measurement mechanisms to monitor and compare the performance of cities around the world (Lützkendorf and Balouktsi, 2017; Merino-Saum et al., 2020). For example, d'Amico et al. (2020) analyzed eight international standards on smart urban metabolism international standards and 534 related indicators: ISO 37120; ISO 37122; ISO 37123; UNECE-ITU; ETSI TS 103 463; ITU-T Y. 4903; ITU-T Y. 4902; and ITU-T Y. 4901.

The authors noticed that most of the indicators were originated from ISO and ITU. Besides analyzing the scopes, in terms of economic and social dimensions, these are most represented in ISO 37123. The environmental dimension did not prevail in any standard, but this dimension was more represented in ISO 37120 and less in ISO 37123. The social dimension was presented in half of the standards, but higher percentages related to ISO 37123. The analysis' outcomes present a balanced distribution in terms of economic, social, and environmental dimensions related to the ISO 37122 and UNECE-ITU standards. Accordingly, Huovila et al. (2019) emphasized the ISO 37120 as mainly focused on sustainability, while the ITU 4901 has a greater focus on smartness.

Although covering a wide range of smart and sustainable cities' features, as these indicators are embedded in politics and related to different purposes, there is no clear consensus regarding methodology or systems' standards (Pires et al., 2014; Ahvenniemi and Huovila, 2021). Focusing on the relation between the attention to people, planet, and prosperity as a sustainable balance, Huovila et al. (2019) have chosen to analyze the ISO 37120 framework considering it as better suited for cities that aim immediate policy measures' implementations towards sustainability.

Specifically related to cities, the ISO 37120 presents 111 services and quality of life indicators. This standard sets out an approach to the scope and focus of measurements through a list of indicators without defining an objective based on a numerical value. Following the principles of ISO 37101 (Sustainable development in communities - Management system for sustainable development - Requirements with guidance for use), the overall objectives are related to performance management over time; performance comparisons to support learning; support for prioritization as for policymaking. This standard is divided into 19 themes: (1) Economy, (2) Education, (3) Energy, (4) Environment and climate change, (5) Finance, (6) Governance, (7) Health, (8) Housing, (9) Population and social conditions, (10) Recreation, (11) Safety, (12) Solid waste, (13) Sport and culture, (14) Telecommunication, (15) Transportation, (16) Urban/local agriculture and food security, (17) Urban planning, (18) Wastewater, and (19) Water and sanitation (ISO, 2018)

ISO 37120 is complemented by two other standards: ISO 37122 (smart cities) and ISO 37123 (resilient cities) (ISO, 2018). ISO 37122 complements the ISO 37120 by establishing support and guidelines progress towards a smart city based on 80 indicators directed to smart city projects, policies, and programs. A smart city challenges climate change, political and economic engagement, infrastructure issues, and rapid population growth. Such posture requires responsiveness, collaborative leadership, optimized data information and technologies, innovative processes, innovative economy, and efficient and prospective management (ISO, 2019a).

ISO 37123 resulted from recognizing the need for supplementary indicators for resilient cities. This standard, composed of 68 indicators, defines a resilient city as a city able to prepare for, manage, mitigate, recover from, and adapt to shocks and stresses efficiently to ensure the quality of its essential services (ISO, 2019b). It is emphasized that resilience, both as a core component and an enabler of sustainable development, characterizes a detailed understanding of risks, defining and taking appropriate measures, and increasing awareness and participation of members of society (ISO, 2019b).

ISO documents 37122 and 37123 are meant to be implemented with ISO 37120. This guideline strengthens the link between sustainable development, smart development, and resilient development. However, these frameworks do not analyze the performance of a smart city as a complex ecosystem composed of interconnected subsystems (Rousseau 2015). For example, Lom and Pribyl (2021) illustrate in a systems approach how, in a smart city, an electric car can communicate directly with the energy grid, or the infrastructure can communicate directly with power plants to optimize energy supply based on vehicle demand. These interactions must be anticipated and integrated into decision support models because they can be sources of rebound effects and positive or negative externalities.

In addition, the economic, social, and environmental dimensions of the smart city should be considered as issues of inclusion or vulnerability. There is little information on these elements in the ISO standards (Verma and Raghubanshi, 2018; Moschen et al., 2019). Finally, there are questions about how the indicator frameworks were developed. They often do not include the degree of stakeholder involvement. Considering the effects on the subsystems in terms of interdependence on all the ecosystem stakeholders, an integrative character must be the basis of a decision support system framework. Therefore, the literature on responsible innovation can provide an appropriate framework for analysis.

2.2. Responsible innovation

The responsible innovation (RI) concept emerged as a policy-driven discourse from the European Commission. It is an innovation that, in addition to aiming for economic benefits, considers its societal implications by being concerned with respect for the environment, human health, working conditions, standard of living, and societal choices in terms of ethics and equity. In that optics, RI "firstly asks what kind of future we want innovation to create, and secondly, given that the future is inherently uncertain and unpredictable, how we should proceed under conditions of ignorance, ambiguity and uncertainty" (Owen and Pansera, 2019, p. 29).

This paper proposes to analyze the performance definitions of smart and resilient cities through this reading grid. Two questions become crucial: what is the desirable future (all stakeholders' needs being addressed), and what model should be used to support decision-making in a situation of uncertainty? In light of this, it is also necessary to reason that some risks are "unquantifiable" (linked to scientific complexity), societies are divided over the weight and social significance of risks, and principles and beliefs (ethical, religious) influence decisions – and these cannot be ruled out (Funtowicz et al., 1998).

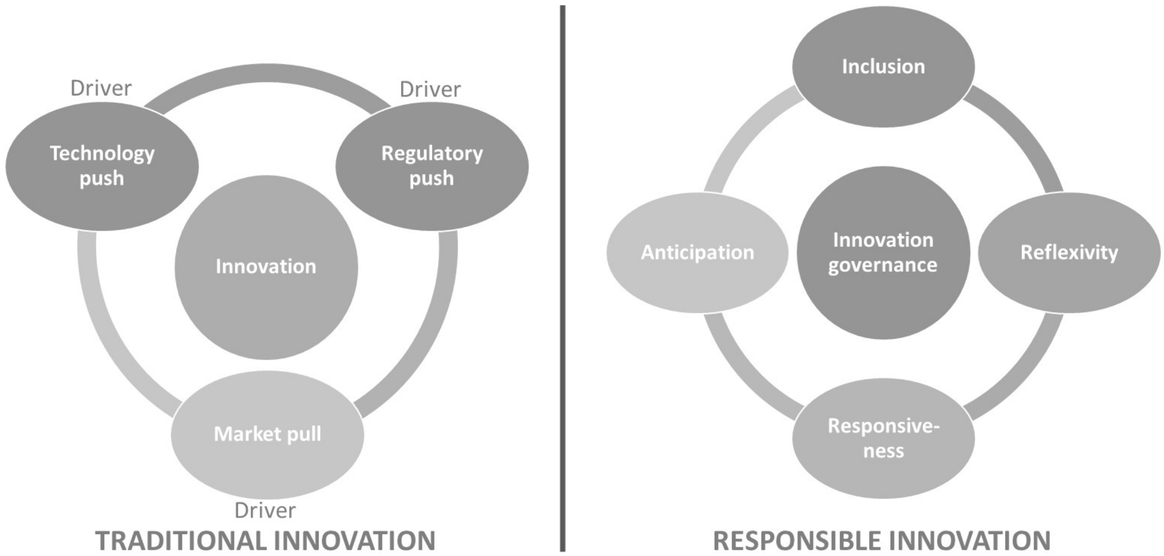
In an uncertain context, the conception of responsibility is based on the understanding that technology is technically, socially, and politically constituted (Winner, 1978). The responsible innovation framework allows for the governance and evaluation of innovations regarding their potential negative consequences and positive contributions to societal challenges. It examines risks whose effects have not materialized but partially identified potential threats (Hoffmann-Riem and Wynne, 2002). This framework can support the proposition of a governance model adapted to the diffusion of new solutions in a radical uncertainty situation and reflect on the objectives and values.

More decentralized and open governance, which is exercised in new places - markets, networks, and partnerships - and of a different nature - regulatory, normative codes, participatory or anticipative governance - is proposed. These initiatives have attempted to introduce a broader ethical reflection into the innovation process by creating new spaces for public dialogue (Irwin, 2006). Bentham (1996) argued that the moral value of action is measured by utility evaluated from the needs and interests of the community. It would imply that everyone will conduct his actions according to the consequences he anticipates maximizing his pleasure and that collective happiness is equal to the sum of individual well-being. Thus, the city of the future should optimize the combination of pleasures and pains for the most significant number of people.

Performance would then be seen as the constant adjustment of our actions to improve them and make them "perfect." However, in a smart city sustainable and resilient, structured with interdependent subsystems, it is difficult to judge the actions by their consequences on the most significant number and define what this "perfection" would be. The importance of deliberation discussions to aim for harmony and goodwill within society is imperative for such innovation governance. Thus, the governance process for smart cities must be based on assessments that also consider societal requirements and values (Grove-White et al., 2000; Macnaghten and Szerszynski, 2013; van Oudheusden, 2014). Boyte (2011, p. 633) defines governance as sustained "efforts by a mix of people who solve common problems and create things, material or symbolic, of lasting civic value". Following the work of Jonas (1979), the manifestation of good can be interpreted as the permanence of real human life.

Stilgoe et al. (2013) define RI as taking charge of the future by collectively managing innovation in the present using its four dimensions of anticipation, reflexivity, inclusion, and responsiveness. Anticipation involves systems thinking and recognizes complexities, uncertainties, and risks in science and societies. It also allows the development of desirable futures and the organization of the resources accordingly. Reflexivity requires the inclusion of broader moral obligations in the roles and responsibilities of different actors. Inclusivity goes beyond stakeholder engagement and reaching out to the general public. Responsiveness is the ability to change form or direction in response to changing actors and public values and circumstances. Figure 1 illustrates a comparison with a traditional innovation approach.

Figure 1: Traditional innovation and RI



Source: Based on Souza et al. (2020)

A co-creation framework and shared learning resulting from such posture require flexibility, adaptation, integration with an inter and trans-disciplinary approach (Owen and Pansera, 2019). RI is intended to be an "anticipatory" innovation that must be accompanied at each stage by in-depth and transparent research to evaluate the current and future opportunities and risks it presents for populations (Pavie and Carthy, 2015). Ethical requirements must be validated in the governance of such an innovation: solidarity (generations), justice (recognition of differences), dignity, and respect (human rights) (von Schomberg, 2013).

Although the literature on RI has developed theoretically over the past decade, its operational terms are under development (Koops, 2015; Timmermans, 2017; Fraaije and Flipse, 2020). For Rivard and Lehoux (2020), one line of research represents actors' practical visions and "real world" conditions related to innovation. RI defines an approach that focuses on transparent and integrative stakeholder interaction based on sustainability principles, mutual accountability, and consensus that develops innovation that positively impacts the market, society, and the environment (Von Schomberg, 2011). Following Carrier and Gartzlaff (2020), context-sensitive approaches are needed to translate the concept of RI into practices and frameworks that take into account different contexts.

3. Methodology

The work of d'Amico et al. (2020) and Huovila et al. (2019) highlights that the ISO 37120 model is more comprehensive in addressing sustainability for cities. Furthermore, as noted by Berman and Orttung (2020), ISO 37120 clearly defines and integrates smartness (ISO 37122) and resilience (ISO 37123). Thus, to examine indicators related to sustainable smart cities in light of responsible innovation assumptions, ISO 37120, 37122 (smart cities), and 37123 (resilient cities) were selected.

These documents propose 259 indicators, of which a majority (23 indicators representing 8.9% of the total) are related to transportation. In order to examine in-depth and propose specific discussions, these transportation indicators were selected for analysis (Figure 2).

Figure 2: Number of indicators of each ISO

Theme		Number of indicators			Total	%
		ISO 37120	ISO 37122	ISO 37123		
1	Economy	9	4	7	20	7,7
2	Education	6	3	4	13	5,0
3	Energy	8	10	3	21	8,1
4	Environment and climate change	9	3	9	21	8,1
5	Finance	5	2	7	14	5,4
6	Governance	4	4	6	14	5,4
7	Health	6	3	4	13	5,0
8	Housing	5	2	6	13	5,0
9	Population and social conditions	4	4	5	13	5,0
10	Recreation	2	1	0	3	1,2
11	Safety	10	1	4	15	5,8
12	Solid waste	10	6	1	17	6,6
13	Sport and culture	3	4	0	7	2,7
14	Telecommunication	2	3	1	6	2,3
15	**Transportation**	**8**	**14**	**1**	**23**	**8,9**
16	Urban/local agriculture and food security	4	3	2	9	3,5
17	Urban planning	4	4	6	14	5,4
18	Wastewater	5	5	0	10	3,9
19	Water and sanitation	7	4	2	13	5,0
Total		111	80	68	259	

Source: Documents' data

The collected documents were analyzed based on the premises of qualitative content analysis. The chosen methodological technique guides an objective, systematic and reliable review and interpretation of documents (textual, visual, or audios) by grouping the information in categories or topic areas (Hayes and Krippendorff, 2007; Krippendorff, 2018). Content analysis, thus, allows the test and theoretical verification, enhancing and improving the data understanding (Elo and Kyngäs, 2008).

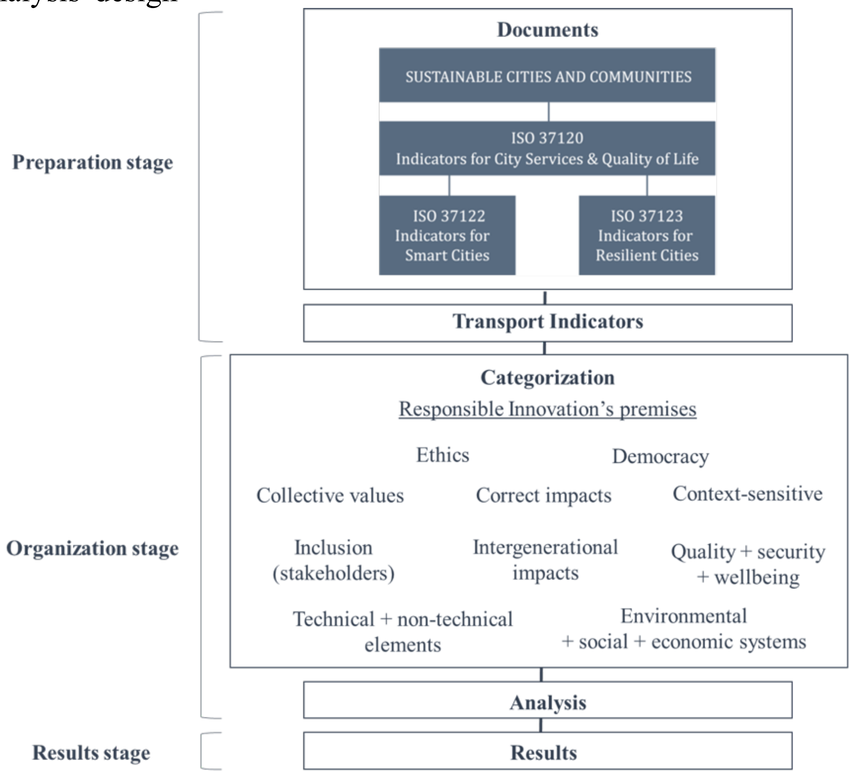
Unlike a narrow quantitative focus on word counts, the qualitative process of content analysis, from objective extracts of texts, summaries, retrieve, examines, and interpret latent meanings, themes, and patterns with greater reliance on a context in order to answer the research question (Hsieh and Shannon, 2005; Prasad, 2019). Themes can be identified through two directions: inductive or deductive approaches. In the inductive approach, categories emerge from the data. It is usually appropriate in cases of limited existing related theory or literature. A deductive approach is useful when previous knowledge is used to structure the analysis' operationalization.

As an example of the inductive approach, Rampini et al. (2019) applied content analyses to ISO pattern (ISO 31000:2018), aiming to identify the main related factors and definitions in the context of risk management systems.

In this paper, the content analysis was performed as a deductive technique, in which specific predetermined RI's premises were used to identify passages of interest. The premises of the RI were based on the work of Souza et al. (2020) according to different items: attention to ethics; collective objectives; technical and non-technical aspects; the connection among social, economic, and environmental goals; integrative proposition; constructive dialogue among stakeholders; intergenerational awareness; a link between quality, security, and well-being; correct impacts; and consideration of contexts as innovative process' elements.

Elo et al. (2014) suggest that content analysis trustworthiness is improved by following preparation, organization, and the reporting phases. Following such ideas, the defined design for the applied content analysis is presented in Figure 3.

Figure 3: Content analysis' design



Source: Elaborated by the author with adaptation from ISO (2018) and Souza et al. (2020)

In the first stage, ISO documents (ISO 37120, 37122, and 37123) were selected, and transport indicators were chosen as the unit of analysis. During the second phase, a categorization matrix was created to facilitate categories identification, correspondence, exemplification, review, and its relations to the content. The matrix facilitates the identification, correspondence, exemplification, review, and representation of the relationship of the content to the categories. The analysis considers twenty-three ISO's transport indicators.

The organizing phase focuses on concepts, categories, interpretation, data reliability, and representativeness within an RI logic of ISO documents. Thematic indicators related to the RI premises thus obtained are ethics, collective values, correct impacts, democracy, consideration of context, a combination of technical and non-technical elements, inclusion of stakeholders, attention to intergenerational impacts, consideration of environmental, social, and economic systems as interconnected, and emphasis on coupling quality, well-being, and safety of innovative solutions.

The interpretive effort involved identifying and analyzing the documents (overall document and transport indicators) related to these categories reflecting RI meanings. The last stage is related to clarity and understandability, assessment of category coverage in terms of data, and process description. Therefore, this stage describes the discussions of content and categories that allow for presenting results. The quality of analysis will depend not only on the nature and variety of the stakeholders encountered but also on the accuracy of the information retrieved.

4. Results and discussions

For ISO (n.d), some principles are key to developing standards: respond to a need in the market; based on global expert opinion; developed through a multi-stakeholder process; based on a consensus. In this paper, such principles are proposed to be enhanced grounded on the premises of RI. The analysis results and general discussions are presented in the following topics.

4.1. Responsibility and indicators: an overview based on ISO patterns ISO 37120, 37122 and 37123

In the content analysis of ISO 37120, 37122, and 37123 each indicator is linked to the contribution to "sustainability goals" by reflecting "sustainability issues". These cross-relationships provided data to support the analyses by comparing them to the RI premises. To contribute to positive change, ISO has adopted Strategy 2021-2030, aligned with the 17 SDGs. The vision is to bring ease, security, and improvement to people. In this sense, it is proposed that the SDGs address current and future global challenges and needs, including all voices, and advance participation, inclusion, and diversity (ISO, 2021b). Figure 4 presents a matrix where relations between transport indicators and RI premises are marked with an "X". The correlation with the SDGs is also presented.

Figure 4: RI's premises into ISO patterns for cities and communities and SDGs

	ISO Transport Indicators	SDGs targeted	Responsible Innovation's Premisses									
			Ethics	Correct impacts	Intergenerational awareness	Quality + security + well being	Technical + non-technical	Collective values	Environmental + social + economic	Context-sensitive	Governance	Integration (stakeholders)
37120	Overall document	3, 9, 11		X		X			X	X	X	
	19.1 Km of public transport system/100000 population	9	X			X				X	X	
	19.2 Annual No. of public transport trips/capita	9, 11	X			X			X		X	
	19.3 % of commuters using a travel mode to work other than a personal vehicle	3, 11	X			X					X	
	19.4 Km of bicycle paths and lanes/100000 population	11	X			X			X		X	
	19.5 Transportation deaths/100000 population	11				X				X	X	
	19.6 % of population living within 0,5km of public transit running at least every 20 min during peak periods	11	X			X					X	
	19.7 Average commute time	11	X			X					X	
	19.8 Transportation profile indicators - 19.8.1 No. of personal automobile per capita	-				X						
	19.8 Transportation profile indicators - 19.8.2 No. of two-wheeled motorized vehicles per capita	-										
37122	Overall document	9, 11, 12	X			X	X		X	X	X	
	19.1 % of city streets and thoroughfares covered by real-time online traffic alerts and information	9, 11				X	X				X	
	19.2 No. of users of sharing economy transportation/100000 population	-	X		X	X	X				X	
	19.3 % of vehicles registered in the city that are low-emission vehicles	11, 12	X			X					X	

Source: Elaborated by the authors based on ISO (2018, 2019a, 2019b) and Souza *et al.* (2020)

Figure 4 (continuation): RI's premises into ISO patterns for cities and communities and SDGs

ISO	Transport Indicators	SDGs targeted	Responsible Innovation's Premisses									
			Ethics	Correct impacts	Intergenerational awareness	Quality + security + well being	Technical + non-technical	Collective values	Environmental + social + economic	Context-sensitive	Governance	Integration (stakeholders)
	19.4 No. of bicycles available through municipally provided bicycle-sharing services/100000 population	11	X			X	X				X	X
	19.5 % of public transport lines equipped with a publicly accessible real-time system	9, 11	X			X	X				X	
	19.6 % of the city's public transport services covered by a unified payment system	11				X	X				X	
	19.7 % of public parking spaces equipped with e-payment systems	-	X			X	X				X	
	19.8 % of public parking spaces equipped with real-time availability systems	9	X			X	X				X	
37122	19.9 % of traffic lights that are intelligent/smart	9, 11	X			X	X				X	
	19.10 City area mapped by real-time interactive street maps as a percentage of the city's total land area	11	X			X	X				X	
	19.11 % of vehicles registered in the city that are autonomous vehicles	-	X			X	X				X	
	19.12 % of public transport routes with municipally provided and/or managed Internet connectivity for commuters	9	X			X	X				X	
	19.13 % of roads conforming with autonomous driving systems	11				X					X	
	19.14 % of the city's bus fleet that is motor-driven	11	X			X	X				X	
37123	Overall document	9, 11, 13	X	X	X	X	X	X	X	X	X	X
	19.1 No. of evacuation routes available/100000 population	9, 11, 13				X						

Source: Elaborated by the authors based on ISO (2018, 2019a, 2019b) and Souza *et al.* (2020)

In terms of SDGs, the SDG11 is the most prominent. This goal describes a focus on better urban management to provide safer, more resilient, inclusive, and sustainable spaces. The SDG9 is also widely referenced. Addressing innovation, resilient infrastructure, inclusive and sustainable industrialization, aggregating structures, physical systems, economic growth, technological capabilities, and new skills, SDG 9 seeks to support affordability, equity, economic development, and human well-being.

In terms of the premises, the discussions start from the ethical lens. The innovation processes in a city are dynamic and integrate the actors and their relationships. This consideration of collective activity requires greater attention to ethics in the governance model (Pandza and Ellwood, 2013). The question of ethics based on virtues and not simply defined by rules and standards must be raised as it will materialize the innovation ecosystem by encouraging researchers, companies, and politicians to reflect on their role in terms of intra and intergenerational impacts created by their activities (Souza et al., 2020).

ISO 37120 and 37122 have an ethical character by including sustainability purposes from ISO 37101: "Preservation and improvement of environment" and "Social cohesion". Specifically, the "Preservation and improvement of environment" on ISO 37120 is referred to in 19.1, 19.3, 19.4. In ISO 37122, it is related to 19.1, 19.3, 19.8, 19.9, 19.10, and 19.11. This purpose focuses on improving environmental performance by reducing greenhouse gas emissions; protecting, restoring, and enhancing ecosystem diversity; and reducing health risks (ISO, 2016). As the future is built in the present, RI treats the impacts of innovation as drivers of economic, environmental, and human growth. Thus, the ethical lens is deployed to include the "p's" of people and planet to the "p's" of technological innovation (product, patent, production, profit, pioneer) (Souza *et al.,* 2020). Thus, according to the RI theory, the concept of ethics is included in the basic definitions of an innovation project.

The "Social cohesion" is related to 19.1, 19.6, and 19.7 on ISO 37120 and 19.2, 19.4, 19.5, and 19.6 on ISO 37122. Social cohesion is focused on "accessibility; culture; dialogue with external parties not limited by boundaries, diversity; equity; heritage; inclusiveness; inequalities reduction; rootedness; a sense of belonging and social mobility" (ISO, 2016, p.8). In the very classic pattern of practical reasoning, solutions are developed based on the broad principles underlying the core beliefs: do good, avoid evil, protect human life. Since individuals are supposed to be free and rational, the moral course of action explains the situation and allows the actors to make decisions. Belief in shared values thus determines actions. Thus, ethics is based on the value of outcomes in terms of social and environmental impacts, which it is desirable to direct towards the human good (Jonas, 1979). In an operational way, this ethics will be translated by taking into account what Von Schomberg (2013) has defined as correct impacts and intergenerational awareness considering environmental, social, and economic aspects.

Considering that the future is not given (in the sense of Stilgoe et al., 2013), a responsible approach to governance of a smart city must define and guide innovation towards desirable and acceptable outcomes. Von Schomberg (2013) thus defines correct impacts as those integrating and contextualizing fundamental rights, social justice, gender equality, solidarity, quality of life, safety, health. Voegtlin and Scherer (2017, p. 4) add social entrepreneurship, shared value creation framework, sustainability-oriented innovations.

In ISO 37120 (ISO, 2018), "correct impacts" refer to resource use and efficiency. This is emphasized in ISO 37120 (ISO, 2018) and ISO 37123 (2019b) when discussing the importance of better understanding potential conflicting impacts, positive or negative, resulting from indicators due to the complexity of the field. In ISO 37120 (ISO, 2018, p. 4), there is the emphasis that "the number of automobiles per capita will potentially result in increased levels of greenhouse gas emissions." Furthermore, it highlights the correlation between single-occupancy vehicles (SOV) and energy consumption and chemical emissions (ISO 37120, indicator 19.3). The idea of 'correct impacts' is directly related to 'intergenerational awareness' due to interrelationships, accumulation, and rebound effects. By focusing on establishing and ensuring long-term prosperity (ISO, 2019a), ISO 37122 underlines the attention to analyzing critical points, interactions, and possible failures. As highlighted as a sustainability issue (ISO, 2016), "Living together, interdependence and mutuality" is referred to in the indicator 19.2/ISO 37122 (ISO, 2019a) as a consideration that collective and collaborative culture generate mutual economic and social benefits with intergenerational equity outcomes. Foley et al. (2016) and Wiek et al. (2016) emphasize the localization of events. The causes and impacts of innovations, stakeholder interests, and values have a significant contextual dimension. Both temporal and spatial scales will need to be considered in decision models.

Quality, safety, and well-being are objectives aimed at obtaining ethically acceptable, socially desirable, and sustainable results. Concern for well-being is defined as a sustainability objective in ISO 37120 (ISO, 2018) with indicators 19.1, 19.2, 19.3, 19.4, 19.5, 19.6 and 19.7 (ISO, 2018) and the standard 37122 (ISO, 2019) for indicators 19.1, 19.2, 19.3, 19.4, 19.5, 19.6, 19.7, 19.2, 19.9, 19.10. The main themes highlighted are access to opportunities; creativity, education; happiness; a healthy environment; improving human capital; the livable city; prosperity; life quality; security; self-confidence; welfare, health and care in the community, living and working environment, and safety and security. These issues refer to the preservation and improvement of citizens' physical and mental health and appropriate access methods for stakeholders to meet their needs and expectations.

Besides, well-being is discussed as related to sustainability issues from ISO 37101: "Health and care in the community", "Living and working environment", and "Safety and security". "Health and care in the community" refers to conserving and improving citizens' physical and mental health. This issue is cited in the indicators 19.5/ISO 37120 and 19.3/ISO 37122. The "Safety and security" issue is linked to the indicator 19.5/ISO 37120. "Living and working environment" is related to the indicators 19.6/ISO 37120 and 19.3/ISO 37122 and address the aim of facilitating and supporting fair and equitable access' definitions aligned to the needs and expectations of concerned parties, promoting quality of life and decent working conditions (ISO, 2016; 2018; 2019).

Quality and security are outlined in the ISO 37101 sustainability issue "mobility" in the indicators 19.1, 19.2, 19.3, 19.4, 19.5, 19.6,19.7/ISO 37120 and in all indicators of ISO 37122, except to the 19.14 (ISO, 2018; 2019). This issue expresses that (ISO, 2016, p. 14):

> Communities are expected to provide safe, comfortable, comprehensive, dependable, efficient, accessible, affordable and appropriate services for different age and special needs groups, in particular for persons with disabilities. They need to maintain a reliable transport system, improve connectivity, encourage non-motorized traffic (e.g. walking and bicycling) and facilitate the transport of goods.

In RI logic, innovations are as technological as socially and politically constructed (Wodzisz, 2015). The ISO 37122 standard presents a complementarity of technical and non-technical dimensions, which facilitates the adoption of a posture of responsiveness and anticipation (Sharifi, 2019). This is highlighted by the text passage (ISO, 2019a):

> The prominence and growth of online civic tools have created a culture of sharing civic data in real time, including online traffic alerts and information. These data can be user-driven by utilizing geospatial crowdsourcing of mobile data, or collected through sensors or cameras installed by road and transportation authorities. The application of such technologies enables authorities to efficiently plan for future conditions, and for users to effectively travel through city streets and thoroughfares. (p. 44)
>
> Real-time interactive street maps provide up-to-date information for people commuting through the city, or planning to travel in and around the city. This allows people to more efficiently plan their travel times and routes, as well as identify points of access that accommodate persons with special needs. (p. 51)

Therefore, it is not about basing decisions on individual intentions but about adopting collective values in a concerted way to contribute to the well-being of society (Stilgoe et al., 2013; Shortall, Raman, and Millar, 2015). In an integrative way, these new solutions must consider the environmental, social, and economic impact (Voegtlin and Scherer, 2017). Moreover, in addressing resilience specifically, ISO 37123 (ISO, 2019b) emphasizes that responsibility rests on the intersectionality of economic, social, and political systems with goals beyond environmental sustainability.

The integration of environmental, social, and economic systems' objectives is synthesized by the passage of ISO 37120 which states that "to achieve sustainable development, the whole city system needs to be taken into consideration" (ISO, 2018, p.xiii). Besides, in ISO 37123 it is highlighted that (ISO, 2019b, p. xi):

> A resilient city is also able to manage and mitigate ongoing human and natural stresses in a city relating to environmental degradation (e.g. poor air and water quality), social inequality (e.g. chronic poverty and housing shortages) and economic instability (e.g. rapid inflation and persistent unemployment) that cause persistent negative impacts in a city.

Thus, it can be stated that the standards analyzed aim at city progress as improved services and quality of life, which requires that there be integrative consideration across disciplines and urban systems. To this end, as highlighted in ISO 37120 (ISO, 2018), definitions and methodologies are needed to analyze aspects and practices fundamental to cities' social, economic, and environmental aspects.

Nevertheless, one path does not define sustainable urban development – there are multiple conditions and options. Neighborhoods, districts, and communities have different circumstances, priorities, and needs those influence cities. These characteristics require that analytical mechanisms such as indicators be contextualized and flexible. As stated on ISO 37120, ISO 37122, and ISO 37123, "for data interpretation purposes, cities shall take into consideration contextual analysis when interpreting results" (ISO, 2018, p. 4; 2019a, p. 2; 2019b, p. 4). Following Ahvenniemi et al.'s (2017) work on performance measurement systems in Finnish cities, the authors highlight the importance of developing a specific representation of governance modes in considering sustainability metrics for smart cities. For example, ISO 37120 (ISO, 2018, p. xiv) explicitly points out these elements of context: "recognizing the differences in resources and capabilities of cities worldwide, the overall set of indicators for city performance has been divided into "core" indicators (those implementing this document shall follow) and "supporting" indicators (those implementing this document should follow".

Similarly, ISO 37123 emphasizes that understanding contextual elements is crucial to a city's ability to be resilient. However, these contextual specificities should not erase the constraint that any assessment system must ensure, namely the need to provide data verifiable, auditable, trustworthy and justified (ISO, 2019a). In addition to this sensitive-context attribute, the inclusion of stakeholder perspectives in the context is also necessary to assume an inclusive and reflexive framework (Lützkendorf and Balouktsi, 2017). For Berman and Orttung (2020), ISO 37120 focuses on benchmarks and does not establish practical guidelines for governance and implementation. Such evaluation can also be stated by analyzing not only ISO 37120 but also ISO 37122 and ISO 37123. The closest approach to a governance guideline is the indication of data sources to be considered in each indicator. The document ISO 37.120 (ISO, 2018, p. 4) refers to "the results of a particular service area, it is important to review the results of multiple types of indicators across themes; to focus on a single indicator can lead to a distorted or incomplete conclusion.". According to ISO 37122, "(...) apply collaborative leadership methods, work across disciplines and city systems." (ISO, 2019a, p. xii). Besides, "the extent to which policymakers and planners are aware of the number of users of sharing economy transportation in the city will allow for better development of plans and reconfiguration of a city's transportation system to accommodate for these changes" (ISO, 2019a, p. 45).

Taking stakeholder integration into account means recognizing, for example, that citizens are simultaneously looking for a better environment, better services, more work and leisure opportunities, health, and quality of life. These visions and expectations should not be an end but a value integrated into the whole innovation process. It is necessary to consider civil society as active actors in the innovation process (Flipse and Puylaert, 2018; Garau and Pavan, 2018). The ideas for this integration are expressed in ISO 37122 and ISO 37123. For example, the indicator 19.4 of ISO 37122 (ISO, 2019a, p. 47) highlights the different stakeholders with different needs, expectations, and roles:

> Users should be able to rent and return bicycles to any docking station within the bicycle-sharing system. Municipally provided bicycle-sharing services shall refer to bicycle-sharing services funded and operated by the city. This shall also include bicycle-sharing services operated under a license or contract agreement with the municipality, such as public-private partnerships.

In terms of indicators, the RI literature points out that an appropriate definition is a combination of top-down and bottom-up approaches. This structure requires that local stakeholders interact at all stages of indicator development, implementation, and analysis (Lützkendorf and Balouktsi, 2017).

A positive point that should be emphasized about the analyzed standards is that they are issued as complementary and recommended to use them together. So, the issue of "technical and non-technical aspects" is more prominent in ISO 37122, while "environmental, social and economic systems" and "context-sensitive" are more present in ISO 37120. For example, in the case of cities, one could consider health and wellness, housing conditions, the public transportation sector, digital and non-digital infrastructure, services in general, environmental/natural resource protection projects, and governance (Garau and Pavan, 2018).

4.2. General discussions

The analysis of the standards allows for a discussion of some elements related to the premises of RI, although these are not directly cited and are not discussed and addressed in-depth. In terms of "ethics," there is a willingness to include ethical elements when it comes, for example, to anticipate likely negative and positive impacts. Similarly, references are made to being concerned with the safety of citizens while thinking in economic terms. Similarly, some ethical outcomes are identified in other premises when they relate, for example, to livability and transport externalities.

The idea of ethics in standards emphasizes the motivation to ensure long-term sustainability in more innovative ways, thereby generating contributions for different generations. These contributions, treated as "right impacts" in the RI literature, are linked to inclusion, deliberation, and democracy processes. These processes must emphasize innovation as a source of potential values beyond economic ones (Owen et al., 2012).

According to ISO 37120, sustainability is a general principle, while smart cities and resilience guide cities' development (ISO, 2018). By considering integrating technical and non-technical aspects, the focus is on using appropriate technologies and data to develop an ecosystem in which knowledge, practices, and policies provide quality, security, and well-being for citizens (ISO, 2019a; 2019b). For such, economic, social, and political systems integrated must be seen as the representation of collective values inserted in particular contexts.

RI emphasizes governance as a definition of more integrative, collaborative, responsive, anticipatory, and adaptive innovation processes. This requires support in a multidisciplinary stakeholder approach (Von Schomberg, 2013).

The analysis developed in this paper highlights that the ISO standards used to characterize a sustainable, resilient, and smart city lack practical guidance for the proposition of appropriate and relevant governance. The ISO standards analyzed are aware of the attractiveness and responsible use of resources and the need to develop a comprehensive and holistic approach. However, the standards do not provide tools for integrating the different dimensions, contexts, issues, and stakeholders' views.

The consideration of the SDGs in interaction with the analyzed ISO standards emphasizes adequate, safe, affordable, and sustainable transportation; participatory governance; integration of stakeholder perspectives; attention to citizen vulnerability; inclusive plans for citizens with special needs; and implementation of a quality management system, positive economic, social, and environmental links; integrated policies and plans; and resource efficiency. In order to improve such considerations, in this paper, the proposal is to theoretically ground the ISO standards in the RI approach. Figure 5 exemplifies this logic.

Figure 5: RI and ISO standards towards SDGs

Source: Elaborated by the authors

The operational implementation of the ISO standards with an in-depth reflection on responsible governance is not explicit. The attention to intergenerational impacts, contextual elements, and stakeholder integration are all part of responsible governance are important to be explicitly included. The responsibility in innovation processes is the basis for better long-term strategies that generate innovations as improvements oriented to sustainable goals. To this end, governance is an imperative factor in creating a culture that seeks to perpetuate positive purposes for society. Thus, to raise ethical awareness to levels of achievement through innovations, taking RI as a guiding principle, ISO standards are seen as tools to support SDG achievement.

The inclusion of a greater focus on ethics in ISOs can be linked to innovation and adaptation of rules, standards, and principles from an operational perspective focused on the inclusion of voices, thus ensuring the development of culture focused on collective values, leading to a consideration of accountability. That is, given the radical uncertainty already observed and the limitations of regulatory frameworks, ethical concerns must be taken into account, also considering users' understanding of the consequences of innovation. This treatment underscores the importance of including stakeholders at all stages of the project to define users' motivation in terms of their contribution to the world through innovation. Thus, attention is paid to developing solutions with a better guarantee of "right impacts" relying on intergenerational awareness.

This discussion is in line with Grinbaum and Groves (2013). The authors state that an ethical definition of innovation should not focus on individual actions and outcomes. The implications of innovation and the appropriate formation of its knowledge flow are systemic. Such a configuration describes the link between technical and social visions, connecting different innovation ecosystem actors, such as researchers, politicians, entrepreneurs, and civil society representatives in a collective responsibility (or co-responsibility). As stated by Von Schomberg (2013), knowledge must be identified, evaluated, processed, and organized within an integrative governance structure. Thus, including the responsibility concept in governance based on the ISOs premises is important for a long-term strategy to align with sustainable goals. To this end, governance thinking is an imperative factor in creating a shared culture on the needs and concerns of societal systems involving ethics, quality, safety, and well-being.

A system of performance evaluation towards sustainable and resilient cities, such as ISO, elaborated contemplating the premises of the RI approach must be based on a governance definition that includes characteristics of reflexivity, anticipation, inclusivity, and responsiveness.

The mobility practices of users are individual, and their preferences vary greatly over time and according to the context of their lives. Besides, public policies on transport vary greatly from one territory to another. Therefore, it is necessary to restructure the innovation process so that rapidly changing environments are not significant obstacles (Meissner, Polt, and Vonortas, 2017). An anticipatory posture can be seen as the first stage of the consideration of an RI approach as it concerns the effort to identify long-term challenges and potential problems. Anticipation is concerned with considering the implications of current actions to avoid harming future generations. Thus, by supporting the recognition of future opportunities and the development of solutions, anticipation fosters the inclusion of new trends in ISOs, clarifying the challenges in urban mobility systems and supporting the definition of new analysis and monitoring instruments.

The reflexivity will support the redesign of practices, processes, and frameworks by directing efforts to elaborate definitions of desirable and undesirable outcomes, thus facilitating the definition of actions as solutions, resulting in the redesign of norms. Furthermore, reflexivity results in identifying knowledge and relationships that must be taken into account. Thus, resulting from anticipation, reflexivity is closely linked to inclusion.

While anticipatory and reflexive stances are identified in ISOs by supporting analysis of modal use, vehicle numbers, pollutant emissions, etc., responsibility goes beyond that. It is necessary to include voices to add responsiveness to ISOs, i.e., it is necessary to consider different perspectives and include in ISOs more focus on supporting the development of solutions to the problems identified by the measurement of metrics.

Inclusivity refers to the involvement of stakeholders in the definition, implementation, monitoring, and review of ISOs. This is aligned with the discussions of Pandza and Ellwood (2013) and Genus and Iskandarova (2018), who state that it is important to include stakeholder dialogue at all stages of an innovation project. That is, by aggregating perspectives, there is a greater flow of knowledge, which demands engagement, deliberation, common language, transparency, and dialogue (Stilgoe et al., 2013; Flipse and Puylaert, 2018). However, inclusion can bring management challenges, which demands that the governance system has effective and appropriate tools and mechanisms to add value to the creation of ISOs (Shortall, Raman, and Millar, 2015).

Some changes in the structures and strategies supported by the smart city are also difficult to implement for reasons of time (construction of infrastructures) or politics. This requires an understanding of "flows, linkages, political environments, infrastructure, markets, diversity, culture, barriers, and limitations" (Souza et al., 2020, p.59). Thus, responsiveness supports the translation of attention into action, into solutions. To this end, contextualization is key, which is highlighted in ISOs. However, it is interesting to include operational guidelines in order to support the development of policies, processes, and structures. This supports more effective governance.

So, to insert a RI feature on ISOs, it is necessary to base the definitions on suitable governance processes. In other words, the aim of including a responsible character on ISO relies on a deliberative capacity to manage sources of knowledge, focusing on diversity and consensus towards solutions based on shared collective values.

5. Conclusion

This paper aimed at analyzing whether the ISO standards for sustainable cities and communities present evidence of RI's premises. ISO 37120 documents' set (ISO 37120, 37122, and 37123) were examined through content analysis. In order to ensure deeper results, as a methodological cutout, the indicators related to transportation were selected since these represent the largest number of indicators of the standards under study. In applying the content analysis method, the documents were critically and deeply read, confronting the content with the proposed theory. This enabled a better understanding of the propositions and goals.

In order to consider the principle of RI, the premises indicated by Souza et al. (2020) were adopted. The content analysis verified that the main ideas of RI are present in the ISOs in a more or less straightforward way, often related to the SDGs. However, the responsible governance dimension with its four attributes (anticipation, reflexivity, inclusion, and responsiveness) is not developed in an integrated and operational manner.

The RI framework is proposed as a theoretical basis for selecting and assessing ISO city-related indicators. RI guarantees a context-sensitive framework for reflection, which relies on stakeholder dialogue to adopt shared objectives; promotes understanding of different purposes, fields of application, and associated scales; supports better identification and integration of stakeholders; and considers context a fundamental element to be inserted into the innovation project from the start. Therefore, RI can support analyzing a city's performance beyond statistical data and economic and technical interests, adding value by integrating ethical considerations and collective values. Thus, the proposal is to include the RI approach in ISOs' definitions - which needs to be done through governance.

Analyzing the RI premises applied in this paper, three axes can be identified as a general orientation for smart cities: ethical principles, human-centered, and governance. In order to validate the ethical principles in the innovation process, the focus is on 'ethics' and 'correct impacts', with particular attention to 'intergenerational awareness' and 'environmental, social, end economic aspects'. Likewise, the human-centered aspect emphasizes 'quality, safety, and well-being' as objectives to consider a sustainable and resilient smart city by the integration of 'technical and non-technical aspects'. Finally, this outcome requires the adoption of 'governance' that incorporates 'contextual aspects' based on 'collective values' and the 'integration of stakeholders'

The results have certain limitations due to the methodology. First, by determining the transport indicators as the methodological cutout, other relevant analyses related to other urban spheres were not considered. Secondly, the content analysis is closely related to the researchers' particular view, even if the analysis was submitted to peer review. The theoretical lens and the content analysis effort can assign some subjectivity. Thirdly, the categories were based on only one study, although this was due to the lack of other references highlighting premises.

A deeper look into such RI ideas in ISOs standards requires research efforts in the sense of considering such RI's lens for other standards. Further studies may consider such a lens responsible for other standards.

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ARTICLE 3: Critical Success Factors for Responsible Mobility Systems: Indicators to Support the Design of Smart and Sustainable Cities and Communities.

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Critical Success Factors for Responsible Mobility Systems: Indicators to Support the Design of Smart and Sustainable Cities and Communities

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Abstract

The current urban context presents multifaceted challenges, which have led to discussions about smart and sustainable concepts as the basis for appropriate solutions. As one of the most complex urban systems, mobility is related to negative impacts. This is mainly due to the current model focused on individualized mobility and the use of fossil fuels as the main resources. In this sense, there is a need to develop improvements and adjustments in the governance definitions in order to support responsible innovative projects. From the proposal of grounding governance actions in the analysis of critical success factors (CSFs), this study provides an assessment framework elaborated by selected and organized indicators based on integrative literature focused on content analysis enhanced by considering the ISO indicators 37120, 37122, and 37123. The discussions were developed considering indicators as CSFs for a responsible urban mobility system, taking this as a central system for defining smart and sustainable cities. The analyses highlight that the inclusion of responsibility in the context of mobility systems governance must be mainly based on the premises of interdisciplinarity and contextual sensitivity. To this end, governance must be defined by combining social, economic, technical, managerial, and sustainable perspectives.

Keywords: Critical success factors. Urban mobility systems. Governance. Indicators. Responsible Innovation. Smart and sustainable cities and communities.

1 Introduction

The unprecedented growth of the urban population, the urbanization level, and the number of cities are aspects of a global movement that poses both opportunities and challenges to traditional forms of urban management, placing cities as a central element to be dealt with in the global sustainability goals (Ojo et al., 2015; ISO, 2017). A rethink is required towards a multidimensional approach to cities, considering social, economic, and environmental domains as indissociable (Mori & Christodoulou, 2012; Shmelev & Shmeleva, 2018).

Despite the popularity increase over the past decade (Rasca & Waeben, 2019), "smart city" does not have an agreed definition, which causes difficulties in its application (Huovila et al., 2019). Definitions of smart cities range from purely ecological to technological perspectives, from economic to organizational and social positions. However, this concept is closely related to information and communication technologies (ICTs) (Lara et al., 2016; Chang et al., 2018).

The smart city is an interdisciplinary subject, being studied and discussed by different areas and perspectives, such as by companies, governments, architects and urban planners, geographers, sociologists, engineers, economists, specialists in technology, computing, and information systems, among other areas (Pinheiro Junior, 2019). In this sense, these are discussions concerning politics, management and organization, technical and technological aspects, governance, people and communities, economy, infrastructure, and environment (Chourabi et al., 2012).

Although as a global phenomenon present in various projects worldwide, some scholars consider smart cities still as a technocratic discourse, since clear evidence on answers to the different complex problems cities face is still lacking (Anthopoulos, 2017; Mora et al., 2017; Praharaj et al., 2017). In this sense, researchers have discussed the need to well incorporate and emphasize the sustainable character into smart city models to provide better support for urban practices, processes, and definitions (Bibri & Krogstie, 2017). As a result of such discussions, the approach of smart and sustainable cities emerged (Garau & Pavan, 2018).

Mobility is one of the most complex urban systems to tackle in metropolitan areas. Transport has several negative impacts and problems for the quality of life in cities, such as pollution, poor traffic conditions, poor infrastructure, limited services, spatial disparities, high costs, new and increased transport needs, unequal access to services, and issues related to safety and security, social health, urban design, and transport system design (Benevolo et al., 2016; Bibri & Krogstie, 2017).

Urban mobility presents a current model based on ownership, individual mobility, and fossil fuels as the key resource that have been intensifying the problems (Mehdizadeh et al., 2019; Nemoto et al., 2021). This scenario challenges developing and implementing appropriate governance of the mobility system (Zawieska & Pieriegud, 2018; Paiva et al., 2021).

The environmental and social aspects are more noticeable, and, in this sense, some data portray the problem in global terms. Road traffic crashes account for millions of deaths. These figures also reflect social issues such as traffic fatality rates and the correlation with road users (pedestrians, cyclists, and motorcyclists)[2]. In terms of environmental impacts, air pollution stands out. Every year, 4.2 million deaths result from poor air conditions, and 9 out of 10 people are exposed to such conditions, which generate costs besides human issues (World Health Organization, n.d.). Problems arising from mobility, such as accidents, should be seen as resulting from a systematic failure to identify bottlenecks and propose integrative solutions.

[2] https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/road-traffic-mortality

Due to such centrality of cities and mobility in global terms, the UN's Sustainable Development Goals (SDGs) devoted one of the 17 goals specifically to cities and communities (SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable), and the majority of the indicators are related to transportation (United Nations, n.d.).

Given such panorama, some research gaps can be highlighted. For Ojo et al. (2015), research related to smart cities still lacks more discussions on sustainable and integrated urban planning, mobility governance, measurement, and success factors. Leal Filho et al. (2017) highlight governance definitions as fundamental to achieving the SDGs, requiring observation and monitoring activities. As discussed by Docherty et al. (2018) and Ahvenniemi and Huovila (2021), it is important to define a governance model that supports implementing solutions considering the actors' network, goals, roles, knowledge, and expectations. In the same vein, Nemoto et al. (2021) highlighted a proper combination of ICTs with sustainability policies and projects as fundamental to promoting positive mobility system changes. Such questions have been raised for a long time, as presented by Wolk et al. (2009). The authors emphasized that necessary improvements and effective resolutions for governance can be boosted by the combination of data, indicators, and analysis.

For Stilgoe et al. (2013), Von Schomberg (2013), and Owen and Pansera (2019), besides the integration of stakeholders' views, a clear and comprehensive set of objectives, urban mobility systems must be substantiated by the commitment to promote not only innovations as economic development but also fundamentally of social and environmental values. A Responsible Innovation underlines such intent (RI) approach The RI's premises applied to urban mobility systems focus firstly on governance definitions, which influences planning and coordinating activities to manage particular contexts, their related complexities, and uncertainties. However, there are no guidelines on operationalizing such governance intents (Souza et al., Paper 1).

In this sense, this paper aims to support governance definitions for responsible urban mobility systems from the definition of Critical Success Factors (CSFs). It is proposed to understand the areas that need more attention, highlight key knowledge as well as contextual characteristics, and provide support for strategically organized action definitions. Therefore, indicators are treated as CSFs (Rockart, 1979; Caralli, 2004; Colauto et al., 2004). To do so, an assessment framework is elaborated by selected and organized indicators based on integrative literature focused on content analysis enhanced by the consideration of the ISO indicators 37120, 37122, and 37123.

This paper is further structured as follows. Section 2 introduces the theoretical approach regarding i) responsible urban mobility systems in smart and sustainable cities and communities and ii) indicators for urban mobility systems. Section 3 describes the methodological definitions. Section 4 presents the analysis and discussions. Section 5 presents the final considerations with discussions on the limitations of this study.

2 Theoretical Background

2.1 Responsible Mobility Systems: A Governance-Based Approach to Smart and Sustainable Cities and Communities

The changes and challenges to cities have culminated in discussions on smart cities as a new format with technology and innovation as central elements. As a 'smart' combination of six characteristics: economy, people, governance, mobility, environment, and life, a smart city is built of participative and conscientious citizens (Giffinger et al., 2007). Smart Mobility is one of the most promising themes of a smart city and involves all smart city paradigms, generating a set of heterogeneous benefits for stakeholders (Benevolo et al., 2016).

Technological innovations widely permeate the approach to support solutions towards quality, connectivity, security, and accessibility of transport services (Benevolo et al., 2016; Fulton et al., 2017; Noy & Givoni, 2018). However, as Hollands (2008) argues, a city to be smart needs more than technological advancements. A better conceptualization must also include different stakeholders' voices and "take much greater risks with technology, devolve power, tackle inequalities and redefine what they mean by smart itself" (p.316). In this sense, the path has been "to incorporate sustainability in smart city approaches and smarten up sustainable city models" (Bibri & Krogstie, 2017, p.186).

Thereby, widespread in the mid–the 2010s, a smart and sustainable cities' approach bends ICTs, human orientations, economic, social, and environmental aspects. This new approach to cities can support urban research, planning, policy, and politics towards achieving the desired efficient, reliable, and resilient outcomes for the whole urban system (Höjer & Wangel, 2015; Dhingra & Chattopadhyay, 2016; Garau & Pavan, 2018). It is fundamental to define a governance paradigm focused on a holistic approach, stakeholders' inclusivity, efficiency, long–term perspective, responsivity, and responsibility to achieve the expected benefits (Carayannis & Campbell, 2010; Baccarne et al., 2016). Responsible Innovation (RI) assumptions can substantiate such goals by providing guidelines to support responsible processes aware of changes, challenges, and trends (Stilgoe et al., 2013; Ludwig & Macnaghten, 2020).

Rooted in policy-driven discourses from the European Commission addressed in the program "Horizon 2020" (Koops, 2015; Von Schomberg, 2013), the general idea of including responsibility in innovation projects is initially referred to as Responsible Research and

Innovation (RRI), considered as a new approach to innovation aiming to support the creation of positive, desirable, and socially acceptable results (Blok & Lemmens, 2015; Stahl et al., 2014). Aware of uncertainties and ambiguities of innovations in wider spheres beyond academic and policy rationalities (beyond RRI), RI idea focuses deeply on engagements with innovation systems to offer greater possibilities for systemic transformations based on co-creation and co-production of results aligned with stakeholders' values, needs, and expectations (Stilgoe et al., 2013; Paredes-Frigolett et al., 2015; Owen & Pansera, 2019).

RI focuses on minimizing potential adverse effects of innovations and generating more positive impacts to the market, society, and environment, taking these as correlated and undissociated systems (Von Schomberg, 2011; Owen & Pansera, 2019). The RI approach moves the question from "why" to "how" to tackle challenges and is grounded on collective values, ethics, flexibility, adaptation, inter and trans-disciplinary approach, integrated stakeholders' visions, transparency, commitment to the present, and future awareness (Owen et al., 2013; van Oudheusden, 2014). Consequently, RI has been developed as a governance framework composed of anticipation, inclusion, reflexivity, and responsiveness dimensions (Stilgoe et al., 2013).

Generically, governance is related to decision-making processes constituted by actors dynamically integrated through a collective issue in a determined context embedded by rules and other policy instruments. The main aim is to define solutions based on coordination, negotiation, and consensus (Kuhlmann, 2001; Torfing & Sørensen, 2014; Gebhardt & Stanovnik, 2016).

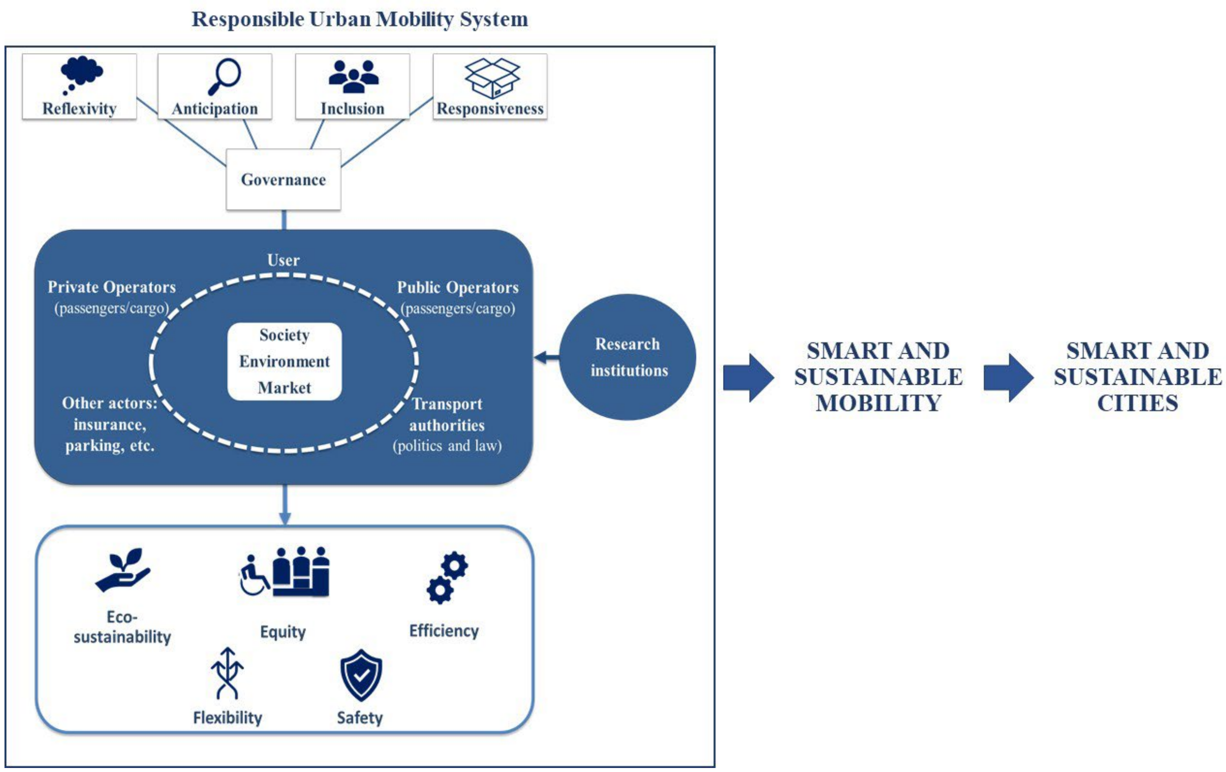
In the changing context of mobility, a key goal of governance is to secure, increase, and improve the value offered to the system's stakeholders. Already visible challenges are related to the emergence of a new logic of consumption, new structures, changes in the composition of networks (actors, resources, and power), and regulatory definitions. Both short- and long-term issues need to be addressed to push the mobility system in ways that do not exacerbate existing as well as potential social and environmental problems - but rather bring solutions and expected benefits (Docherty et al., 2018). Therefore, mobility innovations require governance approaches that provide better and desirable solutions beyond the technology, aware to the whole ecosystem (Dee Angel, 1989; Freudendal-Pedersen & Kesselring, 2016; Attias & Mira-Bonnardel, 2017).

In this sense, Souza et al. (Paper 1) proposed a framework for urban mobility systems based on governance and RI's definitions. A responsible urban mobility system is founded by a governance framework based on ethical, comprehensive, responsive, reflexive, and constructive interchanges between the stakeholders aiming to offer positive results and solutions to environmental, social, and market issues. This definition requires considering an interactive arrangement, a collective vision, a critical view on the supply capacity, the urban characteristics (context-based), and the interrelated technical, social, and environmental aspects. As a result, a responsible urban mobility system offers equitability, efficiency, eco-sustainability, and safety.

Therefore, it is stated that a responsible definition of the urban mobility system is the essential basis to achieve smart and sustainable mobility and, consequently, to support definitions towards smart and sustainable cities.

Figure 1

Responsible Urban Mobility System and Smart and Sustainable Cities



Source: Adapted from Souza *et al.* (Paper 1).

According to Sdoukopoulos et al. (2018), aiming to deliver such results, mobility governance must include monitoring and evaluation mechanisms to support proper support planning, building, development, and analysis of operational, functional, and infrastructural patterns towards innovative solutions. To this end, indicators are useful as sources of information, supporting governance mechanisms and tools to focus on a responsible mobility system.

2.2 Indicators and Critical Success Factors (CSFs): Analysis for Urban Mobility Systems

Cities have increasingly been positioned as central issues to be addressed in order to benefit global sustainability aims. Such a reality resulted in several initiatives to manage and examine urban systems' performances towards social and economic growth aligned to environmental awareness (Lützkendorf & Balouktsi, 2017; Moschen et al., 2019).

In general terms, indicators are symbolic representations of specific objectives. In other words, these are related to analysis and settings to support the target's achievement (Hiremath et al., 2013; Lützkendorf & Balouktsi, 2017). As multifaceted constructs, these are composed of a label (or title), a definition, a detailed unit of measurement (qualitative, quantitative, or descriptive), basic data, a reference point to these data (e.g., a target or an orientation), and a clear link to the associated context. The latter is especially relevant as it sustains the indicator's contribution and the set of indicators, articulating a given topic (ISO, 2019c; Merino-Saum et al., 2020).

As sources for decision-making processes, indicators can also support the analysis and discussions of Critical Success Factors (CSFs). CSFs represent selected topics that, with satisfactory results, ensure successful better performance for a project, an organization, or a department. These topics are fundamental to generating adequate outcomes, resulting in efforts towards goals. So, basic questions should be referred to: what areas should receive more attention? Which ones should be more strategically arranged? (Rockart, 1979; Bullen & Rockart, 1981).

Therefore, CSFs are related to actions or processes - not goals – internal or external, that must be managed (Brotherton, 2004). The focus on CSFs allows the identification and comprehension of information, knowledge, and the main attributes of the context, the identification of points to be prioritized, and the development of a measurement system (Rockart, 1979, Caralli et al., 2004; Colauto et al., 2004). The analysis of CSFs provides relevant suggestions to be taken as qualitative metrics to support the definitions of the indicators (Remus & Wiener, 2010).

By supporting the identification of problems, strengths, and weaknesses, illustrating significant trends, highlighting changes over time, enabling multi-level comparisons, and translating complex situations and contexts in a more accessible and simple way, indicators support prioritization efforts and facilitate the development of the governance approach, especially concerning stakeholder alignment, their roles, resources, interests, and expectations (Sdoukopoulos et al., 2018). Indicators can evaluate CSFs and their conditions, turning assumptions into well-understood information (Wolk et al.,2009; Lavy et al., 2014; Zhuhadar et al., 2017).

Various indicators' tools and frameworks have been developed to access, support, and develop sustainable and smart projects in urban contexts (Sharifi, 2019). D'Amico et al. (2020) and Huovila et al. (2019) analyzed global validated indicators patterns, such as ISO and ITU, and point the ISO 37120 as the more comprehensive in terms of sustainability for cities. ISO 37120 describes and applies intelligence (ISO 37122) and resilience (ISO 37123) as complementary elements to sustainability (Berman & Orttung, 2020).

The ISO city-related standards include comprehensive guidelines for goals and priorities for smarter and more sustainable cities, such as those related to mobility and transport systems. These sets of indicators are developed by the technical committee ISO / TC 268 (Sustainable Cities and Communities), related to the International Classification of Standards - ICS 13.020.20 (environmental economics and sustainability, including responsible sourcing, procurement, sustainable development, sustainable events, management, sustainable communities, smart urban infrastructure, biodiversity). Such proposals expect to assist more efficient and integrated actions focused on intelligence, sustainability, and resilience (ISO, 2017).

In the face of the many options, a strategy for indicators selection is needed to support sustainability assessment in cities. Specifically dealing with sustainability measurements in cities, Tanguay et al. (2010) proposed a selection strategy for indicators. For the authors, three conditions are essential: easy understanding and usefulness, coverage of given related categories, and consensus and literature background for conceptual suitability.

By analyzing 34 smart city assessment (SCA) tools, Sharifi (2019) highlighted needed improvements: include measures to involve stakeholders in both the development and implementation processes; consider specificities of local conditions; address suitability for different scales, situations, capacities, needs, and priorities of end-users. In this way, such tools can inform more efficient, and integrated actions focused on intelligence, sustainability, and resilience. This is corroborated by the ISO report on smart cities (ISO, 2015), which stresses that indicators should be appropriate for cities or communities as they project different particularities.

3 Methodology

This paper aims to support the structuring of a responsible urban mobility system's governance, considering this as a fundamental basis for smart and sustainable cities. To do so, in order to identify indicators related to urban mobility systems, the general methodological approach is based on an integrative literature review.

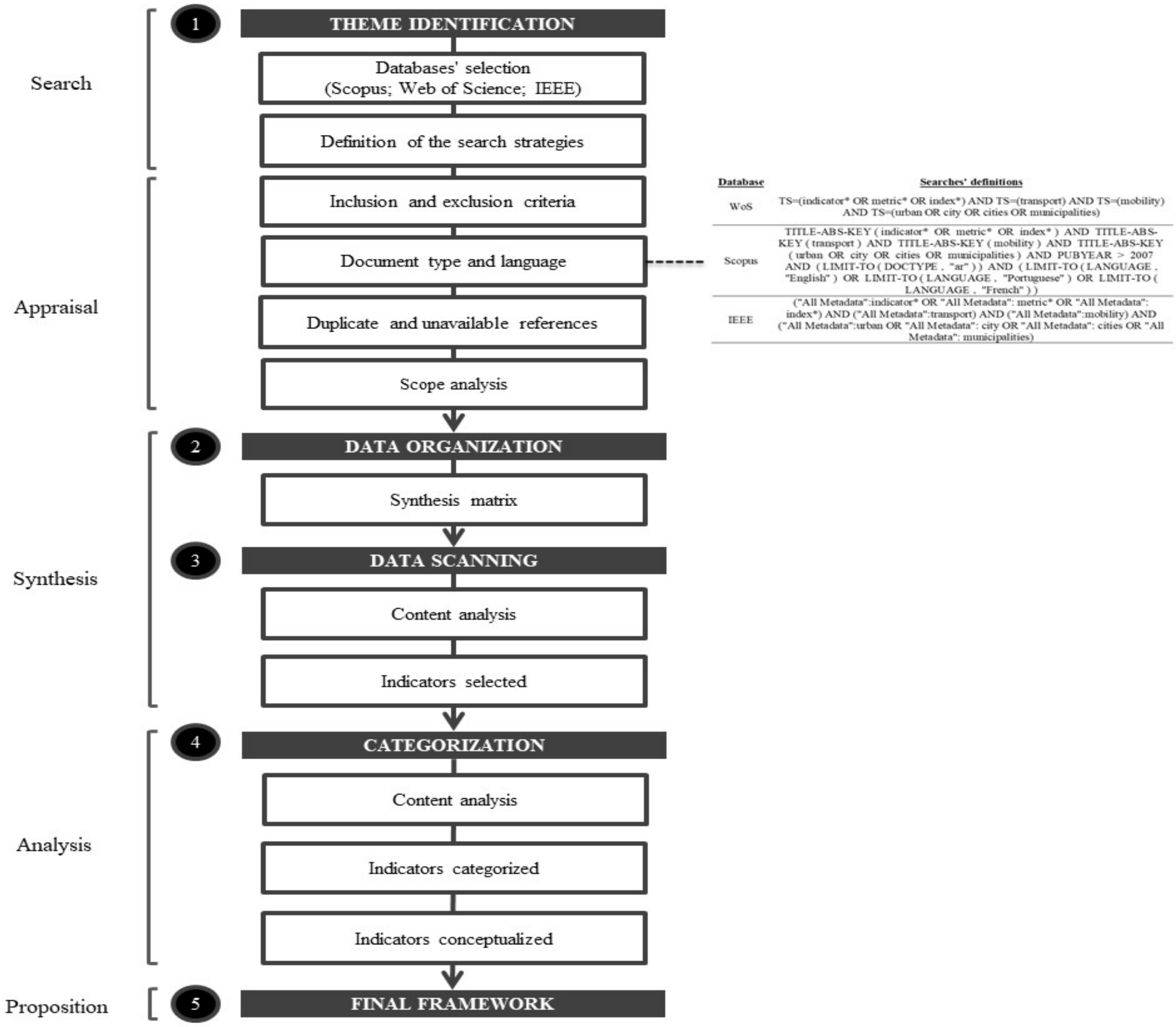
The integrative literature review, a type of systematic review, is developed to review and summarize representative literature topics through rigorous search steps, allowing cross-analysis, perspectives' identification, and insights' highlighting, enabling significant and value-added contributions. In this sense, such a methodological procedure can support understanding urban mobility systems' CSFs by identifying and conceptualizing indicators (Whittemore & Knafl, 2005; Torraco, 2016; Snyder, 2019).

Integrative literature reviews aim to provide synthesis and critical examination of studies relevant to a given topic, focusing on bias reduction, transparency, reproducibility, validity, and rigor in the processes of articles selection and analysis. To this end, it starts from a defined research question, develops the search and selection of documents based on strategic and explicitly presented criteria, and uses clear inclusion and exclusion protocols (Berrang-Ford et al., 2015). According to Booth et al. (2016), the steps can be defined as the SALSA framework: **S**earch, **A**ppraisa**L**, **S**ynthesis, and **A**nalysis. Aligned to the integrative application, a proposition stage is included as an additional step aligned to the main objective of this paper.

Thus, the methodological choice of conducting an integrative literature review is justified by collecting, integrating, categorizing, and describing existing indicators related to urban mobility, thus supporting the development of decision-making processes of responsible urban mobility systems. The procedural design is described in Figure 2.

Figure 2

Integrative literature review procedures



Source: Elaborated by the authors based on Booth et al. (2016).

• Step 1 - Theme identification. After defining the research question, the search for papers in databases is started. Databases covering technological (IEEE) and general (Scopus and WoS) areas were used. As searches' strategies, it was considered the period referring to "from 2008". It is justified based on the literature. As Ingwersen and Serrano-López (2018) discussed, research on smart cities started in the fields of sustainable energy from 1990, evolving with the inclusion of digital and engineering aspects from 1994. Besides the authors, Ojo et al. (2015) and

Mora et al. (2017) analyzed related publications and highlighted the period from 2008 as one of exponential growth of smart cities literature. This period was characterized by the clearest and most consistent conceptual definition, although still with fragmentations between theory and practice. This still results in separations between techno-centric and human-centric visions. However, as Mora et al. (2017) highlighted, from 2014, there was an increase in the focus on combining technological aspects with human, social, economic, cultural, and environmental aspects.

The general search resulted in 1278 papers: 541 from WoS, 656 from Scopus, and 81 from IEEE.

The inclusion criteria consisted of the following definitions: articles published in journals in English, Portuguese, or French (although the Portuguese and French searches did not result in any documents.) As applied by Bergström et al. (2015), Berrang-Ford et al. (2015), Wan et al. (2017), and Karjalainen and Juhola (2021), to ensure quality, significance, and relevance of the articles collected and of the analysis process, conference proceedings and other documents that are not articles published in journals were deliberately disregarded for the sample. Such strategy reduced the initial large sample size, favoring more in-depth analyses and discussions, generating better results for the scientific community, and contributing more clear and relevant outcomes to practical applications. The language selection occurred arbitrarily by convenience.

The selection of documents as "articles" resulted in 432 exclusions, and the language in 34 exclusions. This step resulted in 812 papers: 371 from WoS, 427 from Scopus, and 14 from IEEE. The Boolean operator asterisk (*) was applied to provide reliability and amplitude and better refine the results.

There were 9 exclusions due to the unavailability of the documents in all online sources, and, in terms of duplicity, 234 articles were excluded. To filter the scope of the research, all the indicators presented in the documents and all the abstracts of 569 papers were analyzed; these should be strictly related to the urban mobility context. This step resulted in 467 papers being excluded. Thus, 102 papers were selected for data analysis (Appendix 1).

• Step 2 - Data organization. Data were charted in a synthesis matrix registering title, author, publication's year, country, indicators, and indicators' concepts.

• Step 3 - Data scanning. A qualitative content analysis was performed to identify the indicators presented in the 102 selected articles, focusing on summarizing, examining, and interpreting indicators (Hsieh & Shannon, 2005; Krippendorff, 2018; Prasad, 2019).

The present study focuses on indicators' identification to be presented as an assessment framework. Therefore, the indicators were selected considering their qualitative focus, i.e., those based on numerical metrics, such as measurements in the distance per km, were not considered since it is understood that access to such data can be difficult depending on the urban context. This scanning resulted in a list of 696 indicators.

• Step 5 – Categorization. At this stage, content analysis was used to objectively, systematically, and consistently review and categorize the selected indicators, as stated by Hayes and Krippendorff (2007) and Krippendorff (2018). Firstly, the indicators were reviewed to check similarities in labels and descriptions. It resulted in 35 indicators.

Subsequently, the indicators were categorized and analyzed, considering their contents to relate to the RI's approach, aiming to support anticipation, reflexivity, responsiveness, and inclusiveness premises. This process allowed the theoretical alignment, enhancing the main objective of structuring and supporting a responsible urban mobility framework (Elo & Kyngäs, 2008).

In addition to the systematic methodological effort of the integrative literature review, the indicators from ISO 37120, 37122, and 37123 (ISO, 2018, 2019a, 2019b) related to transport were also analyzed to complement the proposals. This strategy was intended to provide an even better foundation for aligning the mobility's goals with the SDGs since these are included as guidelines in the ISO standards. Figure 3 presents the indicators used as an extra basis for analysis of the indicators found in the literature.

Figure 3

Indicators from ISO 37.120, 37.122, and 37.123

ISO's Transport Indicators	
37.120	19.1 Kilometres of public transport system per 100 000 population
	19.2 Annual number of public transport trips per capita
	19.3 Percentage of commuters using a travel mode to work other than a personal vehicle
	19.4 Kilometres of bicycle paths and lanes per 100 000 population
	19.5 Transportation deaths per 100 000 population
	19.6 Percentage of population living within 0,5 km of public transit running at least every 20 min during peak periods
	19.7 Average commute time
	19.8 Transportation profile indicators - 19.8.1 Number of personal automobiles per capita
	19.8 Transportation profile indicators - 19.8.2 Number of two-wheeled motorized vehicles per capita
37.122	19.1 Percentage of city streets and thoroughfares covered by real-time online traffic alerts and information
	19.2 Number of users of sharing economy transportation per 100 000 population
	19.3 Percentage of vehicles registered in the city that are low-emission vehicles
	19.4 Number of bicycles available through municipally provided bicycle-sharing services per 100 000 population
	19.5 Percentage of public transport lines equipped with a publicly accessible real-time system
	19.6 Percentage of the city's public transport services covered by a unified payment system
	19.7 Percentage of public parking spaces equipped with e-payment systems
	19.8 Percentage of public parking spaces equipped with real-time availability systems
	19.9 Percentage of traffic lights that are intelligent/smart
	19.10 City area mapped by real-time interactive street maps as a percentage of the city's total land area
	19.11 Percentage of vehicles registered in the city that are autonomous vehicles
	19.12 Percentage of public transport routes with municipally provided and/or managed Internet connectivity for commuters
	19.13 Percentage of roads conforming with autonomous driving systems
	19.14 Percentage of the city's bus fleet that is motor-driven
37.123	19.1 Number of evacuation routes available per 100 000 population

Source: ISO (2018, 2019a, 2019b).

Hsieh and Shannon (2005) and Elo and Kyngäs (2008) stated that to categorize data into themes, two approaches differed by source categories: inductive or deductive. The inductive approach has categories resulting from the data and is usually useful in cases with limited literature. A deductive approach is appropriate when previous knowledge is useful to the analysis' operationalization and, thus, adopts concepts previously defined in theory. The latter is adequate according to this paper's objective.

The indicators were organized into categories: eco-sustainability, efficiency, accessibility, equity, and safety (Souza et al., Paper 1). Besides favoring the theoretical alignment and the conceptual and practical development of the responsible urban mobility system proposal, the pre-definition of a categories' framework allowed the reduction of bias risks by the authors. The peer-review system relied on collaboration among authors, leading to a linear and aligned categorization system with fewer inconsistencies (Karjalainen & Juhola, 2021).

• Step 6 – Final framework. Considering the selected indicators categorized and conceptualized, these are proposed as an assessment framework to decision-making processes of responsible urban mobility systems as the basis to develop smart and sustainable cities.

4 Results: A Set of Indicators for Responsible Urban Mobility Systems

Considering the benefits, potential problems, and challenges concerning the urban mobility system, it is paramount to promote discussions regarding assessment tools that can support the achievement of positive results. From the integrative literature review on useful indicators for the governance of a responsible mobility system, building blocks were provided both in constitutive and conceptual terms.

The 696 selected indicators were published in papers from 58 journals in the years: 2008 (1), 2009 (1), 2010 (2), 2011 (2), 2012 (5), 2013 (2), 2014 (4), 2015 (7), 2016 (8), 2017 (14), 2018 (9), 2019 (23), 2020 (17), and 2021 (7).

Most articles stressed the theme 'sustainable mobility', including discussions regarding policies, urban forms, transport solutions, assessment mechanisms, public transit, efficient planning, daily mobility, projects, and mobility transition. Besides, 'active transport' was also a prominent theme, including discussions about walkability, non-motorized modes, cycling, and sharing bike systems.

It is noteworthy that by dealing with aspects such as governance, social inclusion, equity, accessibility, health, technical and non-technical solutions, environmental aspects, the papers are fully in line with RI proposals that are grounded in ethics. This fact corroborates the proposal drawn by Souza et al. (Paper 1) and strengthens the proposal of this work (see Figure 1).

As previously stated, the categorized indicators are representations of CSFs. The premise is that these aspects are useful for guiding applications and discussions across spectra of communities as well as broader spectra such as cities. Here, the contextual aspect is highlighted as the major driver of measures based on such an assessment framework. In order to better support the governance process, some quantitative metrics are suggested related to the categories based on the analyzed papers and complemented by transport indicators' ideas presented in ISO 37120, 37122, and 37123.

The indicators collected from the integrative review were analyzed using the categories grid (Souza et al., Paper 1) and were classified according to their relevance to the category. The 35 indicators are presented in Figure 4 according to the categories: eco-sustainability, equity, efficiency, flexibility, and safety.

Figure 4

An assessment framework for responsible urban mobility systems

Category	Indicators	Some related quantitative metrics
1. Eco-sustainability	1.1. Environment related policies 1.2. Green solutions 1.3. Reduction of air pollutant emissions 1.4. Reduction of noise 1.5. Soft/active mobility and electric technologies	No. of private cars/households % of eletric vehicles registered Air pollution Noise pollution No. of bicycle as transport mode/households No. of two-wheeled motorized vehicles/households % of vehicles low-emission registered
2. Equity	2.1. Affordability 2.2. Inclusion (special needs) 2.3. Social equity programs 2.4. Access in a given radius (stations/modals) 2.5. Easiness/convenience	% Particular expenditures used on private transport % Particular expenditures used on public transport Disabled facilities - bus accessibility ramp /(total bus) Disabled facilities - bus accessibility Wheelchair lift /(total bus) Disabled facilities - sidewalk accessibility ramp/(ratio) km Disabled facilities - % of stations with accessibility ramp % of residents with public transit service within (a given distance)
3. Efficiency	3.1. Coverage 3.2. Infrastructure 3.3. Congestion 3.4. Frequency 3.5. Reliability 3.6. Resilience 3.7. Parking area 3.8. Cleanliness 3.9. Comfort 3.10. Applications for online devices 3.11. Information availability 3.12. Governance 3.13. Public participation 3.14. Transparency and responsibility 3.15. Transport management system	Travel time/modal/day/Inhabitant Trips/modal/day/Inhabitant Distance traveled/Inhabitant Waiting time/Inhabitant Average commute time (min) Public transport/hour/region No. of transfers/day/Inhabitant Total No. of passengers/trips/modal No. of public transport's stations/(urban area)km² No. of evacuation routes available/Inhabitant Average speed/modal Public expenses with infrastructure maintenance

Source: Elaborated by the authors.

Figure 4 (continuation)

An assessment framework for responsible urban mobility systems

Category	Indicators	Some related quantitative metrics
4. Flexibility	4.1. Multimodal system 4.2. Bicycle paths 4.3. Walkability / pedestrian network 4.4. Shared Mobility 4.5. Intermodality/service integration	Walking distance Trips/modal/day Km of bicycle paths/(urban area) km² Km of pedestrian streets/(urban area) km² Public transport network length (km)
5. Safety	5.1. Accidents 5.2. Personal data privacy 5.3. Robberies/thieves security 5.4. Safety and security structure 5.5. Personal safety	No. of traffic crashes/Inhabitant No. of accidents with injuries/Inhabitant No. of accidents with deaths/Inhabitant No. of roberies/Inhabitant No. of privacy's attacks No. of pedestrians injured in traffic accidents/year No. of cyclists injured in traffic accidents/year

Source: Elaborated by the authors.

The categories and the central indicators are conceptualized below.

- Eco-sustainability

This category refers to actions based on the awareness that changes are necessary to develop a mobility system that generates the least possible negative impacts on the environment. This sustainable configuration of urban mobility requires more than just technological projects, requiring behavioral changes from citizens towards an attitude of questioning the need for travel, its duration, chosen modal, among other factors. Attention is given to emissions of pollutants and noise, and energy consumption, preserving natural resources and human health (Sá & Gouveia, 2010; Amoroso et al., 2011; Battarra et al.,2018). In this way, it is possible to meet current mobility needs without compromising future generations' needs (Bocarejo & Oviedo, 2012).

1. Environment-related Policies: This indicator represents the effort through policies aiming at reducing the transportation system's negative impacts on the environment. It supports actions towards the establishment of a monitoring system.

2. Green solutions: Related to new technology and infrastructure, also based on smart concepts, this indicator aims to promote eco-friendly services and solutions. It concerns, for example, resource efficiency and alternative fuels, such as electricity, natural gas, hydrogen fuel cells, among others.

3. Reduction of air pollutant emissions: It aims to lower vehicle emissions, reducing air pollution, resulting in air quality. It can be achieved by promoting actions to reduce transport-induced emissions, such as CO_2 and NO_x.

4. Reduction of noise: This indicator refers to the attention to the population exposed to traffic noise and thus aims to promote related actions.

5. Soft/active mobility and electric technologies: It refers to the aim of reducing the car dependency/the individual motorized traffic, creating mechanisms to subside the prioritization of soft/active mobility (such as walking and biking) and electric vehicles (e-bikes, e-scooters, electric cars, etc.). To do so, specific projects related to technology and infrastructure must be defined.

- Equity

Considering that people and groups do not have the same opportunities and the accessibility to different life aspects, equity designates appropriate actions to compensate for the vulnerabilities. Thus, it aims to promote fair distribution of the supply of transportation services to the population, consequently promoting access to better economic and social conditions (Sá & Gouveia, 2010; Verseckiene et al., 2017; Appolloni et al., 2019; Bartzokas-Tsiompras & Photis, 2019).

To this end, it focuses on inclusion (vertical and horizontal) of different user groups in terms of physical disabilities, gender, and socio-economic conditions, for example (Bocarejo & Oviedo, 2012; Silva et al., 2015; Clauss & Döppe, 2016; Munira & Santoso, 2017; Chen et al., 2018; Basu & Alves, 2019; Nemoto et al., 2021).

Accessibility is a central related concept based on the location and destination of the mobility system's users. The main concern is to ensure the well-being and the efficient operation of cities' systems (Filipović et al., 2009; Jaji, 2011; Bocarejo & Oviedo, 2012; Cheng & Chen, 2015; Battarra et al., 2018; Bartzokas-Tsiompras & Photis, 2019; Basu & Alves, 2019; Bounaceur et al., 2019; Kraft et al.,2020).

Thus, the equity's main focus is on the supply side. As a direct result, it improves safety and efficiency and supports actions aimed at flexibility, generating results that support eco-sustainability actions.

1. Affordability: This indicator seeks to promote better socio-economic access to the mobility system, aiming to support actions and projects. By analyzing the perceptions, projects on transport costs can be defined based on deeper analysis of household's incomes and expenditures both for the public and private transport (such as fuel, parking, fuel, sharing sources, etc.)

2. Inclusion (special needs): It analyses the accessibility facilities for people with disabilities, the elderly, and young users. It includes physical access (infrastructure) to transport and other related spaces, such as stations, stops, and parking spaces. As a result, it subsides inclusive planning.

3. Social equity programs: It highlights the need for equity analysis from a planning and policy perspective to create and promote actions to avoid social exclusion and disadvantages, resulting in social responsibility.

4. Access in a given radius (stations/modals): This indicator stresses the importance of analyzing the existing points of access to the transport system in terms of distance from the user's origin. The existing stations and access points of different modals (public transport and shared transports) and routes must be designed based on closeness. This is mainly based on spatial accessibility, availability, and distribution of services at a local level.

5. Easiness/convenience: It aims to promote good and convenient use of the transport system. A deeper analysis can be made based on time to access, the conditions to physically access the transport modes (effortlessness and easiness of entrance and exit).

- Efficiency

This category is related to operational maintenance and improvements of the mobility and transport system (performance), aiming to provide positive social, economic, and environmental results. The related indicators make it possible to generate strategic improvements in the existing structure and create new capabilities on the service's production. To this end, in short, the transportation and mobility network is analyzed in terms of operation and maintenance, focusing on infrastructure, management systems, and information and communication technologies (ICTs), that is, the allocated resources are analyzed based on the demand characteristics (Filipović et al., 2009; Black & Schreffler, 2010; Bocarejo & Oviedo, 2012; Garau et al., 2016; Alonso et al., 2017; Alonso et al., 2018; Vidović et al., 2019). One of the main objectives is to provide quality, which means user satisfaction and/or acceptance in terms of perceived benefits and instrumental utility.

1. Coverage: This indicator aims to evaluate the reachability to destinations considering the origin and transport availability (per modals). To achieve coverage, factors such as distance traveled, straightness, remoteness, number of routes, connectivity, and capillarity must be considered. Referring to destiny and routes, it must be based on specificities of coverage ratio definitions.

2. Infrastructure: Related to parking spaces, stations/stops, ride facilities, public lighting, independent traffic lines (bicycles, pedestrians, cars, public transports, etc.), pavement conditions, and others.

3. Congestion: Attention to the traffic congestion rate to avoid issues such as the impact on travel time.

4. Frequency: Related to service frequency/modals' schedule. It directly supports accessibility.

5. Reliability: As one of the core performance features, it refers to time efficiency, punctuality, consistent schedule in terms of travel times, and breakdowns.

6. Resilience: Closely related to unexpected occurrences or disruptions, it refers to adaptation, recovery, awareness, responsiveness to maintain the system performance (or being impacted more softly).

7. Parking area: Availability and adequacy of parking (for cars, bicycles, motorcycles, etc.).

8. Cleanliness: It is related to the service quality, which means the users' perception. Cleanliness is considered in terms of the vehicle, the stations, paths, etc.

9. Comfort: It is also related to the service quality/users' perception. It can be related to the available space (vehicle occupancy/crowded), the temperature inside the vehicle, the staff helpfulness, etc.

10. Applications for online devices: Availability of electronic and online ticket payment system and/or travel planner for the journey calculation.

11. Information availability: Integration with ICTs. It aims to provide real-time service information at stations, vehicles, and online about schedules, waiting times, routes, traffic alerts, etc.

12. Governance: It supports the possibility of network expansion, infrastructure, improvements on services, compatibility with the urban and local master plan and policies, integration of land-use and transportation planning, etc. This indicator interrelates actors through integrated and comprehensive planning, which means the commitment to long-term plans with well-defined goals for all spheres of urban mobility. It also demands regional cooperation and political commitment.

13. Public participation: Closely related to governance, this indicator aims to promote public participation in mobility decision-making in its different stages. This indicator can also be labeled as public engagement, public commitment, community participation, and active citizenship.

14. Transparency and responsibility: These are characteristics of efficient decision-making and definition of urban mobility's policies and regulations. As fundamental factors to determine governance processes, it subsides the expected results for society, market, and environment.

15. Transport management system: It refers to the organization, support, and control of all spheres of the transport and mobility system, such as traffic (stationary and moving, including all means of transportation - active, public, and personal), operational arrangements (providers), infrastructure, speed, prices, resources use, land use, etc. It aims to provide coordination of the urban mobility flow (people, goods, and vehicles), offering more suitable solutions, resulting in efficiency for all stakeholders.

- Flexibility

Considering the needs and expectations of mobility users, flexibility drives behavior changes by proposing complementary solutions that impact all the other categories. This category seeks to promote multimodal integration (public transport, shared, on-demand, non-motorized modes) and to support planning efforts about routes, modals, connectivity, availability, and autonomy (Clauss & Döppe, 2016; Garau et al., 2016; Jasti & Ram, 2019; de Oña, 2021).

1. Multimodal system: It refers to the travel choice, including different modals (modal split). An adequate network based on integration can support the definition of a multimodal system and the behavior change from the focus on private cars. Thus, aiming to provide a flexible route and modal choice, it demands connectivity and travel options.

2. Bicycle paths: This indicator analyzes the existence, the extent, and the quality of the bike path network in order to subside accessibility, promoting the viability of the modal (modal choice). Factors that can be analyzed: surface/pavement, obstructions, continuity, connectivity, parking, etc. It defines a bike-friendly ambiance.

3. Walkability/pedestrian network: This indicator analyzes the existence, the extent, and the quality of the pedestrian path network in order to subside accessibility, promoting the viability of the walkability (modal choice). Factors that can be analyzed: surface/pavement, obstructions, continuity and connectivity, zebra crossing, etc. It defines a pedestrian-friendly ambiance.

4. Shared Mobility: This indicator analyzes the existence, the extent, and the quality of shared options in order to subside accessibility, promoting the viability of the modal (modal choice).

5. Intermodality/service integration: Referring to the integration of transportation/mobility services, this indicator is based on analyzes of transport connectivity, network integration, intermodal terminals, among others.

- Safety

Directly related to the quality of life, this category deals with safety on board transportation as well as in all urban spaces. To that end, it assesses safety regarding accidents, theft and violence, infrastructure, and cyber-privacy aspects (Clauss & Döppe, 2016; Appolloni et al., 2019; Buenk et al., 2019; Gonzalez-Urango et al., 2020; Petrova et al., 2020; de Oña, 2021; Nemoto et al., 2021).

1. Accidents: It designates the attention to the protection against accidents: traffic accidents, injuries, and fatalities.

2. Personal data privacy: It refers to the privacy of data collection.

3. Robberies/thieves security: This indicator is related to the awareness of crime occurrences (robbery and violence).

4. Safety and security structure: It concerns well-being in the transport and mobility network. The attention is to the infrastructure: darkness, road markings, signage and lighting, pedestrian and bicycle paths, traffic management mechanisms, crossing, among other factors.

5. Personal safety: Provision of conditions to provide the ability to feel safe with confidence in the transport and mobility network. It is related to personal physical integrity.

The quantitative indicators were not determined with exact numbers as occurs in indicator 19.1 from ISO 37120, which is determined to analyze "kilometres of public transport system per 100 000 population" (ISO, 2018, p. 66). The objective of this papers' proposal is to consider the contextual specificities, providing an adaptability character to different urban realities.

5 Discussion

The role of the mobility system in supporting economic growth, social progress, environmental protection, and human health is increasingly recognized, leading to several initiatives around the world highlighting the role in supporting the definition of sustainable and smart cities. In this sense, as Ahvenniemi and Huovila (2021) discussed, a strategic implementation considering current and desirable plans and conditions is necessary. For Karjalainen and Juhola (2021), it requires an assessment framework balanced in terms of economic, social, and environmental aspects, which results in solutions to promote efficiency, economic viability, accessibility, safety, security, affordability, equity, and awareness of environmental impacts. Along these lines, the assessment framework was proposed to support the governance of responsible urban mobility systems, emphasizing such a system as fundamental to developing sustainable and smart solutions for cities.

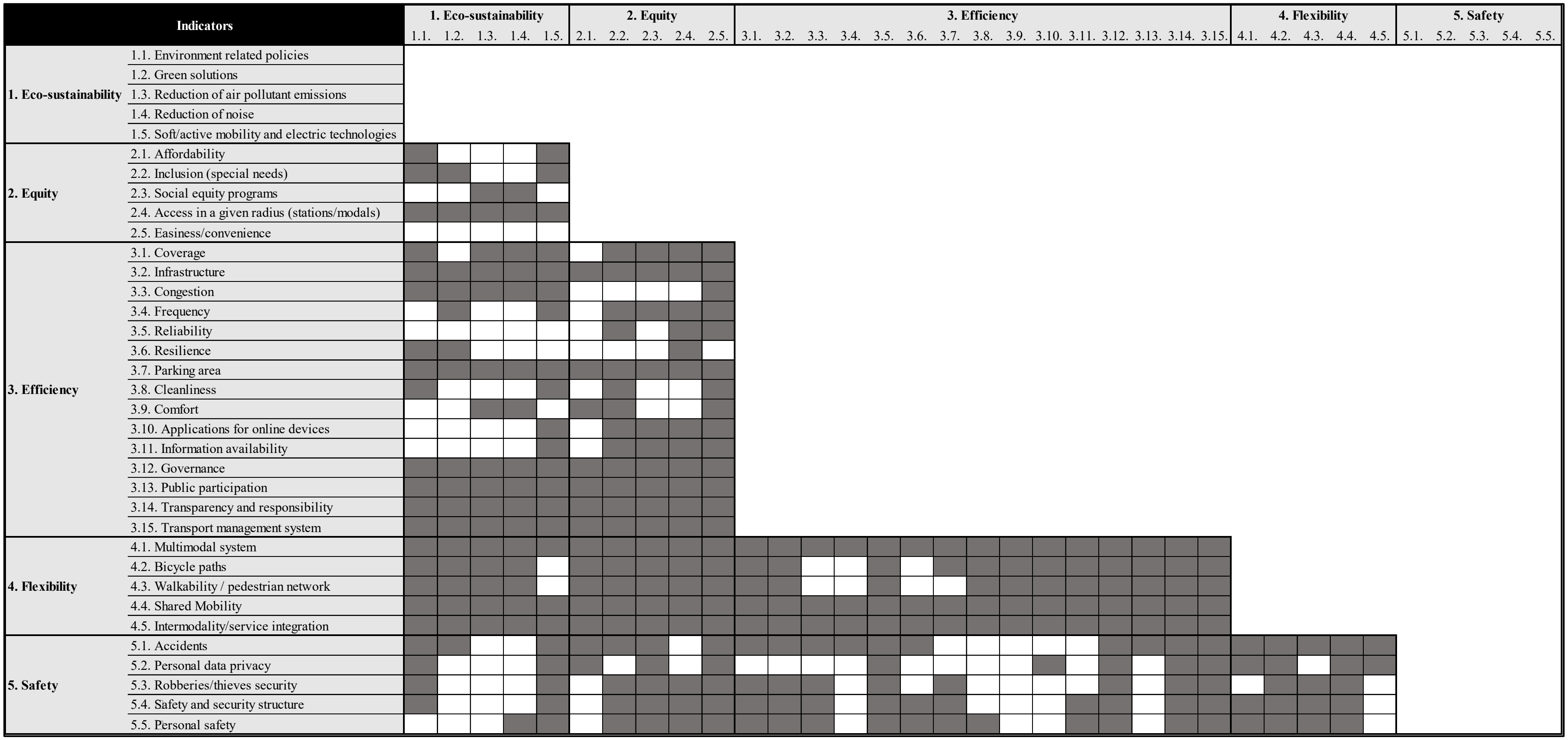
It is proposed that a responsible definition of the mobility system should result in intelligent and sustainable solutions, goals, and measurements. In order to support an integrative governance structure, the set of indicators is proposed to be discussed as CSFs to support the search for proposals for emerging issues. To this end, the stakeholders (companies, public authorities, research representatives, society) should be included as representatives in the decision-making processes from the beginning of the mobility innovation projects (Souza et al., 2020). Besides, the governance must consider contexts as specifics.

Qualitative indicators were proposed to be used to highlight users' perceptions regarding the CSFs, generating information that allows a complete understanding of the system and, therefore, allowing the improvement of the mobility system and the city. To improve the support for governance processes, some quantitative indicators were highlighted to be used, also useful as a direction to search for more appropriate quantitative measurements.

As stated, the purpose of considering indicators in cities is to provide data sources that can support analyses of the different and complementary aspects and elements of cities, thus allowing the direction of actions for better performance in social, environmental, and economic terms. Thus, the indicators were not defined to be employed independently but rather as a holistic framework (Kitchin et al., 2015). This aspect is highlighted in Figure 5 from a representation of the correlation between indicators and categories.

Figure 5

Correlation of indicators and categories



Source: Elaborated by the authors (2022).

The framework is proposed to be a direction for governance discussions and analysis of the aspects raised, allowing cities to build their mobility solutions upon suitable and smart concepts. Considering the RI lens and ISO documents and the urban mobility discussions, it should be noted that contexts are specific, and this condition must be inserted in governance processes. Besides, users' perceptions are dynamic, a character reflected in CSFs discussions and analysis, requiring cyclical reviews. It reinforces the need to define the mobility governance system based on an intermediary structure composed of representatives of the different mobility systems, including society.

By providing real analysis of circumstances, contexts, conditions, bottlenecks, opportunities, and challenges, the discussions on CSFs can support economic growth, social progress, environmental protection, and human health, taking these as interrelated structures. Therefore, different structures, such as cities and communities, can be benefited from CSF discussions.

6 Concluding Remarks

Based on the integrative review and analysis of the selected papers, this paper proposes an assessment framework composed of indicators that can support the definition and development of responsible urban mobility systems. It was possible to find an extensive list of indicators from the integrative review. A framework was presented and discussed to highlight the findings from the literature. The discussions were developed considering such indicators as CSFs to responsible urban mobility systems, sought to provide insights to support governance processes to define, implement, and evaluate proposals to improve mobility system projects, taking this as a central system for smart and sustainable cities' definitions.

The categories and indicators expressed in the assessment framework and further conceptualized reinforce the idea that sustainability must be included and highlighted in smart city concepts. To this end, the indicators are based on the premises of interdisciplinarity, relevance, contextual sensitivity, dynamicity, and flexibility.

The urban mobility field is characterized by emerging technologies, policies, laws and incentives, economic, social, and environmental aspects. This paper argues that positive outcomes for all these elements and related actors depend on responsible definitions grounded in governance settings. It is discussed that governance must be defined by combining social, economic, technical, managerial, and sustainable perspectives. In this sense, this paper takes a step forward in discussions of indicators and approaches to smartness and sustainability of mobility and, consequently, of cities.

This article presents limitations regarding the method chosen for the study and the selection of indicators. Understanding that many studies may not have been contemplated due to the selected filters applied, future studies should include other sources of indicators, such as documents from consultancies, governments, and other institutions. In addition, the methodology did not include verification with experts, which can be done by other studies.

Future studies can also address the CSFs in real contexts, seeking to highlight challenges, aspects of improvements, and theoretically and empirically analyzing the correlation between the indicators. Besides, papers can focus on quantitative measurements, expand the suggested list, analyze usability, highlight contexts' particularities, and develop comparative analysis. Future studies can also identify the stakeholders involved in urban mobility systems and discuss new relationship formats, new players, new roles, new interests, new challenges, analyzing whether these can generate new CSFs.

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ARTICLE 4: Responsible mobility system as a support for a smart and sustainable definition: critical aspects of universities campuses in Brazil and France.

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RESPONSIBLE MOBILITY SYSTEM AS A SUPPORT FOR A SMART AND SUSTAINABLE DEFINITION: CRITICAL ASPECTS OF UNIVERSITIES CAMPUSES IN BRAZIL AND FRANCE

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Abstract

The concepts of smartness and sustainability have been increasingly included in the urban context. As cutouts of cities, university campuses have been applying such concepts using their territory, knowledge, and people to base experiences as laboratories of urban realities. As one of the main project actions, responsible formatting of the mobility system can provide a basis for a more holistic decision-making process. Considering the university campuses of the Federal University of Lavras (Brazil) and the University of Paris-Saclay (France) as case studies, this paper proposes a discussion of indicators as critical success factors for establishing a responsible mobility system (RMS), based on the users' perspectives. To this end, this study consists of two stages. In the first stage, focus groups were developed to refine with experts the pre-selected indicators; the second stage consists of applying questionnaires to mobility system users from both universities. As the main result, this paper provides a basis for discussions about the criticality of the factors considering contextual particularities, highlighting central aspects that need to be considered when defining the governance of RMSs. The insights can also be discussed in broader contexts, such as cities and other communities.

Keywords: Smart and sustainable communities. Mobility system. Governance. Responsible Innovation. Quintuple Helix. University campus.

1. Introduction

Context and history are potential influences on the governance of urban systems, such as mobility and transportation. Due to population growth and the consequent urbanization, cities have faced many challenges in creating urban mobility solutions adaptive to provide safety, well-being, jobs, basic services, and infrastructure such as suitable and well-connected transport systems, and to other elements that impact the urban life (Corwin et al., 2019; Butler et al., 2020). The old patterns of cities and their systems reflect the past cultural, technological, environmental, social, and political needs, reflecting different infrastructure requirements and demand characteristics (Paiva et al., 2021). What has been seen increasingly strongly in recent years is the emergence (or solidification) of new actors (interests, expectations, and roles), networks, and technologies challenging the existing regime (Lützkendorf and Balouktsi, 2017; Axelsson and Granath, 2018).

Throughout the years, seeking to develop a multidimensional approach to cities, two concepts emerged: "sustainable city" and "smart city" (Mori and Christodoulou, 2012; Shmelev and Shmeleva, 2018; Rasca and Waeben, 2019). As one of the urban's systems, mobility is also related to smart cities' ideas. Benevolo et al. (2016) highlight smart mobility as a definition that aims to support the achievement of smart cities' goals, mainly those related to citizens' quality of life and environmental concerns. According to Paiva et al. (2021), there are still open questions regarding service improvements that are opportunities for all stakeholders: citizen participation in projects and decisions, public-private cooperation, infrastructure improvement and adaptation, modal interoperability, alternative routes, and cheaper options.

Even though the initial idea of smart cities comprises awareness of sustainable development, there are criticisms about how this concept includes sustainable goals (Ahvenniemi and Huovila, 2021). So, a Smart and Sustainable Cities' approach emerged in the mid–2010s to support urban planning and policy towards efficient, reliable, and resilient outcomes for the whole urban system (Dhingra and Chattopadhyay, 2016; Bilbri and Krogstie, 2017).

Considering the existence of multifaceted and multi-level stakeholders, a smart and sustainable definition requires new definitions of governance. Ruhlandt (2018) states that this opens a room for new research that entails deepen analysis of critical aspects of the contexts that can potentially impact the decision-making processes. To this end, one of the central aspects to consider the stakeholders involved, their interests, roles, and attributions (Axelsson and Granath, 2018). This paper discusses such identification based on the quintuple helix approach (5H). Furthermore, a reflection on analysis' development is needed to keep a prospective vision aware of the aspects' dynamics and possible impacts.

The concept of 'smart' is also associated to community. Focusing on a local level, Smart Communities are a pre-condition for smart cities development (Kummitha & Crutzen, 2017). As specific communities, smart universities bring out challenges and needs similar to urban settings (Prandi et al., 2020). As highlighted by Alshuwaikhat and Abubakar (2008), university campuses are cutouts of cities and can be considered as suitable laboratories to test and apply concepts of smartness and sustainability. Besides, universities are significant trip-generating areas (Shannon et al., 2006; Menini et al., 2021).

According to Negreiros et al. (2020), one of the challenges associated with smartness and sustainability in the university context is assertive decision-making considering a high amount of data and the complex and dynamic scenario that composes it. A system of indicators is considered a solution to collect and monitor data adequately, providing access by the different actors involved. In this sense, to deeper the discussions on governance of smart and sustainable configurations, this paper is based on the responsible approach inserted in the model of Responsible Urban Mobility Systems (RUMS) (Souza et al., Paper 1) as well as in the discussions on indicators and critical success factors (CSFs) to such systems as proposed by Souza et al. (Paper 3).

This paper aims to discuss the criticality of CSFs to establish a responsible mobility system (RMS) based on users' perspectives. In order to address a context of less complexity than cities, this article proposes an application of the indicators in University Campuses, taking these as communities. For the case study approach, the university campuses in Brazil and France are analyzed. The methodological data collection is based on focus groups and questionnaires.

From this introduction, this paper is organized as follows: Section 2 presents the theoretical approach of the context is presented regarding a) mobility as a system of smart and sustainable cities, b) smart and sustainable universities campuses, c) governance of responsible urban mobility systems, d) critical success factors, and e) quintuple helix; section 3 presents the methodological definitions; in section 4 the results and discussion are presented; lastly, there are the final considerations in section 5.

2. Theoretical Background

2.1 Smart and sustainable universities campuses: the mobility system governance

Mobility is one of the most complex urban systems to tackle in metropolitan areas as it directly impacts the economy, environment, and, consequently, the community's quality of life (Benevolo et al., 2016). Transport has several negative effects, such as pollution, poor traffic conditions, poor infrastructure, limited services, spatial disparities, high costs, new and increased transport needs, unequal access to services, and issues related to safety and security, social health, urban design, and transport system design (Bibri & Krogstie, 2017).

Although without a precise definition, a Smart City has six key dimensions: smart economy; smart environment; smart people; smart living; smart mobility; and smart governance (Lombardi et al., 2012). The concept is related to a set of physical, social, and market structures associated with information and communication technologies (ICTs) focusing on collective results, aiming to promote efficiency through the integration and optimization of institutional, digital, and physical operations. As a result, an enabling environment for innovations is supported and encouraged by connecting virtual and real contexts (Appio et al., 2019; Dameri et al., 2019).

Aiming to provide suitable solutions, the concept of Smart Mobility was developed linked to the main concepts of Smart City (Noy & Givoni, 2018). Smart Mobility includes improvements in flexibility, efficiency, integration, sustainability, and safety aiming to offer user-centric services, temporal and geographical allocation, availability, integrated data between players, connectivity, cost-efficiency, sustainability, and reliability (Nicolaï & Le Boennec, 2018).

The concept of ‘smart’ is also related to community contexts. According to ISO 37101 (International Organization for Standardization [ISO], 2016, p. 2), a community “is a group of people with an arrangement of responsibilities, activities and relationships”. Smart Communities are based on a focus and engagement at a local level, resulting in investments in human capital and capabilities, being seen as a pre-condition for smart cities (Kummitha & Crutzen, 2017). Extended to this concept of communities emerged the idea of Smart Campus taking the universities’ campuses as a specific local context (Prandi et al., 2020). Due to geographical, socio-economic, environmental, and management characteristics and sharing resources and structures with cities, universities present challenges and needs similar to urban settings and are therefore considered communities or small cities (Dong et al., 2020). Alrashed (2020, p. 02) discuss that "university campuses are ideal candidates to construct and test smart city model". To this end, planning must be defined that includes strategic management integrating the community and other stakeholders and aspects of sustainability, innovative solutions, and smart services aligned with the core proposals of university life.

The smart campus is a conceptual proposal that seeks to support educational institutions applying smart definitions to services, sustainability, physical infrastructure, decision-making, etc. (Min-Allah & Alrashed, 2020). A smart campus’ definition aims to reduce costs, develop effective use of resources, and promote improvements in the quality of life through the delivery of high-quality services (Prandi et al., 2020).

A concept related to the smart proposal is the sustainable university campus. The idea is to highlight the goal of universities to minimize potential negative environmental, economic, social, and health effects. Thus, it is possible to support society's transition to sustainable lifestyles from the main functions of teaching, research, and administration. To this end, it is important to create a sustainability committee that focuses on establishing goals, strategies, policies, and practices (Velazquez, Munguia, Platt & Taddei, 2006). Min-Allah and Alrashed (2020) point out that sustainability goals in campus proposals depend on stakeholders’ engagement (including community).

Therefore, the desired improvements in cities from smart concepts claim more than a focus on ICTs (Neirotti et al., 2014). Accordingly, a smart and sustainable cities' approach emerged in the 2010s combining technological, human, economic, social, and environmental aspects as a basis for research, planning, policy, and legislation of urban systems (Garau & Pavan, 2018). In this paper, it is argued that, based on proposals for stakeholders' integration and attention to social, economic, and environmental factors, the proposal of smart and sustainable campuses can be enhanced by the RI's premises.

For smart mobility to be a positive transformation, there is an urgent need to rethink current governance systems, which stresses the need to foster a democratic debate about desirable economic, environmental, and social outcomes and the related actions to achieve them (Docherty, 2018). Considering RI as an innovation governance approach to practical contexts, Souza et al. (Paper 1) proposed a responsible urban mobility system framework. For the authors, the responsible feature aims to support positive results and solutions to environmental, social, and market issues by developing a responsible urban mobility system that offers equity, efficiency, eco-sustainability, and safety.

The starting point for such a framework is the development of decision-making processes based on collaborative knowledge integration supported by evaluations systems (Schillo & Robinson, 2017). Governance debates based on Critical Success Factors (CSFs) can provide significant sources for decision-making processes. CSFs are topics that can ensure better performances towards adequate and desirable goals. These topics highlight areas that must be focused on and prioritized, which are more strategic (Bullen & Rockart, 1981).

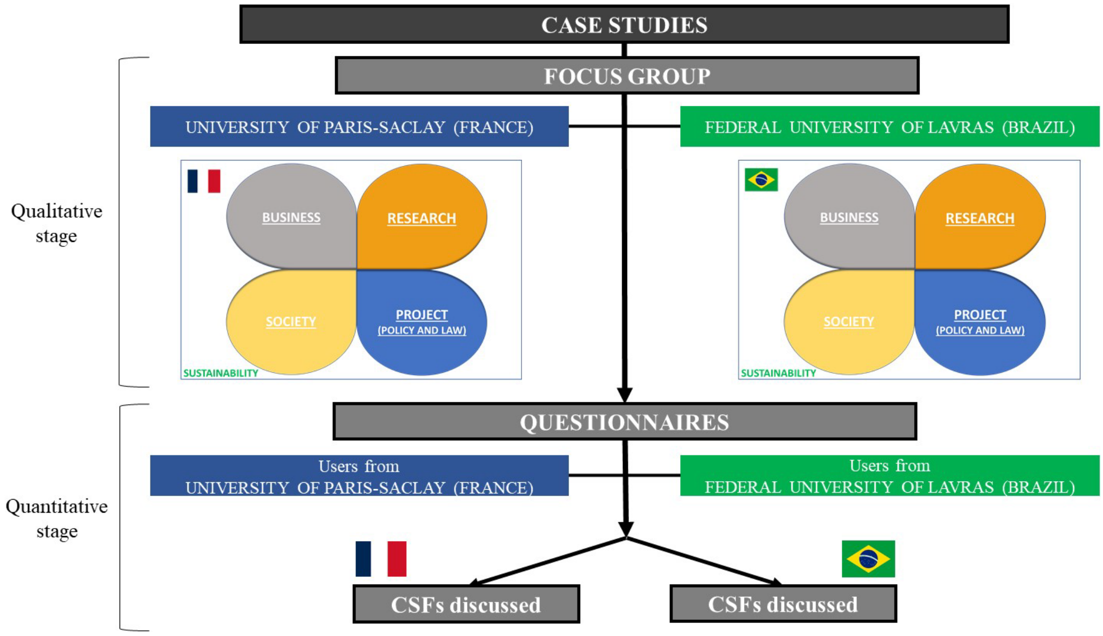
Urban mobility's evaluation and monitoring systems require a strategic, useful, available, actionable, assessable, and consistent definition to provide quality and reliability for governance over time (Karjalainen & Juhola, 2021). However, as pointed out by Halla, Merino-Saum, and Binder (2022), in order to provide a basis for pertinent analyses and discussions connected to the complexities of the real world, considering, to this end, the stakeholders with a collaborative and participative governance format, it is essential to treat the indicators considering local pertinence and with adequate scope, thus sustaining a higher quality of the information collected.

Therefore, appropriate governance of smart and sustainable cities needs to consider their system full of relationships and feedback among the subsystems involved. One of the central aspects of governance is the involvement of civil society as a stakeholder along with industry, academia, and government in the design of solutions grounded in sustainability awareness. This integrative framework is defined by the quintuple helix model (5H) (Etzkowitz & Zhou, 2006). The 5H model is based on five perspectives, four of which are actors. The 'sustainability' helix, rather than an actor, is a representation of a project (or contextualization) that guides the actions of the 4H actors (Mineiro, Souza, Castro, 2018; Carayannis and Campbell, 2021). The success of smart and sustainable urban planning depends on the interaction between these actors (Lombardi, Giordano, Farouh & Yousef, 2012).

3 Methodology

This paper follows a multiple case study approach (Yin, 2009), since focus on understanding CSFs for a RMS considering diverse contexts. University of Paris-Saclay (UPS, France) and the Federal University of Lavras (UFLA, Brazil) were chosen due to their smart campus projects. Also, they represent different social, cultural, geographic, demographic, and political compositions, all of which are relevant for further discussion regarding CSFs. Besides, both institutions have a focus on smart and sustainable definitions. Figure 2 presents the methodological design.

Figure 2: Methodological design



Source: Elaborated by the authors (2022).

The next sections present further details of the methodological procedures developed.

3.1 Qualitative data collection: the focus group

The first data collection was qualitative, carried out through the focus group method. This methodological choice was based on the aim of promoting discussions on the CSFs proposed by Souza et al. (Paper 3), gathering insights to address the topic of interest for the research. To do so, discussions were promoted based on problematization, critical visions, and creativity considering the experts' point of view (Nyumba, Wilson, Derrick, Mukherjee, 2017).

Unlike face-to-face groups that are composed of 8 to 12 participants, in this paper, the on-line focus group technique was applied, taking the guidelines highlighted by Malhotra (2020). Considering the national contexts addressed in this paper, two focus groups were conducted considering the premises of the 5H (four actors and the 'sustainability' helix as a contextualization). Figure 3 presents and identifies the representatives of each country.

Figure 3: Stakeholders' representatives

	French Focus Group	**Brazilian Focus Group**
Society Representative	*SFr*	-
Politics Representative	*PFr*	*PBr*
Business Representative	*BFr*	*BBr*
Research Representative	*RFr*	*RBr*

Source: Elaborated by the authors

The France focus group was the first one held (October 2021). Due to the time availability of the participants, the Brazil focus group was developed in two meetings (November 2021). Unfortunately, the society representative from the Brazilian context had an unforeseen last-minute problem at the time scheduled for the focus group. However, the other representatives, as they also have vision and experience as individuals from society and users of mobility systems, the perceptions were not impaired. In France, the company was represented by a transport system user from the Île-de-France metropolitan area, including the Paris-Saclay region. In terms of politics, the focus group was attended by a member of the recently finished MoveInSaclay project in France. In Brazil, the participation was of the representative of the sector in charge of the smart campus project at UFLA. The business area in France was represented by an executive from a European startup in the field of RI. In Brazil, it was the founder of a company focused on solutions based on a Data-Driven Business platform. The research area (academia) was represented in France by a researcher from the Transportation Economics area, while in Brazil, there was a researcher from the Human Factors and Ergonomics, Usability, User Experience (UX), and User-Centered Design (UCD) approach. Besides, the focus group had a moderator and two assistants (Malhotra, 2020).

The dynamics of the focus groups were based on sharing and alignment of ideas aiming at consent on a final list of indicators. The indicators were presented along with their concepts. In order to improve the dynamics of the virtual format, favoring the sharing of ideas, the Miro® platform was used. The participants were encouraged to create an atmosphere of debate and consensus.

3.2 Quantitative data collection: the questionnaires

Given the benefits of online data collection (Evans & Mathur, 2018), a questionnaire was sent by e-mail, social media, and mobile phone applications. Convenience sampling was used to select students, professors, and employees interacting with Paris-Saclay or UFLA. Employees of enterprises within or nearby both universities were also addressed.

Following Hair Jr. et al. (2015), the thirty-five predictive variables from the questionnaire required at least 210 respondents. The number of valid responses exceeded that number, reaching 254 from Brazil and 314 from France, after eliminating 94 responses with incorrect answers to five control questions. Demographical data can be found on Appendix 2.

The indicators included in the study were selected from an extensive literature review and study of ISOs 37120, 37122, and 37123 (Souza et al., Paper 3) and discussed in the focus groups. In order to understand respondents' agreement to the indicators found in the focus group a five-point Likert-type scale was used. Each question was built using a five points Likert-type scale, ranging from (1) strongly disagree to (5) strongly agree. Since there were two contexts, Brazil and France, the questions were translated into English, France, and Portuguese and reviewed by native speakers of each language. The questionnaire also included demographics and a few open-ended questions. Pre-tests in the three idioms allowed the rewriting of a few questions to improve understandability.

The pre-tests revealed that the items were clear and understandable, thus ensuring content validity. Data collection was conducted between November/2021 and January/2022. Initially, an ANOVA was conducted with 50 respondents to assess their understanding of the questionnaire statements and response pattern. Subsequently, pre-test responses were incorporated into the final sample because no difficulties were identified. For the presentation of discussions and analysis, the comments in Portuguese and French were translated to English.

The questionnaires were distributed through institutional emails and student groups from both institutions via social media applications. The data were analyzed using the SPSS 2.0 (Statistical Package for the Social Sciences). Descriptive statistical techniques (frequency analysis and crosstabs) were applied, in addition to chi-square analysis considering a 5% significance level and Pearson's correlation coefficient (Hair Jr. et al., 2006). For the presentation of the discussions, aiming to highlight the correlations with better representation of perceptions, it was considered the effects r > 0.11 (Cohen, 2013).

3.3.2. Sampling Profile: Description of Brazilian and French respondents

In Brazil, 59% of the respondents were women, and 40% were men, most between 21 and 35 years old (74%). As for the financial situation, 51.6% of the respondents had a monthly family income between R$1,101.00 and R$3,300.00, while 9.4% were between R$3,301.00 and R$5,400.00, and still, 15.7% declared to receive more than 5,501.00 per month. More than 50% of the respondents are graduate students, more than 23.6% are undergraduate students, 12.2% declared to be professors. The remaining respondents are distributed among the other classifications defined in the survey.

In France, the respondents were 31.8% female and 65.3% male. The majority also aged between 21 and 35 (59.9%). The family income of 36.9% of the respondents was described as between 1 and 3 minimum wages, while 10.2% have a family monthly income of up to 1 minimum wage. Furthermore, 47.8% declared that they have no income per month. In terms of profiles, similar answers were found in the UPS context: graduate students (40%), undergraduate students (over 28%), and professors (8.9%).

Most respondents from both Brazil (64,6%) and France (42,4%) use only one modal to get to the campus; 30,7% of Brazilian respondents use two modals, while in France, it is 23,6%. Also, 26,8% of French respondents use three modals to get to the campus. The other values for this description were not representative. It was also asked about the modes used in the two countries. In both cases the Public Transport followed by the private car prevailed.

4. Results and Discussions

4.1 A refined assessment framework for RMSs

The discussions that occurred during the focus groups resulted in the refinement of the indicators considering the integrated perceptions of the stakeholders related to the mobility system (Figure 5). Flexibility was an important factor regarding different priorities for different areas and time visions. Thus, dealing with uncertainty and dialogue are also primary elements in building the integrative structure. To this end, the roles and responsibilities of the actors must be deeply understood, and the legal and operational elements must be clarified. In this way, it is possible to address prioritization considering the different points of view.

To discuss the indicators, some precautions were taken to improve the outcome of the final list and the concepts. For Tanguay et al. (2010), three conditions for a selection strategy for indicators are essential: easy understanding and usefulness, coverage of given related categories, and consensus and literature background for conceptual suitability. Thus, based on the qualitative definition, we sought to structure the indicators clearly, relevantly and aim for feasibility. According to the focus group participants, the indicators collected from the literature and organized by Souza et al. (Paper 3) already clearly covered the CSFs of the mobility context. The changes were made, essentially, as text and term adjustments.

Figure 5: A refined assessment framework for RMSs

Category	Indicators		Concept
Eco-sustainability	I-1	Incentives for the use of "greener" routes and modes	"It refers to the aim of reducing the car dependency/the individual motorized traffic, creating mechanisms to subside the prioritization of soft/active mobility (such as walking and biking)" (p. 23)
	I-2	Reduction of GHG Emissions	"It aims to lower vehicle emissions, reducing air pollution, resulting in air quality. It can be achieved by promoting actions to reduce transport-induced emissions, such as CO2 and NOx." (p. 23)
	I-3	Noise pollution reduction	"This indicator refers to the attention to the population exposed to traffic noise" (p. 23)
	I-4	Electrical technologies	"It refers to the aim of support the spread of electric vehicles (e-bikes, e-scooters, electric cars, etc.). To do so, specific projects related to technology and infrastructure must be defined." (p. 23)
	I-5	Reduce fossil fuel dependency	"This indicator aims to promote eco-friendly services and solutions. To do so, it concerns, for example, resource efficiency and alternative fuels, such as electricity, natural gas, hydrogen fuel cells, among others." (p. 23)
Efficiency	I-6	Coverage	"This indicator aims to evaluate the reachability to destinations considering the origin and transport availability (per modals). To achieve coverage, factors such as distance traveled, straightness, remoteness, number of routes, connectivity, and capillarity must be considered. Referring to destiny and routes, it must be based on specificities of coverage ratio definitions." (p. 26)
	I-7	Parking area	"Availability and adequacy of parking (for cars, bicycles, motorcycles, etc.)." (p. 26)
	I-8	Cleanliness	"It is related to the service quality, which means the users' perception. Cleanliness is considered in terms of the vehicle, the stations, paths, etc." (p. 27)
	I-9	Infrastructure	"Related to parking spaces, stations/stops, ride facilities, public lighting, independent traffic lines (bicycles, pedestrians, cars, public transports, etc.), pavement conditions, and others." (p. 26)
	I-10	Comfort (of modals)	"It is also related to the service quality/users' perception. It can be related to the available space (vehicle occupancy/crowded), the temperature inside the vehicle, the staff helpfulness, etc." To this end, it is also important to monitor the occupancy rate of the vehicles. (p. 27)
	I-11	Information availability	"Integration with ICTs. It aims to provide real-time service information at stations, vehicles, and on-line about schedules, waiting times, routes, traffic alerts, etc." (p. 27)
	I-12	Frequency	"Related to service frequency/modals' schedule. It directly supports accessibility." (p. 26)
	I-13	Congestion	"Attention to the traffic congestion rate to avoid issues such as the impact on travel time." (p. 26)
	I-14	Governance/management of mobility	"It supports the possibility of network expansion, infrastructure, improvements on services, compatibility with the urban and local master plan and policies, integration of land-use and transportation planning, etc. This indicator interrelates actors through integrated and comprehensive planning, which means the commitment to long-term plans with well-defined goals for all spheres of urban mobility. It also demands regional cooperation and political commitment." (p. 27)
	I-15	Transport management system	"It refers to the organization, support, and control of all spheres of the transport and mobility system, such as traffic (stationary and moving, including all means of transportation - active, public, and personal), operational arrangements (providers), infrastructure, speed, prices, resources use, land use, etc. It aims to provide coordination of the urban mobility flow (people, goods, and vehicles), offering more suitable solutions, resulting in efficiency for all stakeholders." (p. 28)
	I-16	Transparency and responsibility in decisions	"These are characteristics of efficient decision-making and definition of urban mobility's policies and regulations. As fundamental factors to determine governance processes, it subsides the expected results for society, market, and environment." (p. 28)
	I-17	Resilience	"Closely related to unexpected occurrences or disruptions, it refers to adaptation, recovery, awareness, responsiveness to maintain the system performance (or being impacted more softly)." (p. 26)

	I-18	Reliability	"As one of the core performance features, it refers to time efficiency, punctuality, consistent schedule in terms of travel times, and breakdowns." To this end, it is also important to monitor user demand in order to work better at predictability. Besides, it includes the need of consider the aspect of door-to-door time. (p. 26)
Equity	I-19	Affordability	"This indicator seeks to promote better socio-economic access to the mobility system, aiming to support actions and projects. By analyzing the perceptions, projects on transport costs can be defined based on deeper analysis of household's incomes and expenditures both for the public and private transport (such as fuel, parking, fuel, sharing sources, etc.)." (p. 24)
	I-20	Citizens' participation in decisions	It highlights the need of including the beneficiary's viewpoints from the start of the planning/projects.
	I-21	Inclusion (special needs)	"It analyses the accessibility facilities for people with disabilities, the elderly, and young users. It includes physical access (infrastructure) to transports and other related spaces, such as stations, stops, and parking spaces. As a result, it subsides inclusive plannings." (p.25)
	I-22	Actions to promote mobility with social equity	"It highlights the need for equity analysis from a planning and policy perspective to create and promote actions to avoid social exclusion and disadvantages, resulting in social responsibility." (p. 25)
	I-23	Access in a given radius - time and space (stations/modals)	"This indicator stresses the importance of analyzing the existing points of access to the transport system in terms of distance from the user's origin. The existing stations and access points of different modals (public transport and shared transports) and routes must be designed based on closeness. This is mainly based on spatial accessibility, availability, and distribution of services at a local level." (p. 25)
	I-24	Easiness	"It aims to promote good and convenient use of the transport system. A deeper analysis can be made based on time to access, the conditions to physically access the transport modes (effortlessness and easiness of entrance and exit)." (p.25)
Flexibility	I-25	Multimodal system (physical connectivity)	"It refers to the travel choice, including different modals (modal split)" focusing on physical and digital connectivity. "An adequate network based on integration can support the definition of a multimodal system and the behavior change from the focus on private cars. Thus, aiming to provide a flexible route and modal choice, it demands connectivity and travel options." (p. 28)
	I-26	Infrastructure for micro mobility	"This indicator analyzes the existence, the extent, and the quality of the" network dedicated to micro mobility "in order to subside accessibility, promoting the viability of the modal (modal choice). Factors that can be analyzed: surface/pavement, obstructions, continuity, connectivity, parking, etc." It defines a micro mobility-friendly ambiance. (p. 29)
	I-27	Infrastructure for active mobility	"This indicator analyzes the existence, the extent, and the quality of the" network dedicated to active mobility "in order to subside accessibility, promoting the viability of the" modal choice. "Factors that can be analyzed: surface/pavement, obstructions, continuity and connectivity, zebra crossing, etc.". It defines a active mobility-friendly ambiance. (p. 29)
	I-28	Shared Mobility	"This indicator analyzes the existence, the extent, and the quality of shared options in order to subside accessibility, promoting the viability of the modal (modal choice)." (p. 29)
	I-29	Friendly-user tools for trip customization	This indicator highlights the offer of friendly tools focused on the personalization of trips considering lifestyles, needs and/or expectations. To this end, such tools should offer real-time information on traffic and mobility solutions, as well as the possibility of rescheduling trips in real time, suggesting alternative routes.
	I-30	Service integration	"Referring to the integration of transportation/mobility services, this indicator is based on analyzes of transport connectivity, network integration, intermodal terminals, among others." (p. 29)
Safety	I-31	Accidents	"It designates the attention to the protection against accidents: traffic accidents, injuries, and fatalities." (p. 29)
	I-32	Personal data protection	It refers to the privacy of the data collected.
	I-33	Robberies/thieves security	"This indicator is related to the awareness of crime occurrences (robbery and violence)." (p. 30)
	I-34	Safety and security structure	"It concerns well-being in the transport and mobility network. The attention is to the infrastructure: darkness, road markings, signage and lighting, pedestrian and bicycle paths, traffic management mechanisms, crossing, among other factors." (p. 30)
	I-35	Personal integrity	"Provision of conditions to provide the ability to feel safe with confidence in the transport and mobility network. It is related to personal physical integrity." (p. 30)

Source: Elaborated by the authors based on Souza *et al.* (Paper 3).

The main aspects highlighted in the focus groups' discussions are considered, along with presentations of the results of the questionnaires.

4.2 RMSs in smart and sustainable universities campuses: the cases of Brazil and France

Besides technology, the effectiveness of the changes is also grounded in subjacent cultural aspects. As stated by Paiva et al. (2021, p. 35), "citizens must realize the negative consequences for the environment of maintaining the current state and the impossibility of managing so many cars within the cities with the highest population density".

Following the ideas of Halla, Merino-Saum, and Binder (2022), assessments must to serve governance, telling a 'story' based on a context rather than simply presenting facts. Thus, in order to verify how critical are the CSFs from the users' perspective, the context was into the analyses of responses, highlighting aspects as insights for a context-sensitive governance approach, as the RI and the 5H theories emphasize.

Appendix 3 presents the results of the indicators' measurement in the Brazilian context, while Appendix 5 represents the French context.

4.2.1 Users' perceptions: the indicators

Transportation issues are big challenges for university campuses mainly due to de mobility's choices/behaviors from the different users (profiles), being causes of environmental problems. This culminates in many plans worldwide to develop a sustainable structure (Dehghanmongabadi & Hoşkara, 2018; Menini et al., 2021).

Eco-sustainability is related to making efficient and effective use of resources, guiding more sustainable options considering individual needs. From the comparative analysis of the significance levels of the contexts, it can be stated that, in general, users want greener modes (I-1) in a way that does not harm the monthly expenses with transportation (I-19), nor the physical access (I-24), and, consequently, does not promote social exclusion (I-22). Thus, we have that the understanding of "green values", besides representing environmental aspects, also reflects social concerns, including safety.

The importance of the users' perception is highlighted since they are the ones that will determine the acceptance of the proposed solutions. This aspect was related to discussions about incentives in both focus groups. The University of Florence and the University of Catania (Italy) bring an interesting example. The Universities worked to financially support a public transport card for students, which resulted in a very reasonable cost (Fissi et al., 2021). At UFLA, this aspect has also been identified as important, and actions have been planned to encourage shared concepts, such as incentives as discounts on services provided within the university.

In both cases (UFLA and UPS), it can be seen that there is an understanding of the direct relationship between the role of green options and their benefits, i.e., with pollution (I-2), noise (I-3), EVs (I-4), and modes that do not use fossil fuels (I-5). Thus, it is said that there was validation. The responses of the Brazilian sample revealed a greater correlation with the equity indicators; in France, the greatest emphasis was on flexibility.

Air pollution (I-2) is a widely known aspect due to individuals' environmental and health impacts. Relevant actions are those aimed at solving congestion, which, according to Lu et al. (2021), is one of the main causes of the increase in pollutants' emission. In this sense, at UFLA, some actions are consistent with the Ranking Green Metrics aiming to reduce the number of vehicles on the campus.

Such actions align with the discussions highlighted by Toledo e La Rovere (2018) and the International Transport Forum (ITF, 2021). Thus, analyzing the answers, it can be confirmed that one of the paths to solutions is the encouragement of micro-mobility and active mobility, these being green options that seek to shift the focus away from the private vehicle as the main modal.

Regarding noise (I-3), it is worth noting its relationship with the congestion (I-13) present in both countries, which is in line with the discussions proposed by Muzet (2007). A study carried out by Zannin et al. (2013) presented as a result the verification of the nuisance caused by noise pollution in the Polytechnic Center of the Federal University of Parana (Brazil), this being the greatest nuisance reported by research participants. Besides, as highlighted by Tao et al. (2020), the effect of noise exposure raises stress levels. Thus, health impact assessments are important. This aspect can be related to the significance of the indicator 'physical integrity' (I-35).

It is worth mentioning that within the 5H model, the model adopted for the analysis and proposals in this paper, sustainability is seen as a background for the actions of the other actors. In general, this was verified in the analyses of the CSFs since, although, without high correlation among indicators, the eco-sustainability indicators present relevant significance to the other categories. That said, in some cases of analyses, such indicators will not be highlighted for discussions.

The role of efficiency regarding mobility involves developing solutions with accessibility based on the optimization of resources' use, considering environmental issues, traffic conditions, geographical particularities, users' needs, quality of services, travel time, and infrastructure, all of which are based on integrative governance. This is aligned with Neirotti et al. (2014), ITF (2021), and Paiva et al. (2021).

It is worth highlighting the 'coverage' (I-6) with a greater significance with infrastructure (I-9) and frequency (I-12) for the UPS respondents, while for the UFLA respondents, the correlations with comfort (I-10) and real-time data about the mobility system (I-15) stand out. As for equity, both cases emphasize travel time (I-23) and present the same correlation with affordability (I-19). Moreover, the respondents from Brazil highlight an important relationship between coverage and social exclusion (I-22).

As highlighted by Leurent and Li (2020), mobility demand is related to geographical issues (distance between origin and destination) and consequently to the number of trips to reach the destination and behavioral patterns (choices). In other words, the coverage factor must be based on demand (particularities of use). Thus, planning policies must be tailored to the demand to connect campuses to residential, work, and leisure areas, providing coverage that impacts comfort and safety. The UPS region (including Paris) has a transport network that helps in coverage and also has a multimodal infrastructure (RER, buses, shuttles, trains, etc.), so it is an already known value that generates comfort; in the UFLA context, coverage is an aspect that needs to be developed along with adequate infrastructure (stops, stations, modals, etc.). By analyzing the correlation of coverage with the multimodality (I-25), it is possible to affirm that distance influences the modal choice among universities' mobility users, as highlighted by Vich et al. (2020).

The coverage aspects were highlighted by the questionnaire respondents from UFLA and UPS: "internal transportation traveled all the campus and not only the central area" (UFLA respondent), "topography of the campus" (UFLA respondent), and "night bus (or other) lines" (UPS respondent).

Hygiene and cleanliness can be highlighted as important aspects to maintain the safety of people with special needs (I-21); too much trash on the floor is dangerous for people with vision restrictions, wheelchair users, the elderly, and other limited personal mobility generating more access difficulties. In the same sense, we highlight the importance of these factors to maintain the safety of people who choose active mobility also for different reasons of safety on the way and health (for example, bushes and garbage can attract animals). Thus, hygiene and cleanliness are important conditions to be included in structure decisions (I-34) to maintain the safety of users.

Infrastructure (I-9) is highly correlated with efficiency and is fully related to equity. Both for UPS and UFLA, there is a strong relationship with travel time (I-23). In general terms, it can be said that the infrastructure is one of the main aspects to promote equity in the mobility system. To do so, it must be developed including multimodality options (I-25), including micro-mobility (I-26) and active mobility (I-27), besides using ICTs to develop customizable applications (I-29) that also include integrated payment services (I-30). The infrastructure benefits the users' sense of security, decreasing the risk of accidents (I-31), robberies (I-33), supporting the feeling of guaranteed physical integrity (I-35).

Concerning comfort, a general analysis of the correlations is appropriate (considering strong correlations, i.e., those with significance >0.3). For UFLA respondents, comfort refers to attention to reducing air pollution, network coverage, frequency, governance, transparency and responsibility, resilience, actions to avoid social exclusion, travel time, and customizable applications. For UPS respondents, comfort comes from perceived hygiene and cleanliness, infrastructure, real-time information on services, frequency, governance, management of the transportation system, resilience, reliable system (punctual and flawless), actions to avoid social exclusion, travel time, customizable applications, integrated services, and all indicators from safety. This is congruent with the discussions of Leurent and Li (2020) that present the relationship of modal choice with convenience/comfort. Moreover, such discussions are aligned with the work of Shannon et al. (2006). The authors highlight barriers and motivating aspects for changing user behavior. The barriers are time, distance, frequency of public transportation, while the motivating factors are: saving money (monthly expenses), the possibility of improving health, contributing to improvements in air pollution, and the consequent no need to look for parking.

In terms of equity, frequency for the UPS respondents is a source of improvement in travel time (I-23), while for the UFLA respondents, it is more correlated with ease of access (I-24). As for safety, comparing the answers from both contexts, it can be concluded that the better the frequency, the less time spent at the stops/stations, the less susceptible the users are to the risk of robbery. In other words, frequency is not a CSF; besides counting on the frequency of transportation, it is necessary that the mobility system is easily accessible, reaches users in urban and peri-urban areas (coverage), and, therefore, needs to have adequate infrastructure. As a direct consequence, frequency impacts travel time, comfort, and safety of users.

Regarding congestion (I-13), as Crozet (2020) discussed, one of the main actions is to reduce the prioritization of individual vehicles. The author still brings the questioning: “Is it possible to cut down traffic by leveraging new technologies and promoting shared mobility?” (p. 06). According to UPS responses, it can be stated that yes, applications with real-time information about traffic conditions and mobility services (I-11 and I-15) and sharing culture (I-28) are important to improve congestion problems. Such an interpretation cannot be made from the UFLA responses. This discussion is aligned with the insights of

Mohamed et al. (2019). It is important to consider the differences of the two contexts to make a a more detailed analysis of CSF congestion.

In general, it can be said that the more frequent, more integrated in multimodal terms, with greater coverage and with better real-time information is the mobility system considering public transport, the better it is for the personal organization of commuting times and, consequently, congestion levels can be reduced. As a result, besides the time issue, congestion care also impacts noise and air pollution (Crozet, 2020). Considering economists' visions, Kilani, Diop, and De Wolf (2022, p. 09) highlight that road pricing "is the most efficient tool to reduce congestion and emissions to their efficiency level".

According to Toledo and La Rovere (2018), transparency in municipal mobility systems is especially related to the quantification of public transport costs and can foster innovative solutions. In the present research, considering the answers of the campuses selected for study, transparency, and responsibility in mobility actions (I-16) are related (moderate correlations) to programs for pollutant emission reduction (I-2), comfort (I-10), governance (I-14), attention to the different special needs of users (I-21), avoid social exclusion (I-22), travel time (I-23), ease of access (I-24), micro-mobility (I-26), applications with integrated services (I-30), accident prevention (I-31), and protection of physical integrity (I-35). Looking specifically at UFLA's responses, the presence of the highest amount of moderate correlation, it can be highlighted that transparency and responsibility are key to promoting equity.

Resilience (I-17) is a multifaceted concept that demands proactive and reactive measures in action projects. A central measure is the implementation of communication plans between operators and users so that possible disruptions are known, and then adjustments can be made by both operators and users (Svenson et al., 2021). For Azolin, Silva, and Pinto (2020, p. 14), "the overall indicator of resilience is the share of trips that can be maintained on or transferred to active modes plus the share of trips that can be maintained on or transferred to the operational public transport routes in each scenario". Accordingly, the authors discuss that transportation policies aimed at improving resilience should focus on infrastructure, resulting in better operational performance. In addition, it is also important to consider active modes of transportation since there is no risk regarding fuel dependency; equity, avoiding social exclusion; the spatial distribution of trips, which highlights that the location of origin and destination points has an impact on measures for resilience. Considering such theoretical propositions, it can be verified an alignment with the correlations of the results of the case studies. Besides, it should be mentioned that the responsibility for making a system resilient lies with different actors, i.e., there is a need to act collaboratively (Svenson et al., 2021). Such an idea can be verified with the significant correlations with the inclusion of citizens in discussions about mobility (I-20).

Unlike what was proposed by Azolin, Silva, and Pinto (2020), this research does not show the relationship of spatial distribution (territorial range of origins and destinations) with resilient travel, which is explained, for example, with larger territoriality with a consequent more unequal distribution of resilience. Bringing such discussion to the relationship with the indicator 'coverage' (I-6), the answers of UPS, being the campus with a greater range of origins and destinations, there is less significance than in the UFLA context.

Reliability (I-18) in mobility services significantly impacts users' perceptions of both the quality and utility of public service compared to other modal options. Consequently, this implies the use of multimodal arrangements (Achar, Bharathi, Kumar, Vanajakshi, 2020). The responses of the case studies are congruent with such theoretical discussions.

The attention to accessibility adds new analysis to sustainability issues (Crozet, 2020). This leads to the need to consider the analysis of potential users in order to really adopt project proposals. To this end, it is essential to propose actions with social benefits. In this sense, attention is given to the supply of services and solutions that provide equal opportunities and guarantee support to improve users' quality of life (Paiva et al., 2021).

In terms of affordability (I-19), it can be interpreted how pricing issues, considering users' monthly expenses, should be analyzed in the context of mobility: it is necessary to consider greener routes and modals that do not overcharge the already existing expenses, and these modals should be included in the multimodal structure; it is expected that the expenses with transportation and mobility are reverted in actions that promote a resilient system facing possible problems; the sharing systems should be accessible in economic terms; applications with integrated payment systems can favor the price analysis, grounding the choice of modals; monthly expenses and special needs should be analyzed together so as not to generate social exclusion. Such analyses are aligned with the vision of accessibility discussed by Crozet (2020).

One of the pillars of RI is the integration of voices. Stakeholders should be seen as co-creative partners (Axelsson & Granath, 2018). The proposal of co-creating solutions is a key element in the definitions of better proposals, as emphasized by the focus group participants. In the absence of such integration, there is a risk that discrepancies between actors' perceptions will undermine the desired results for developing smart and sustainable frameworks (Vidiasova & Cronemberger, 2020). According to the statistical results of the questionnaires, highlighting the correlations, the inclusion of citizens in decisions (I-20) may benefit projects with transparency and responsibility (I-16) related to "greener" routes and modals (I-1), projects with EVs (I-3), improvement and adequacy of infrastructure (I-9), offer solutions for users' comfort (I-10), multimodal system (I-25), shared mobility (I-28), projects for accident prevention (I-31), security against assaults (I-33), fair access for users with different needs (prices, boarding priority, priority in seats, physical structure, etc.) (I-21), thus avoiding social exclusion (I-22).

The attention to the different needs of users should be included in the proposals that seek to promote flexibility in the mobility system. According to Machado et al. (2021), equity is strongly associated with the sharing of urban space by different user profiles, directly impacting accessibility. In line with the authors, there is a strong correlation presented in both contexts regarding the attention to special needs (I-21). Besides, according to the results, there is a relationship between accessibility and modal options. Therefore, it is important to consider that smart and sustainable definitions without the apparatus of social analysis will not solve problems and may even generate new ones (Groth, 2019).

Actions to avoid social exclusion should also include attention to infrastructure conditions (I-9), prices (I-19), travel time (I-23), ease of access and use (I-24), shared mobility (I-28), protection against accidents (I-31), and against assaults (I-33). For UPS respondents, a multimodal system that includes active mobility (I-27) and micro-mobility (I-26) is important for avoiding social exclusion. However, no significance occurs with active mobility in the UFLA context.

In addition to being an aspect included in equity, since it is impacted by social differences, time management, such an important factor for users in the university context, is also an aspect of transportation system efficiency (Mohamed et al., 2019). This fact can also be verified in this research by analyzing that travel time (I-23) has significance with all efficiency indicators.

In both UFLA and UPS contexts, there is a strong correlation with real-time information from mobility services (I-11) and customizable applications (I-29) and with integrated services (I-30). Thus, the central role of information for users' time management and modal choice is highlighted.

At UFLA, in terms of modals, the following were mentioned: bus (private operator), internal bus, individual car, ride, bike, and walk. The RER, bus, ride, apps, bike, walk, train, metro, and tram were mentioned in the UPS context. This means that the mobility structure brings differences regarding the various aspects of mobility. The definition of a multimodal system is directly related to the coverage of the mobility system and the users' choice based on objective and subjective considerations (Rérat, 2021). Mehdizadeh, Zavareh, and Nordfjaern (2019) state that modal choices are based on age, place of residence (proximity to the campus), cost and travel time, access to public transportation, facilities for active mobility, climate/weather conditions, ownership of vehicle and driver's license, and other individual aspects.

Considering the parameters set for analysis (significance at the 1% level), a multimodal system can positively impact all indicators, except the issue of pollutants, in the view of UPS respondents. As for the UFLA respondents, there is significance with all indicators of eco-sustainability and flexibility; as for safety, only physical integrity (I-35); in the equity category, there is no with ease of access (I-24); as for efficiency, there is no with parking (I-7), hygiene and cleanliness (I-8) and frequency (I-12).

Besides the CSFs analyzed, it is worth considering the relevant significance of the correlation with customizable applications (I-29). As Neirotti et al. (2014) discussed, it is important to improve real-time information services as well, enabling the selection and organization of routes and modes, improving travel expectations by allowing users to consider the modal options and choose the one that meets their needs.

So, in short, it can be said that a multimodal system can help a responsible mobility system. However, further infrastructure analysis is needed in addition to modal analysis, including micro-mobility and active mobility. In order to become attractive, about micro-mobility (I-26), it is necessary for UPS respondents to also address attention to the development of a reliable system (I-18). For the UFLA respondents, there was a significant correlation with pollutant reduction programs (I-2) and coverage (I-6). Active mobility (I-27) and accident prevention (I-31) stand out in both contexts. Regarding equity, besides the indicators already previously discussed, the micro-mobility is highlighted both in the context of UPS and UFLA with significant correlation with the attention to the special needs of users (I-21).

Such observations can be considered aligned with Abduljabbar, Liyanage, and Dia's (2021) discussions. According to the authors, the modes of micro-mobility present more efficiency, which can be a consequence of the improvement in congestion levels (with significance for the UFLA context, but it is not the most relevant; as for the UPS, there was low significance); and can contribute to reducing the negative impact on air pollution (at this point the electric modes are considered). In addition, there is a contribution to social inequality issues. However, these benefits result from an integration of these modes considering a holistic vision.

Dehghanmongabadi and Hoşkara (2018), in their study at the Eastern Mediterranean University (EMU) campus, highlighted that, in general, safety and infrastructure are barriers to active modal use. In Cadurin and Silva's (2017) study at the São Carlos campus of the University of São Paulo, topography, considering the physical effort, is a barrier to the use of conventional bicycles. For Mesquita et al. (2020), factors that need to be well analyzed to provide attractiveness are: physical structures, traffic direction, ramps, road dimensions, and specific laws for motorized vehicles (such as speed).

Regarding the flexibility category, it is worth noting that the correlation with the time used to make the origin-destination trajectory (I-23) was highlighted for all indicators. Such analysis is reinforced by the studies of Jokinen, Sihvola, and Mladenovic (2017) and Inturri et al. (2019). Moreover, according to UPS respondents, customizable applications (I-29) are important tools. Such highlights are aligned with the discussions proposed by Machado et al. (2018).

In line with Silva and Silva's (2020) discussions, safety is addressed in this article as related to the perception of violent occurrences, such as thefts and harassment, in public spaces. During the French focus group, personal safety and safety perception were highlighted as important factors. According to Silva and Silva (2020, p. 3), "the relationship between violence and choice of transportation, especially non-motorized modes, exists and is relevant". This fact is verified in the answers of the users of the UPS mobility system (I-27). However, in the UFLA context, there was only significance specifically concerning infrastructure. This can be explained by the restriction of modal options in this context.

Montgomery and Roberts (2008) also recognized the safety relationship with night-time conditions, especially for children, the elderly, and women. This can be verified with the significant correlations of all safety indicators with special needs (I-21), including gender. In addition to the lighting concern, Silva and Silva (2020) also considered the university campuses and identified the lack of surveillance equipment. However, in the UPS context, respondents argued that security through cameras is not necessary.

5 Final Considerations

This paper aimed to discuss the CSFs for the definition of a RMS considering an assessment framework composed of indicators proposed by Souza et al. (Paper 3). The premises of the RI and 5H, the context (context-sensitive), the stakeholders' perspectives, and the users' points of views were considered as central aspects.

From the discussions occurred on the two groups (one from France and one from Brazil), it was observed that coordination, although a challenge, is key to unlocking the potential of solutions and avoiding negative effects. Besides, the questionnaires sent to mobility system users from the universities' campuses highlighted how the indicators can be seen as CSFs and how critical they are. The results align with the smart mobility attributes proposed by Paiva et al. (2021): flexibility, efficiency, integration, sustainability, security and safety, social benefits, connectivity, accessibility, and user experience. However, this work goes beyond entailing and emphasizing sustainable aspects.

Considering a human-centered approach, which places accessibility as a transversal factor to all CSFs, such perspectives and discussions are opportunities for authorities to understand in a more detailed way the perceptions of use in the mobility system, the preferences, the adopted practices, the expectations, as well as to obtain insights that can be translated into actions for the development of the campuses. Combined with a deeper analysis of other governance and institutional relations issues, the results highlighted in this paper can support planning and political efforts based on aligned goals and collective actions to support value creation and delivery for the users.

It is worth noting that, even as a limitation due to the methodological proposal selected, cases on university campuses highlight important social, environmental, institutional, behavioral, and structural aspects. Moreover, such CSFs represented as indicators can guide discussions in broader contexts, such as cities. In this sense, future research may seek to delve deeper into a methodological way to create a tool that facilitates the collection and organization of indicators. Furthermore, as practical endeavors, such research can be replicated in other community contexts and university campuses in other countries and/or regions.

This study has a limitation in terms of correlation analysis. The statistically significant correlations were considered, but given their great significance, in order to deepen the analysis and discussion, those considered weak, moderate, and strong were discussed. However, the fact of being defined as correlation does not imply causality, and, in this sense, it is suggested that future studies identify and focus on measuring the causes of the correlations.

Further studies can also take an in-depth look at how demographic issues can impact user perceptions and behaviors. Besides, research gaps can be found throughout the discussion. Many aspects can be better understood with more specific and detailed analyses, enriching both the theoretical and practical fields that permeate the themes.

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Appendix 1:

Mobility and transportation system

Do you agree to participate in this research? *
( ) Yes
( ) No

Demographics' data
How do you identify yourself?
( ) Man
( ) Female
( ) Other
( ) I prefer not to answer

What is your age?
( ) Under 20 years old
( ) 21 - 35 years old
( ) 36 - 50 years old
( ) Over 50 years old

What is your current position at the University?
( ) Undergraduate student
( ) Post-graduate student
( ) Former student (up to 2 years after graduation)
( ) Professor
( ) Researcher
( ) Administrative staff
( ) Staff of other areas
( ) Employee of a company located on the Paris-Saclay campus
( ) Frequent Visitor

What is your monthly income? (2021 values)
( ) No income
( ) Up to 1 minimum wage
( ) From 1 to 3 minimum wages
( ) From 3 to 5 minimum wages
( ) More than 5 salaries
( ) I prefer not to answer

How many modals (means of transport) do you use to get to Paris-Saclay from your home? (walking can be considered if it takes more than 15 minutes). *

( ) 1
( ) 2
( ) 3
( ) More than 3

What means of transportation do you use the most to go to the University? Please list up to 3.

Questions
This questionnaire is made up of statements. Thus, you only need to read and give your opinion based on the scale of agreement (strongly disagree to strongly agree).

To facilitate your understanding, here is a simple glossary with key terms used in this questionnaire:
- Modal/modalities: means of transportation used to go from one point to another.
- Multimodal system: a mobility system configuration that relies on more than one modal (mode of transportation), integrating and combining them into solutions focused on agility and efficiency for trips.

There are no right answers. Please choose the options that match your personal opinion.

"In my opinion, it is essential that [the university]:"

In this step the statements will be presented along with the answer options.
Each statement is referring to your opinion regarding the essential factors for the mobility and transportation system on the University campus.

The statements follow the basic orientation "In my opinion, it is essential that the University..." following the idea that the University can act with direct actions or influence third party actions (companies, urban planning, etc.).
Furthermore, it should be noted that the statements come from actions found in the literature. Thus, some solutions may already exist on the Paris-Saclay campus, while others may be seen as interesting to be analyzed for implementation.

QUESTIONS	**Cod.**
... have projects that encourage the use of "greener" routes and modals (examples: discounts in services [e.g. restaurant] for bicycle and car sharing users, etc.).	I-1
... have programs focused on reducing pollutants from mobility.	I-2
... have programs focused on reducing the noise coming from the mobility system.	I-3
... offer conditions for the use of electric vehicles, such as cars, motorcycles, bikes, scooters, etc.	I-4
... encourage the use of modals that do NOT use fuels such as alcohol, gasoline, and diesel.	I-5

... offer different transportation options based on origins and destinations with a focus on improving the coverage of the mobility system (modals, schedules, lines, etc.).	I-6
... have parking facilities (spaces, infrastructure) that meet the needs of the users.	I-7
... be attentive to the cleanliness and hygiene of the means of transport, including vehicles, stations, stops, etc.	I-8
... be committed to improving and adapting the mobility infrastructure (stations, public lighting, independent traffic lines, pavement conditions, etc.).	I-9
... be aware of the comfort (standing and seating capacity, seats, etc.) offered to users in the modals.	I-10
... provide real-time service; for example, information at stations, in vehicles, and on-line about schedules, waiting times, routes, traffic alerts, etc.	I-11
... have a mobility system that is reliable in terms of frequency (timetables) of public transport.	I-12
... have a mobility structure that minimizes congestion (e.g. focus on sharing principles, alternate-day travel, lines dedicated solely to cars, freight or buses, etc.).	I-13
... have strategic information about the mobility system and is able to plan the necessary changes (infrastructure and services) in the medium and long term.	I-14
... have real-time data about the mobility system, such as traffic, speed, road signs, lanes, congestion, accidents, breakdowns, etc.	I-15
... be transparent and responsible about decisions regarding mobility system resources.	I-16
... have a mobility system that is able to continue functioning even with possible transportation-related problems or occurrences (examples: floods, accidents, road construction, etc.).	I-17
... have a transportation system that is on-time and without breakdowns.	I-18
... consider in its planning the attention to the price of modals considering the individual income of the users.	I-19
... include citizens/individuals from the community in discussions and decisions about the mobility system.	I-20
... have programs to promote fair access (pricing, boarding priority, seating priority, physical structure, etc.) for users with different needs (physical, gender, elderly, pregnant women, people with babies, etc.).	I-21
... promote social equity to avoid social exclusion within the mobility system.	I-22
... offer boarding/drop-off points that reduce the travel time of users.	I-23
... have a mobility system that can be easily used and accessed (in physical terms) by anyone.	I-24
... have a multimodal mobility system that allows having physical connectivity to more than one alternative (bike, bus, on-demand, metro, etc).	I-25
... offer a structure that enables micro mobility (bicycles, scooters, skateboards, tricycles, etc., which can be electric or not).	I-26
... provide structure for the use of active mobility options such as bike lanes, walking paths, etc.	I-27
... facilitate shared mobility, whether by rides, transportation by apps, shared bikes, among others.	I-28

... offer user-friendly, customizable tools and applications for my transportation needs.	I-29
... offer integrated services (applications) for both the planning of trips and the paying of the tickets.	I-30
... have programs for traffic accident prevention (vehicles, pedestrians, motorcyclists, cyclists, etc.).	I-31
... act to protect the personal data entered in the mobility system applications.	I-32
... have programs to prevent robberies/thefts on the mobility system.	I-33
... have a safe mobility infrastructure for users, with adequate lighting, road signs, video surveillance/security cameras, etc.	I-34
... be concerned with the personal physical integrity of the users of the mobility system.	I-35

Do you have any additional points/opinions that you would like to highlight, complement, or suggest?

Appendix 2

Descriptive analysis
Brazil

How do you identify yourself?

		Frequency	Percentage	Valid percent	Cumulative percentage
Valid	Woman	150	59,1	59,1	59,1
	Man	101	39,8	39,8	98,8
	Other	3	1,2	1,2	100,0
	Total	254	100,0	100,0	

What is your age?

		Frequency	Percentage	Valid percent	Cumulative percentage
Valid	Under 20 years old	15	5,9	5,9	5,9
	21 - 35 years old	188	74,0	74,0	79,9
	36 - 50 years old	41	16,1	16,1	96,1
	Over 50 years old	10	3,9	3,9	100,0
	Total	254	100,0	100,0	

What is your current position at the University?

		Frequency	Percentage	Valid percent	Cumulative percentage
Valid	Undergraduate student	60	23,6	23,6	23,6
	Post-graduate student	129	50,8	50,8	74,4
	Former student (up to 2 years after graduation)	11	4,3	4,3	78,7
	Professor	31	12,2	12,2	90,9
	Researcher	4	1,6	1,6	92,5
	Administrative staff	9	3,5	3,5	96,1
	Staff of other areas	3	1,2	1,2	97,2
	Employee of a company located on the University campus	2	,8	,8	98,0
	Frequent Visitor	5	2,0	2,0	100,0
	Total	254	100,0	100,0	

What is your monthly income? (2021 values)

		Frequency	Percentage	Valid percent	Cumulative percentage
Valid	No income	25	9,8	10,3	10,3
	Up to 1 minimum wage (up until R$ 1.100,00).	23	9,1	9,5	19,8

	From 1 to 3 minimum wages (up to R$ 1.101,00 to R$ 3.300,00).	131	51,6	53,9	73,7
	From 3 to 5 minimum wages (up to R$ 3.301,00 to R$ 5.500,00).	24	9,4	9,9	83,5
	More than 5 salaries (more than R$ 5.501,00)	40	15,7	16,5	100,0
	Total	243	95,7	100,0	
Absent	System	11	4,3		
Total		254	100,0		

How many modals (means of transport) do you use to get to Paris-Saclay from your home? (walking can be considered if it takes more than 15 minutes). *

		Frequency	Percentage	Valid percent	Cumulative percentage
Valid	Only one	164	64,6	64,6	64,6
	Two modals	78	30,7	30,7	95,3
	Three modes	10	3,9	3,9	99,2
	More than 3	2	,8	,8	100,0
	Total	254	100,0	100,0	

Appendix 3
Correlation – Brazil

	Eco-sustainability					Efficiency												
Correlação de Pearson	I-01	I-02	I-03	I-04	I-05	I-06	I-07	I-08	I-09	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18
I-01	1,000	,271**	,289**	,428**	,384**	,265**	,087	,071	,117	,224**	,241**	,061	,174**	,150*	,257**	,254**	,276**	,150*
I-02	,271**	1,000	,347**	,159*	,393**	,221**	,119	,071	,243**	,303**	,223**	,137*	,203**	,220**	,375**	,356**	,243**	,160*
I-03	,289**	,347**	1,000	,073	,175**	,148*	,104	,192**	,222**	,198**	,151*	,105	,263**	,211**	,188**	,207**	,258**	,263**
I-04	,428**	,159*	,073	1,000	,389**	,341**	,028	,082	,053	,267**	,172**	,037	,158*	,109	,170**	,170**	,224**	,124
I-05	,384**	,393**	,175**	,389**	1,000	,254**	,093	,087	,145*	,249**	,125*	,078	,118	,106	,222**	,185**	,260**	,079
I-06	,265**	,221**	,148*	,341**	,254**	1,000	,279**	,186**	,179**	,395**	,260**	,297**	,175**	,244**	,360**	,223**	,357**	,230**
I-07	,087	,119	,104	,028	,093	,279**	1,000	,245**	,250**	,178**	,069	,108	,117	,304**	,099	,158*	,181**	,033
I-08	,071	,071	,192**	,082	,087	,186**	,245**	1,000	,363**	,214**	,065	,304**	,294**	,262**	,131*	,124*	,208**	,158*
I-09	,117	,243**	,222**	,053	,145*	,179**	,250**	,363**	1,000	,281**	,154*	,371**	,190**	,432**	,209**	,204**	,301**	,185**
I-10	,224**	,303**	,198**	,267**	,249**	,395**	,178**	,214**	,281**	1,000	,175**	,309**	,286**	,333**	,197**	,412**	,370**	,241**
I-11	,241**	,223**	,151*	,172**	,125*	,260**	,069	,065	,154*	,175**	1,000	,090	,226**	,262**	,406**	,176**	,273**	,241**
I-12	,061	,137*	,105	,037	,078	,297**	,108	,304**	,371**	,309**	,090	1,000	,105	,303**	,086	,109	,246**	,234**
I-13	,174**	,203**	,263**	,158*	,118	,175**	,117	,294**	,190**	,286**	,226**	,105	1,000	,352**	,203**	,149*	,264**	,108
I-14	,150*	,220**	,211**	,109	,106	,244**	,304**	,262**	,432**	,333**	,262**	,303**	,352**	1,000	,221**	,357**	,313**	,180**
I-15	,257**	,375**	,188**	,170**	,222**	,360**	,099	,131*	,209**	,197**	,406**	,086	,203**	,221**	1,000	,250**	,368**	,310**
I-16	,254**	,356**	,207**	,170**	,185**	,223**	,158*	,124*	,204**	,412**	,176**	,109	,149*	,357**	,250**	1,000	,283**	,153*
I-17	,276**	,243**	,258**	,224**	,260**	,357**	,181**	,208**	,301**	,370**	,273**	,246**	,264**	,313**	,368**	,283**	1,000	,499**
I-18	,150*	,160*	,263**	,124	,079	,230**	,033	,158*	,185**	,241**	,241**	,234**	,108	,180**	,310**	,153*	,499**	1,000
I-19	,220**	,187**	,166**	,188**	,097	,221**	,176**	,239**	,178**	,226**	,221**	,157*	,247**	,256**	,285**	,245**	,299**	,175**
I-20	,333**	,274**	,260**	,264**	,239**	,187**	,133*	,141*	,279**	,298**	,181**	,143*	,186**	,238**	,222**	,239**	,249**	,186**
I-21	,334**	,296**	,205**	,250**	,176**	,218**	,103	,278**	,204**	,245**	,214**	,116	,267**	,245**	,291**	,314**	,285**	,210**
I-22	,344**	,390**	,152*	,268**	,220**	,265**	,142*	,145*	,206**	,343**	,216**	,093	,137*	,169**	,249**	,341**	,333**	,281**
I-23	,261**	,252**	,060	,240**	,210**	,257**	,234**	,205**	,220**	,346**	,369**	,178**	,262**	,346**	,205**	,311**	,334**	,213**
I-24	,179**	,283**	,159*	,134*	,198**	,219**	,129*	,169**	,194**	,264**	,040	,203**	,092	,230**	,167**	,354**	,260**	,284**
I-25	,292**	,235**	,204**	,224**	,287**	,313**	,089	,144*	,184**	,265**	,274**	,072	,189**	,172**	,275**	,239**	,294**	,245**
I-26	,242**	,351**	,175**	,270**	,237**	,324**	,082	,150*	,207**	,216**	,188**	,140*	,290**	,213**	,259**	,201**	,232**	,194**
I-27	,274**	,253**	,141*	,155*	,188**	,152*	,128*	,174**	,131*	,215**	,214**	,091	,209**	,241**	,183**	,221**	,163**	,160*
I-28	,221**	,205**	,076	,279**	,358**	,123	,073	,112	,131*	,275**	,346**	,052	,283**	,215**	,132*	,246**	,219**	,064
I-29	,307**	,219**	,221**	,199**	,246**	,366**	,173**	,183**	,214**	,302**	,350**	,113	,236**	,263**	,410**	,195**	,374**	,326**
I-30	,385**	,302**	,179**	,329**	,291**	,290**	,099	,097	,268**	,296**	,340**	,196**	,210**	,295**	,436**	,321**	,330**	,277**
I-31	,273**	,357**	,189**	,182**	,267**	,154*	,035	,123*	,289**	,210**	,228**	,161*	,106	,271**	,239**	,311**	,227**	,103
I-32	,225**	,245**	,148*	,151*	,215**	,188**	,097	,195**	,145*	,247**	,131*	,222**	,141*	,235**	,225**	,297**	,198**	,200**
I-33	,171**	,321**	,119	,174**	,135*	,189**	-,021	,062	,251**	,219**	,268**	,218**	,101	,204**	,364**	,270**	,201**	,189**
I-34	,175**	,238**	,081	,124*	,184**	,114	,104	,381**	,514**	,242**	,217**	,319**	,139*	,253**	,115	,281**	,197**	,087
I-35	,237**	,231**	,183**	,233**	,196**	,194**	,061	,152*	,182**	,292**	,240**	,237**	,209**	,364**	,199**	,316**	,310**	,219**

	Equity						Flexibility						Safety				
Correlação de Pearson	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30	I-31	I-32	I-33	I-34	I-35
I-01	,220**	,333**	,334**	,344**	,261**	,179**	,292**	,242**	,274**	,221**	,307**	,385**	,273**	,225**	,171**	,175**	,237**
I-02	,187**	,274**	,296**	,390**	,252**	,283**	,235**	,351**	,253**	,205**	,219**	,302**	,357**	,245**	,321**	,238**	,231**
I-03	,166**	,260**	,205**	,152*	,060	,159*	,204**	,175**	,141*	,076	,221**	,179**	,189**	,148*	,119	,081	,183**
I-04	,188**	,264**	,250**	,268**	,240**	,134*	,224**	,270**	,155*	,279**	,199**	,329**	,182**	,151*	,174**	,124*	,233**
I-05	,097	,239**	,176**	,220**	,210**	,198**	,287**	,237**	,188**	,358**	,246**	,291**	,267**	,215**	,135*	,184**	,196**
I-06	,221**	,187**	,218**	,265**	,257**	,219**	,313**	,324**	,152*	,123	,366**	,290**	,154*	,188**	,189**	,114	,194**
I-07	,176**	,133*	,103	,142*	,234**	,129*	,089	,082	,128*	,073	,173**	,099	,035	,097	-,021	,104	,061
I-08	,239**	,141*	,278**	,145*	,205**	,169**	,144*	,150*	,174**	,112	,183**	,097	,123*	,195**	,062	,381**	,152*
I-09	,178**	,279**	,204**	,206**	,220**	,194**	,184**	,207**	,131*	,131*	,214**	,268**	,289**	,145*	,251**	,514**	,182**
I-10	,226**	,298**	,245**	,343**	,346**	,264**	,265**	,216**	,215**	,275**	,302**	,296**	,210**	,247**	,219**	,242**	,292**
I-11	,221**	,181**	,214**	,216**	,369**	,040	,274**	,188**	,214**	,346**	,350**	,340**	,228**	,131*	,268**	,217**	,240**
I-12	,157*	,143*	,116	,093	,178**	,203**	,072	,140*	,091	,052	,113	,196**	,161*	,222**	,218**	,319**	,237**
I-13	,247**	,186**	,267**	,137*	,262**	,092	,189**	,290**	,209**	,283**	,236**	,210**	,106	,141*	,101	,139*	,209**
I-14	,256**	,238**	,245**	,169**	,346**	,230**	,172**	,213**	,241**	,215**	,263**	,295**	,271**	,235**	,204**	,253**	,364**
I-15	,285**	,222**	,291**	,249**	,205**	,167**	,275**	,259**	,183**	,132*	,410**	,436**	,239**	,225**	,364**	,115	,199**
I-16	,245**	,239**	,314**	,341**	,311**	,354**	,239**	,201**	,221**	,246**	,195**	,321**	,311**	,297**	,270**	,281**	,316**
I-17	,299**	,249**	,285**	,333**	,334**	,260**	,294**	,232**	,163**	,219**	,374**	,330**	,227**	,198**	,201**	,197**	,310**
I-18	,175**	,186**	,210**	,281**	,213**	,284**	,245**	,194**	,160*	,064	,326**	,277**	,103	,200**	,189**	,087	,219**
I-19	1,000	,286**	,376**	,324**	,271**	,225**	,280**	,046	,125*	,128*	,286**	,318**	,157*	,123	,226**	,070	,172**
I-20	,286**	1,000	,317**	,252**	,233**	,163**	,264**	,196**	,120	,267**	,214**	,273**	,281**	,096	,298**	,214**	,290**
I-21	,376**	,317**	1,000	,489**	,308**	,299**	,285**	,306**	,224**	,182**	,289**	,406**	,400**	,169**	,280**	,184**	,247**
I-22	,324**	,252**	,489**	1,000	,360**	,443**	,265**	,217**	,108	,132*	,279**	,289**	,332**	,138*	,381**	,228**	,273**
I-23	,271**	,233**	,308**	,360**	1,000	,208**	,232**	,241**	,280**	,229**	,325**	,335**	,244**	,105	,194**	,255**	,305**
I-24	,225**	,163**	,299**	,443**	,208**	1,000	,131*	,214**	,145*	,160*	,132*	,245**	,306**	,175**	,268**	,315**	,343**
I-25	,280**	,264**	,285**	,265**	,232**	,131*	1,000	,382**	,197**	,303**	,368**	,252**	,152*	,107	,146*	,085	,170**
I-26	,046	,196**	,306**	,217**	,241**	,214**	,382**	1,000	,388**	,287**	,253**	,279**	,205**	,165**	,168**	,172**	,160*
I-27	,125*	,120	,224**	,108	,280**	,145*	,197**	,388**	1,000	,385**	,228**	,240**	,121	,121	,002	,188**	,051
I-28	,128*	,267**	,182**	,132*	,229**	,160*	,303**	,287**	,385**	1,000	,201**	,278**	,221**	,060	,203**	,275**	,282**
I-29	,286**	,214**	,289**	,279**	,325**	,132*	,368**	,253**	,228**	,201**	1,000	,516**	,225**	,203**	,318**	,198**	,322**
I-30	,318**	,273**	,406**	,289**	,335**	,245**	,252**	,279**	,240**	,278**	,516**	1,000	,348**	,228**	,445**	,244**	,454**
I-31	,157*	,281**	,400**	,332**	,244**	,306**	,152*	,205**	,121	,221**	,225**	,348**	1,000	,348**	,381**	,346**	,344**
I-32	,123	,096	,169**	,138*	,105	,175**	,107	,165**	,121	,060	,203**	,228**	,348**	1,000	,221**	,277**	,289**
I-33	,226**	,298**	,280**	,381**	,194**	,268**	,146*	,168**	,002	,203**	,318**	,445**	,381**	,221**	1,000	,305**	,491**
I-34	,070	,214**	,184**	,228**	,255**	,315**	,085	,172**	,188**	,275**	,198**	,244**	,346**	,277**	,305**	1,000	,321**
I-35	,172**	,290**	,247**	,273**	,305**	,343**	,170**	,160*	,051	,282**	,322**	,454**	,344**	,289**	,491**	,321**	1,000

Appendix 4

Descriptive analysis
France

How do you identify yourself?

		Frequency	Percentage	Valid percent	Cumulative percentage
Valid	Woman	100	31,8	31,8	31,8
	Man	205	65,3	65,3	97,1
	Did not opine	9	2,8	2,5	100,0
	Total	314	100,0	100,0	

What is your age?

		Frequency	Percentage	Valid percent	Cumulative percentage
Valid	Under 20 years old	58	18,5	18,5	18,5
	21 - 35 years old	188	59,9	59,9	78,3
	36 - 50 years old	34	10,8	10,8	89,2
	Over 50 years old	29	9,2	9,2	98,4
	Did not opine	5	1,6	1,6	100,0
	Total	314	100,0	100,0	

What is your current position at the University?

		Frequency	Percentage	Valid percent	Cumulative percentage
Valid	Undergraduate student	126	40,1	40,1	40,1
	Post-graduate student	90	28,7	28,7	68,8
	Former student (up to 2 years after graduation)	11	3,5	3,5	72,3
	Professor	28	8,9	8,9	81,2
	Researcher	13	4,1	4,1	85,4
	Administrative staff	26	8,3	8,3	93,6
	Staff of other areas	5	1,6	1,6	95,2
	Employee of a company located on the University campus	4	1,3	1,3	96,5
	Frequent Visitor	8	2,5	2,5	99,0
	Did not opine	3	,9	,9	100,0
	Total	314	100,0	100,0	

What is your monthly income? (2021 values)

		Frequency	Percentage	Valid percent	Cumulative percentage
Valid	No income	150	47,8	47,8	47,8
	Up to 1 minimum wage (up to 1554,58€ BRUT).	32	10,2	10,2	58,0
	From 1 to 3 minimum wages (up to 1554,58€ to 4663,74€ BRUT).	116	36,9	36,9	94,9
	From 3 to 5 minimum wages (up to 4663,75€ to 7772,90€ BRUT).	5	1,6	1,6	96,5
	More than 5 salaries (more than 7772,91€ BRUT)	2	,6	,6	97,1
	Did not opine	9	2,9	2,9	100,0
	Total	314	100,0	100,0	

How many modals (means of transport) do you use to get to Paris-Saclay from your home? (walking can be considered if it takes more than 15 minutes). *

		Frequency	Percentage	Valid percent	Cumulative percentage
Valid	Only one	133	42,4	42,4	42,4
	Two modals	74	23,6	23,6	65,9
	Three modes	84	26,8	26,8	92,7
	More than 3	22	7,0	7,0	99,7
	Did not opine	1	,3	,3	100,0
	Total	314	100,0	100,0	

Appendix 5
Correlation - France

	Eco-sustainability					Efficiency												
Correlação de Pearson	I-01	I-02	I-03	I-04	I-05	I-06	I-07	I-08	I-09	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18
I-01	1,000	,269**	,187**	,204**	,384**	,165**	-,019	,079	,057	,054	,092	,103	,233**	,179**	,141*	,114*	,089	,036
I-02	,269**	1,000	,199**	,449**	,512**	,121*	,131*	,095	,119*	,085	,069	,067	,178**	,169**	,142*	,200**	,133*	,020
I-03	,187**	,199**	1,000	,239**	,126*	,071	,221**	,104	,037	,184**	,143*	,106	,162**	,113	,215**	,123*	,145*	,149*
I-04	,204**	,449**	,239**	1,000	,369**	,272**	,166**	,186**	,241**	,281**	,076	,120*	,344**	,188**	,269**	,218**	,282**	,101
I-05	,384**	,512**	,126*	,369**	1,000	,192**	-,009	-,045	,067	,073	-,015	,038	,232**	,120*	,035	,223**	,019	-,032
I-06	,165**	,121*	,071	,272**	,192**	1,000	,188**	,154**	,268**	,186**	,170**	,247**	,188**	,229**	,240**	,096	,151**	,172**
I-07	-,019	,131*	,221**	,166**	-,009	,188**	1,000	,332**	,259**	,273**	,184**	,252**	,118*	,139*	,181**	,149**	,303**	,391**
I-08	,079	,095	,104	,186**	-,045	,154**	,332**	1,000	,399**	,464**	,407**	,223**	,223**	,374**	,399**	,235**	,394**	,383**
I-09	,057	,119*	,037	,241**	,067	,268**	,259**	,399**	1,000	,428**	,289**	,324**	,295**	,438**	,381**	,281**	,308**	,282**
I-10	,054	,085	,184**	,281**	,073	,186**	,273**	,464**	,428**	1,000	,373**	,303**	,286**	,425**	,391**	,230**	,375**	,339**
I-11	,092	,069	,143*	,076	-,015	,170**	,184**	,407**	,289**	,373**	1,000	,290**	,313**	,340**	,593**	,207**	,381**	,386**
I-12	,103	,067	,106	,120*	,038	,247**	,252**	,223**	,324**	,303**	,290**	1,000	,256**	,334**	,330**	,105	,340**	,418**
I-13	,233**	,178**	,162**	,344**	,232**	,188**	,118*	,223**	,295**	,286**	,313**	,256**	1,000	,305**	,317**	,265**	,310**	,227**
I-14	,179**	,169**	,113	,188**	,120*	,229**	,139*	,374**	,438**	,425**	,340**	,334**	,305**	1,000	,481**	,262**	,371**	,326**
I-15	,141*	,142*	,215**	,269**	,035	,240**	,181**	,399**	,381**	,391**	,593**	,330**	,317**	,481**	1,000	,265**	,331**	,394**
I-16	,114*	,200**	,123*	,218**	,223**	,096	,149**	,235**	,281**	,230**	,207**	,105	,265**	,262**	,265**	1,000	,214**	,089
I-17	,089	,133*	,145*	,282**	,019	,151**	,303**	,394**	,308**	,375**	,381**	,340**	,310**	,371**	,331**	,214**	1,000	,417**
I-18	,036	,020	,149*	,101	-,032	,172**	,391**	,383**	,282**	,339**	,386**	,418**	,227**	,326**	,394**	,089	,417**	1,000
I-19	,215**	,093	,024	,135*	,184**	,221**	,196**	,152**	,203**	,225**	,172**	,215**	,192**	,155**	,122*	,247**	,270**	,161**
I-20	,143*	,242**	,052	,297**	,181**	,232**	,161**	,211**	,287**	,278**	,122*	,184**	,208**	,251**	,176**	,293**	,271**	,266**
I-21	,235**	,143*	,161**	,204**	,190**	,054	,226**	,244**	,164**	,264**	,227**	,144*	,264**	,167**	,228**	,218**	,260**	,239**
I-22	,216**	,167**	,220**	,323**	,224**	,093	,134*	,214**	,249**	,321**	,204**	,151**	,248**	,156**	,178**	,335**	,291**	,105
I-23	,151**	,093	,104	,134*	,024	,280**	,230**	,316**	,272**	,318**	,438**	,284**	,313**	,344**	,390**	,180**	,254**	,290**
I-24	,094	,135*	,164**	,107	,097	,116*	,156**	,233**	,218**	,216**	,220**	,253**	,134*	,251**	,239**	,141*	,282**	,242**
I-25	,277**	,135*	,194**	,157**	,228**	,173**	,161**	,207**	,197**	,261**	,350**	,228**	,248**	,269**	,337**	,263**	,237**	,339**
I-26	,271**	,100	,105	,150**	,113*	,033	,061	,128*	,182**	,145*	,067	,011	,116*	,168**	,140*	,280**	,085	,188**
I-27	,095	,134*	,126*	,163**	,175**	,051	,057	,183**	,179**	,167**	,167**	,032	,176**	,223**	,164**	,223**	,141*	,064
I-28	,239**	,141*	,144*	,245**	,165**	,171**	,023	,199**	,197**	,171**	,182**	,073	,234**	,243**	,218**	,267**	,289**	,159**
I-29	,151**	,112	,260**	,193**	,052	,168**	,232**	,362**	,239**	,357**	,386**	,165**	,191**	,383**	,444**	,209**	,308**	,264**
I-30	,143*	,127*	,214**	,107	-,007	,123*	,213**	,400**	,235**	,314**	,433**	,192**	,197**	,343**	,475**	,179**	,310**	,284**
I-31	,167**	,145*	,170**	,290**	,124*	,102	,188**	,318**	,446**	,355**	,262**	,188**	,280**	,335**	,342**	,363**	,351**	,178**
I-32	,046	,176**	,111	,201**	,133*	,118*	,249**	,361**	,323**	,360**	,292**	,229**	,213**	,244**	,310**	,317**	,299**	,197**
I-33	,069	,168**	,197**	,189**	,004	,068	,241**	,385**	,279**	,304**	,329**	,243**	,140*	,230**	,342**	,217**	,308**	,264**
I-34	,043	,106	,203**	,167**	-,009	,049	,299**	,304**	,284**	,312**	,319**	,141*	,210**	,180**	,276**	,114*	,381**	,382**
I-35	,131*	,146*	,179**	,212**	,136*	,123*	,188**	,311**	,254**	,301**	,170**	,123*	,205**	,297**	,277**	,261**	,213**	,162**

	Equity						Flexibility						Safety				
Correlação de Pearson	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30	I-31	I-32	I-33	I-34	I-35
I-01	,215**	,143*	,235**	,216**	,151**	,094	,277**	,271**	,095	,239**	,151**	,143*	,167**	,046	,069	,043	,131*
I-02	,093	,242**	,143*	,167**	,093	,135*	,135*	,100	,134*	,141*	,112	,127*	,145*	,176**	,168**	,106	,146*
I-03	,024	,052	,161**	,220**	,104	,164**	,194**	,105	,126*	,144*	,260**	,214**	,170**	,111	,197**	,203**	,179**
I-04	,135*	,297**	,204**	,323**	,134*	,107	,157**	,150**	,163**	,245**	,193**	,107	,290**	,201**	,189**	,167**	,212**
I-05	,184**	,181**	,190**	,224**	,024	,097	,228**	,113*	,175**	,165**	,052	-,007	,124*	,133*	,004	-,009	,136*
I-06	,221**	,232**	,054	,093	,280**	,116*	,173**	,033	,051	,171**	,168**	,123*	,102	,118*	,068	,049	,123*
I-07	,196**	,161**	,226**	,134*	,230**	,156**	,161**	,061	,057	,023	,232**	,213**	,188**	,249**	,241**	,299**	,188**
I-08	,152**	,211**	,244**	,214**	,316**	,233**	,207**	,128*	,183**	,199**	,362**	,400**	,318**	,361**	,385**	,304**	,311**
I-09	,203**	,287**	,164**	,249**	,272**	,218**	,197**	,182**	,179**	,197**	,239**	,235**	,446**	,323**	,279**	,284**	,254**
I-10	,225**	,278**	,264**	,321**	,318**	,216**	,261**	,145*	,167**	,171**	,357**	,314**	,355**	,360**	,304**	,312**	,301**
I-11	,172**	,122*	,227**	,204**	,438**	,220**	,350**	,067	,167**	,182**	,386**	,433**	,262**	,292**	,329**	,319**	,170**
I-12	,215**	,184**	,144*	,151**	,284**	,253**	,228**	,011	,032	,073	,165**	,192**	,188**	,229**	,243**	,141*	,123*
I-13	,192**	,208**	,264**	,248**	,313**	,134*	,248**	,116*	,176**	,234**	,191**	,197**	,280**	,213**	,140*	,210**	,205**
I-14	,155**	,251**	,167**	,156**	,344**	,251**	,269**	,168**	,223**	,243**	,383**	,343**	,335**	,244**	,230**	,180**	,297**
I-15	,122*	,176**	,228**	,178**	,390**	,239**	,337**	,140*	,164**	,218**	,444**	,475**	,342**	,310**	,342**	,276**	,277**
I-16	,247**	,293**	,218**	,335**	,180**	,141*	,263**	,280**	,223**	,267**	,209**	,179**	,363**	,317**	,217**	,114*	,261**
I-17	,270**	,271**	,260**	,291**	,254**	,282**	,237**	,085	,141*	,289**	,308**	,310**	,351**	,299**	,308**	,381**	,213**
I-18	,161**	,266**	,239**	,105	,290**	,242**	,339**	,188**	,064	,159**	,264**	,284**	,178**	,197**	,264**	,382**	,162**
I-19	1,000	,257**	,256**	,313**	,257**	,113	,247**	,198**	,217**	,253**	,161**	,179**	,170**	,206**	,146*	,062	,157**
I-20	,257**	1,000	,252**	,280**	,146*	,138*	,329**	,258**	,199**	,341**	,118*	,062	,252**	,217**	,115*	,158**	,183**
I-21	,256**	,252**	1,000	,507**	,264**	,334**	,236**	,218**	,326**	,292**	,260**	,208**	,319**	,186**	,191**	,285**	,315**
I-22	,313**	,280**	,507**	1,000	,199**	,397**	,307**	,282**	,227**	,280**	,238**	,179**	,300**	,281**	,156**	,262**	,281**
I-23	,257**	,146*	,264**	,199**	1,000	,275**	,383**	,186**	,211**	,298**	,433**	,431**	,260**	,220**	,339**	,248**	,248**
I-24	,113	,138*	,334**	,397**	,275**	1,000	,245**	,134*	,258**	,199**	,212**	,305**	,271**	,163**	,105	,354**	,271**
I-25	,247**	,329**	,236**	,307**	,383**	,245**	1,000	,352**	,287**	,330**	,310**	,328**	,223**	,229**	,266**	,204**	,123*
I-26	,198**	,258**	,218**	,282**	,186**	,134*	,352**	1,000	,302**	,263**	,225**	,163**	,246**	,053	,177**	,140*	,176**
I-27	,217**	,199**	,326**	,227**	,211**	,258**	,287**	,302**	1,000	,278**	,188**	,222**	,248**	,196**	,151**	,119*	,217**
I-28	,253**	,341**	,292**	,280**	,298**	,199**	,330**	,263**	,278**	1,000	,340**	,312**	,299**	,164**	,252**	,156**	,125*
I-29	,161**	,118*	,260**	,238**	,433**	,212**	,310**	,225**	,188**	,340**	1,000	,646**	,362**	,269**	,435**	,394**	,246**
I-30	,179**	,062	,208**	,179**	,431**	,305**	,328**	,163**	,222**	,312**	,646**	1,000	,328**	,270**	,402**	,400**	,268**
I-31	,170**	,252**	,319**	,300**	,260**	,271**	,223**	,246**	,248**	,299**	,362**	,328**	1,000	,295**	,446**	,410**	,462**
I-32	,206**	,217**	,186**	,281**	,220**	,163**	,229**	,053	,196**	,164**	,269**	,270**	,295**	1,000	,296**	,215**	,301**
I-33	,146*	,115*	,191**	,156**	,339**	,105	,266**	,177**	,151**	,252**	,435**	,402**	,446**	,296**	1,000	,421**	,420**
I-34	,062	,158**	,285**	,262**	,248**	,354**	,204**	,140*	,119*	,156**	,394**	,400**	,410**	,215**	,421**	1,000	,418**
I-35	,157**	,183**	,315**	,281**	,248**	,271**	,123*	,176**	,217**	,125*	,246**	,268**	,462**	,301**	,420**	,418**	1,000