Smart Road Plan: The Future of Mobility

Data Leveraging and Analytics in the Smart Urban Renaissance.

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ABSTRACT

This study investigates the development of the Smart Road Plan, implemented by Anas S.p.A in Italy. This initiative aims to integrate mobility and accessibility into the urban fabric through digital solutions integrated into physical infrastructures for safety reasons. The road network functions and management is built on synergic integration among processes by obtaining interoperability and seamless system integration between citizens and infrastructures that cooperatively and synergically produce public value. Consequently, citizens have become both consumers and producers of services and information by continuously sharing data to the infrastructures and stakeholders through personal devices and on–board systems obtained directly from vehicles. This urban Renaissance strives to enable long–term economic growth while increasingly impacting citizens' quality of life. Smart Road Plan represents a promising scenario to increase national competitiveness and sustainable prosperity development. This attractive scenario is positively portrayed for its effectiveness and beneficial application to significant issues and challenges.

However, the road network has become a surveillant assemblage of information hubs whose collective intelligence is dictated by actionable data flows to sustain urban functionality. The concept of smartness may overlook potential harms and risks. The right to privacy is particularly threatened by advanced predictive analytics and hyper–monitoring of citizens from their spatial and temporal context. Furthermore, potential technological vulnerabilities to cybersecurity threats and attacks pose critical concerns about safeguarding personal and sensitive information. Then, it raises ethical and social issues relevant to citizens' privacy who are concerned about their security due to the ubiquitous and pervasive penetration of services and platforms. However, the current literature fails to address the privacy and security implications pertaining real–time data exchanges between citizens and infrastructures. The Italian government and the European Commission have been closely working on policies and strategies to regulate the connectivity among users, vehicles, objects, and infrastructures. Therefore, it becomes important to explore how the Italian and European regulatory frameworks integrate citizens' privacy and security with the technological progress in the Smart Road Plan.

Qualitative content analysis in a case–study research design was conducted, with a mix of theory–driven and data–driven methodologies for developing a systematic coding scheme. The regulatory frameworks (N = 14) explore the Italian and European strategies and policies from relevant stakeholders and organizations involved. It was found that the regulatory context is fragmented and uncoordinated, characterized by a plurality of normative and strategical instruments. There is a lack of in–depth investigation of related risks and concerns, although privacy and security represent the biggest challenges and major worries of citizens in smart Renaissance. However, technical and organizational measures and standards are introduced.

KEYWORDS: *Smart City, Smart Mobility, Smart Road, Privacy, Cybersecurity.*

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1. Introduction

The Renaissance refers to an intellectual and cultural phenomenon that occurred in Italy in the 14th century and spread throughout Europe during the 15th and 16th centuries. This historical period was significantly innovative as a philosophical, artistic, scientific, literary, and political renewal. Therefore, this socio–cultural revolution paved the way for modern civilization as an era of progressive enlightenment. During this period, the city was conceived as the ideal environment for human life. It was envisioned as a place of civil coexistence, harmony, and the common good. The conception of the 'ideal city' was built around the principles of rationality and functionality that referred to the order of the intersections between the streets, the division of the spaces and their inhabitants based on social class (Marchi et al., 2012). Leon Battista Alberti, an Italian Renaissance architect and humanist, reports the rational and geometric criteria in his classic architectural treatise, known as *De Re Aedificatoria* (1485). He states that the city is an organic (*firmitas*), harmonious (*venustas*), and functional (*utilitas*) whole based on rational and geometric criteria. As a result, the urban spatiality and its disposition were rigorously symmetric to ensure effective autonomy and control by providing public value to the citizens in response to their demands and urban challenges. Indeed, cities were geometrically reorganized in opposition to the urban overpopulation of the Middle Ages by proposing classical elements and omitting the fortresses for defensive purposes of the previous centuries.

The ideal Renaissance city was designed to optimize the urban space based on perfection, balance, and functionality. It was intended to offer public value for its citizens while resolving urban challenges, such as overpopulation. Over 500 years, this conception of the 'ideal city' has been enhanced by adopting sophisticated technologies to facilitate social, environmental, economic, and cultural development. The phenomenon of smart cities is undoubtedly linked to promoting sustainable improvements for its citizens' quality of life. This digitalization process enables to increase in competitiveness for flourishing economic growth by effectively managing their infrastructure and natural resources (Giffinder & Gudrun, 2010). Integrating technologies into strategic urban governance enhances the socio–economic, ecological, logistic, and competitive performance of the cities' ecosystem. They empower citizens to actively participate in public life towards better community inclusiveness and equal participation (Kourtit & Nijkamp, 2012). Essentially, the core element of smart cities refers to sustainable competitiveness development in terms of economic growth, living quality, and socio–spatial cohesion. Therefore, urban development is seen as the result of a thorough grasp of competition, impacted by a number of important elements in the economic, social, demographic, environmental, and cultural spheres. Urban development is also seen as the result of economic and demographic growth (Giffinger & Gudrun, 2010). Thus, smart cities refer to "investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" (Caragliu, Del Bo & Nijkamp, 2011, p. 70, as cited in Voordijk & Dorrestijn, 2021, p. 8). Digital solutions bring innovative opportunities for citizens' involvement and participation while enhancing public service delivery and boosting trust in the government.

This concept of the smart ecosystem refers to the “extension of smart space from the personal context to the larger community and the entire city” as an organic system (Nam & Pardo, 2011, p. 283). The adoption of advanced information technologies has bridged the physical and virtual worlds by producing a vast quantity of actionable data as valuable assets in a knowledge economy (Yovanof & Hazapis, 2009). The smart ecosystem is balanced by integrating physical, digital, and human systems effectively. Indeed, a smart city’s fundamental components are technology, people, and institutions (Nam & Pardo, 2011). These initiatives combine social capital, including local skills, community institutions, and infrastructures, with digital technologies to support long–term economic growth and provide an attractive and flourishing environment.

In this dynamic ecosystem, technological breakthroughs have facilitated the flourishment of a new harmony of connected and accessible mobility in reaction to an increase in urban population that causes more traffic on city roadways, creating both a mobility challenge and an environmental concern. Thus, smart cities "influence how we connect in the urban design and minimize the externalities of connection" (Lyons, 2018, p. 10). Networked information systems have significantly offered information production and consumption opportunities by creating a favorable market environment and mobilizing citizens' participation. The digitalization of transportation infrastructures represents the possibility of improving quality and safety; while, generating data from sensors, measurements, and processing processes enhance urban and traffic management, including citizens’ behavior in a sustainable and inclusive manner. Hence, the goal of smart cities is to deliver efficient public services, while facilitating a seamless integration of end–systems thanks to interconnected devices and sensors.

As a key component of smart cities, smart roads could be understood as cutting–edge technological breakthroughs for citizen mobility and security. The technological applications provide real–time monitoring by processing metadata acquired by the direct dialogue between citizens and infrastructures within the surrounding spatial territory. As a surveillant assemblage, smart mobility converges and integrates the citizens' data from their spatial and temporal context by reassembling various dataflows (Haggerty & Ericson, 2003). As a result, it generates predictive analytics and recommendations that may be useful for cities' development, such as for smart public security, smart emergency affairs response, and smart government (Wei et al., 2021). Consequently, the monitored urban space could optimize its resources for security reasons and maximize services for its citizens.

These technological applications and practices are re–engineering cities’ urban fabric. A free flow of information and open data governance has been created a complex digital re–evolution (Allwinkle & Cruickshank, 2011). Smart cities are highly interconnected in combination with cross–domain Internet of Things (IoT) applications within collaborative and participatory governance. Large volumes of actionable data are produced, processed, analyzed, shared, and stored; but this poses a number of concerns and challenges, resulting in cybersecurity threats, profiling, and control of urban living. Thus, dataflow hyper–connectivity presents potential users' personal data and storage privacy implications, and cybersecurity threats and attacks (e.g., information leakage, malicious cyberattacks, unauthorized information sharing). Clearly, data privacy and security are recognized as crucial challenges and concerns in a smart ecosystem. The urban fabric has become an information hub thanks to the ubiquitous technological and digital solutions requiring a large collection of personal and sensitive data. Therefore, it is vital to consider data privacy and security as crucial requirements in all layers of network infrastructures.

The given debate highlights the crucial value of big data and its significantly limitless benefits in implementing urban governance in smart cities for producing public value through digital solutions. Indeed, the current literature focuses on the benefits of the sustainable prosperity development of smart cities, presented as an attractive future perspective. However, the debate also emphasizes cybersecurity threats and vulnerabilities of technological intelligence and its applications, including practices of data mining and its manipulation. Then, researchers should focus on the downsides of the digital technologies adopted to enhance urban governance and growth, including potential pitfalls and challenges in developing smart city policies. This phenomenon is relevant because it raises ethical and social issues; citizens are particularly concerned about the current surveillance capitalism ecosystem. In response to cybersecurity and urban challenges, the various stakeholders, both governments and private companies, play an active role in shaping the process of developing and regulating smart city policies in the interests of citizens' privacy and security. Indeed, Van Zoonen (2016) underlines the necessity for additional strategies and regulations for addressing technological advancements and data practices to inform the citizens about the data economy's implications. This study explores personal privacy and information security in the broader Italian and European regulatory framework, accordingly to the technological advancement of the Smart Road Plan. This study is conducted through qualitative content analysis in a case study research. The ultimate goal is to offer recommendations to researchers, stakeholders, and policymakers in developing ethical smart roads concerning an emancipatory, empowering, and inclusive smart urbanism ecosystem. It would be achieved by combining ethical and theoretical components with practical solutions and scenarios for balancing digital innovation with citizens' privacy and security in the current regulatory framework.

The following research question, therefore, emerged from the study's purpose:

RQ: How do the Italian and European regulatory frameworks integrate citizens' privacy and security with the technological progress in the Smart Road Plan?

1.1. Scientific Relevance

Smart cities are dynamic constellations of networks regulated by information and communication technologies (ICTs) and intelligence applications integrated into physical, social, and business infrastructures. These components are intertwined as they synergically collaborate to create a multi–level system that ensures their entirety and functionality. Thus, the complexity of smart cities could be seen as the structure of the human organism, in which ICTs are equivalent to the nervous system (Orlowski &

Romanowska, 2019). Their structural organizations are constituted of multiple intertwined components and systems with a particular function and structure that cooperatively maintain the efficient functioning of the whole entity. Therefore, this linked organic network represents an integrated system that does not work in isolation (Dirks & Keeling, 2009). According to Nam & Pardo (2011), the nervous system's intelligence (brain) coordinates the various telecommunication networks (nerves), connected from both physical and virtual sensors (organs), for producing real–time data (knowledge and cognitive competence). Essentially, smart cities are understood as living organisms built on technology–based systems. They create a significant flow of data through global sensorization supported by data analytics and artificial intelligence with multiple interconnected layers corresponding to the various components of the urban environment.

On the other hand, smart cities depend on technology and human involvement to maintain their effectiveness and strengthen the city's collective intelligence, while the human organism is self–sustaining. Indeed, the smartness of a city is determined by the source of data flow. In a networked city, urban spatiality is managed by the constant co–production of big data in a hyper–connected spatiotemporal context to ensure efficient citizens' mobility and public value thanks to digital technologies applications. The comparison with the human organism highlights the interconnection and interdependency of the components in smart cities as they have become highly dynamic; in particular, it emphasizes the importance of their integration and coordination in building ethical smart cities for achieving sustainable progress by expanding the economy fairly without compromising the ecosystem.

The progressive digitization in an urban organism represents the main driving force for sustaining social, environmental, economic, and cultural development. Due to the ubiquitous application of technologies, smart cities have become surveillant assemblage (Haggerty & Ericson, 2003). So, it is crucial to reconfigure technological components and applications by safeguarding big data flow management throughout the whole process, from sensing, transmitting, processing, and storage (Wei et al., 2021). The cybersecurity protection inadequacies result in privacy concerns and challenges, such as predictive profiling, social sorting, anticipatory governance, behavioral nudging, control creep, data protection, and data security (Kitchin, 2016; Eckhoff & Wagner, 2017). These potential pitfalls of technologies and their monitoring practices pose challenges in developing smart cities' privacy policies against digital attacks in scale and complexity. So, the infrastructures must ensure strategies and regulatory frameworks to strengthen cybersecurity through implementing policies, guidelines, and control. Moreover, data interoperability between service providers and data protocols raises concerns about personal data and privacy (Habibzadeh et al., 2019). It is extremely crucial among the various formats and locations where data are stored, especially in relation to the capabilities to exchange and consume data to produce predictive data analytics insights and recommendations. Essentially, it is fundamental to evaluate these technological innovations against sustainability criteria and provide specific policy recommendations based on these findings, given the goal of achieving a more sustainable transportation system.

1.2. Societal Relevance

The transportation infrastructure represents a core driver for economic growth within contemporary society. It delivers an efficient and effective network by significantly influencing the environment and communities. The future of integrated mobility is oriented toward citizens–focused services, ensuring accessibility and inclusiveness while reducing the environmental impact. The integration with digital technologies will create an intelligent infrastructure through the collection and analysis of data. However, citizens are heavily concerned about security and protection (45%), data privacy (25%), and transparency of services (8%) in the penetration and adoption of smart city services, according to Lytras & Visvizi (2018). It is essential to assess the cybersecurity risks, including the guidelines and requirements of smart technologies, to ensure privacy and security solutions in their design (Andrade et al., 2020). It is worth mentioning that current literature fails to consider the implications hidden in the evolution of smartness in smart cities initiative from users' perspectives without identifying potential privacy and security solutions for smart system designs (Del Vecchio et al., 2019; Majid, 2023). Relatively, a fundamental dilemma is whether users could control and transfer their data across platforms or if it could all be consolidated with one platform provider. Therefore, corresponding regulatory measures are required as the current regulatory framework lacks a practical and pragmatic perspective on privacy for strengthening public awareness and influencing policymakers, particularly at the local level (Fabrègue & Bogoni, 2023). It is, therefore, critical to draw place–based public policies in shaping the economic scenario of a specific geographical urban performance and wealth according to its local characteristics. Moreover, smart city initiatives must consider the interrelationships among the systems on which they are built, and the challenges they confront in the urbanization transformation's policies and regulations (Dirks & Keeling, 2009). Eventually, policymakers, stakeholders, city managers, and third parties must actively engage in establishing a set of cybersecurity policies and guidelines relating to the data privacy of personal data storage and process, taking into consideration the data interoperability between the different technologies and components involved in smart city governance to ensure transparency and accountability.

1.3. Structure

This study adopts an inductive approach through qualitative content analysis in a case study research. The conceptual foundations relevant to the notion of Smart Roads are extensively examined based on the comprehensive theoretical framework, to be found in Chapter 2. The research design, with the methodological justifications, is then thoroughly explained in Chapter 3. Subsequently, the empirical findings and data analysis are observed in Chapter 4. Ultimately, conclusive reflections and remarks are discussed with a critical outlook in relation to the research question, to be found in Chapter 5. Potential limitations, together with opportunities and perspectives for future research, are also noted.

2. Theoretical Framework

This chapter offers a comprehensive overview of theories, concepts, and frameworks related to the phenomenon of smart mobility by laying the theoretical foundations for the research question formulated. First, the urban sustainable prosperity development within a smart city scenario is analyzed, including its relationships with integrated mobility and smart roads. After understanding the revolutionary progress to urban challenges, the risks and implications are investigated. The exploration poses significant attention to citizens, including their right to privacy, establishing cybersecurity effects of technologies. Lastly, final remarks are explored in smart governance toward ethical management to tackle the highlighted debates.

2.1. Sustainable Prosperity Development of Smart Cities

Smart cities represent a new generation of urban renaissance regulated by the progressive digitization of roads, city services, and infrastructures, which have become responsive, competitive, and equitable. They reflect an "effective integration of physical, digital, and human systems in the built environment to deliver a sustainable, prosperous, and inclusive future for its citizens" (Toh et al., 2020, p. 29). They innovatively upgrade traditional urban governance by adopting technological intelligence solutions to deliver added value to citizens' quality of life while increasing competitiveness and innovation. They automatically adjust to the context and improve the management of human life by promoting social development in a networked city (Yovanof & Hazapis, 2009; Pompigna & Mauro, 2022). In other words, a smart city dynamically learns and adapts to its surroundings and inhabitants by exploiting such information to enhance their experience within a space, while increasing urban performance and wealth.

Smart cities have gained greater attention from a growing community of scholars and researchers thanks to their attractiveness in urban planning as a significant market–changing opportunity. There have been various definitions of such a concept, although no one is universally accepted. It is often understood as a fuzzy concept, offering various perspectives applied to different contexts. Hence, it is a significant broad concept as “every city is unique, with its own historical development path, current characteristics, and future dynamics” (Koźlak & Pawlowska, 2019, p. 34). However, smart cities offer intelligent solutions with a sustainable development outlook that does not compromise the capacity of future generations to fulfill their own needs (Bellini & D’Ascenzo, 2020). Indeed, the term refers to a dynamic and iterative process toward sustainable progress. It first appeared in 1992 as “urban development towards technology, innovation, and globalization (Gibson et al., 1992, as cited in Koźlak & Pawlowska, 2019, p. 34). In 2008, IBM, a pioneer in technology, was the first to address the Smart City Initiative (Dirks & Keeling, 2009, p. 1), as follows:

> Cities are gaining greater control over their development, economically and politically. Cities are also being empowered technologically, as the core systems on which they are based become instrumented and interconnected, enabling new levels of intelligence. In parallel, cities face a range of challenges and threats to their sustainability across all their core systems that they need to

address holistically. To seize opportunities and build sustainable prosperity, cities need to become smarter.

The progressive concept of the smart city lays the foundations of urban development based on technologies intended to improve a city's functionality by managing the economy, society, and environment. Smart cities are built on fundamental core systems made up of various networks, infrastructures, and environments linked to their primary functions: city services, citizens, business, transport, communication, water, and energy. Various researchers have found that a smart city integrates government, technology, and culture to foster the development of the core components of each dimension, namely smart economy, smart mobility, smart environment, smart people, smart living, and smart governance (Giffinger & Gudrun, 2010; Koźlak & Pawlowska, 2019). These six smart components are intertwined and mutually integrated with technological, institutional, and human factors (Nam & Pardo, 2011; Nicolaï & Le Boennec, 2018; Del Vecchio et al., 2019). In a nutshell, smart cities are complex and powerful network infrastructures to fuel sustainable prosperity and growth in citizens' quality of life through the cooperation among human and social capital in promoting technological advancement and digital solutions.

Smart cities are open–ended systems of information hubs embedded into the fabric of a city (Ruhlandt, 2018; Cosgrave & Tryfonas, 2012). This multi–faceted ecosystem involves several interconnected actors and sectors within a wide range of networked information technologies that facilitate the operations and development of the urban fabric. Therefore, it is crucial to provide a unified data center to collect data flows from the different sensors and applications (Wei et al., 2021). Essentially, the process of digitalization originates interconnected networks of data points. They are used to improve the performance and effectiveness of the decision–making thanks to the globally integrated political economy and service–based approach through seamless multi–modal integration of advanced intelligent transport systems. Intelligent services may be created upon forecasts and suggestions by combining different data flows. Hence, a smart city enables citizens to engage with customized services and infrastructures to meet their needs better and develop sustainable and economic progress. The ultimate purpose is to increasingly build synergic integration among processes by obtaining interoperability and seamless system integration in automation development (Pribyl et al., 2022). As a result, cities have become information hubs as smarter system of systems. This innovative paradigm has transformed the urban fabric into "artificial ecosystems of interconnected, interdependent intelligent digital organisms" (Yovanof & Hazapis, 2009, p. 448). The dynamic process of reshaping cities is highly interconnected and intertwined with the complex interactions between processes and systems. Smart cities intend to optimize the seamless integration among the processes by improving collaborative synergy and increasing interoperability and automation (Pribyl et al., 2022). Indeed, the scale and nature of sustainability challenges are significantly interconnected as the fundamental source of competitiveness to enhance social, economic, political, ecological, and logistic growth.

Smart cities need to streamline their strategic and planning management, accordingly to a novel scenario enriched with innovative possibilities. Indeed, the main goal is to create a sustainable action plan with a flexible and inclusive approach in response to the unprecedented urbanization situation. It is crucial to transform these challenges into opportunities with a sustainable, innovative, connected, and socially cohesive perspective. The long–term results aim to deliver sustainable prosperity for citizens, businesses, and governments by creating new power dynamics and responsibility and strengthening public value and welfare. The United Nations has established the 2030 Agenda for Sustainable Development with 17 Goals, according to which the economic, social, and environmental pillars are integrated toward a fair and peaceful future, accordingly to international law and fundamental human rights. This social transformation involves a sustainable prosperity development that acknowledges the connections and interdependencies between eradicating poverty in all its forms and dimensions. It addresses inequality within and between nations, protecting the environment, achieving sustained, inclusive, and sustainable economic growth, and promoting social inclusion. Indeed, the collaboration between state and non–state actors is essential for this process at all political levels (global, regional, national, and sub–national), in various societal spheres (politics, society, and economy), and across sectors (energy, transportation, food, etc.). In the context of cities and urban fabric, practitioners, governments, and policymakers strive to make cities and human settlements inclusive, safe, resilient, and sustainable, according to the 11 Goal (Sustainable Cities and Communities). It also includes sustainable transport, in relation to infrastructure, public transportation systems, networks for the delivery of commodities, the cost, effectiveness, and practicality of mobility, as well as the improvement of urban air quality and human health, and the reduction of greenhouse gas emissions (United Nations, 2015). Therefore, transportation innovations are one of the forces behind the development of a sustainable transportation system, along with other coordinated strategies such as promoting more active, public, and shared transportation, telecommuting, and better utilization of available road capacity, all of which are used to address major issues (e.g., vehicular emissions, transportation costs, travel times, congestion, safety, accessibility, and social equity). Indeed, sustainability transport is inherently intertwined with several other goals and targets, particularly food security, health, energy, economic growth, infrastructure, cities, and human settlements. Ultimately, smart cities balance and coordinate social, environmental, and economic development components integrated into political agendas on both local and international levels. This process of sustainability prosperity development aims to create a safe, affordable, and accessible transportation system, housing, and basic services. Lastly, it aims to create an inclusive and equitable urbanization process considering human, social, and technological capital.

2.1.1.Integrated Mobility

Smart mobility is a crucial component of the smart city as a key pillar of the digital metropolis' economic function and productivity. As it is inextricably linked to smart cities, it could be viewed as both a cause and an effect of the intelligent configuration and management of the urban fabric. It contributes to full accessibility, efficient use of resources, and development of sustainable behaviors impacting the quality of life of its citizens (Pribyl et al., 2022). In a nutshell, its performative efficiency affects the economy, people, governance, and mobility. It is extremely significant to citizens and local government due to mobility's effects on other aspects of the smart city, such as economics, living standards, and the environment (Koźlak & Pawlowska, 2019). Essentially, mobility facilitates the movement of citizens and resources supplying utility services in an urban area. The intelligent transport services include “real–time traffic operations, consumer–means administration, applications and logistics monitoring, automobile parking maintenance, automobile parking maintenance, automobile allocation services” (Bıyık et al., 2021, p. 3). Smart mobility is critically relevant for smart cities’ growth and intelligent development in a complex data–driven scenario, thanks to the adoption of technological innovations such as IoT, collaborative robotics, Big Data, artificial intelligence, drones, and 3D production (Del Vecchio et al., 2019). Accordingly, it enhances economic and social progress by promoting an innovative paradigm of configuration, nurtured by big data transportation analytics that delivers effective solutions regarding traffic routing, road congestion control, urban sprawl, and routing (Bıyık et al., 2021). Furthermore, it could be brought into play to track road construction and maintenance, traffic accidents and fatalities. It assesses safety and security concerns by tracking citizens’ movements in space and time.

The open–data and open–source ecosystem creates vibrant, interconnected social progress in the configuration of smart cities by collecting valuable information. It enhances citizens’ mobility by offering alternative means of transport and route information leading to a reduction of monetary costs, time, and resources. Additionally, smart mobility is a strategy that helps to drastically reduce the harmful emissions that vehicles and human congestions release into the air. Similarly, environmentally friendly smart mobility helps to improve transportation quality. Smart urbanization optimizes land use, improves the efficiency and environmental friendliness of the transportation system, and offers reasonably priced mobility services to ensure the welfare of citizens. Smart mobility refers to intelligent applications for urban developments and challenges in the context of transportation and infrastructures connected to data networks that generate and share information and knowledge for urban developments and challenges. It describes contemporary transportation and logistics systems using ICT systems to enhance their integrity with the environment. In particular, citizens are actively involved in producing data to design and execute their mobility (Del Vecchio et al., 2019). In essence, smart mobility empowers citizens, encouraging smarter and more rational behavior in their interactions with the urban environments and integrating technology into urban infrastructure.

Connectivity is a crucial component of smart mobility as it offers "affordable, effective, attractive, and sustainable" solutions for transportation by integrating seamless networks (Lyons, 2018, p. 9). The cross–modal data traffic flows create a personalized inter–communication between drivers, vehicles, and infrastructure. Therefore, it allows users to submit all journey data instantly while members of the local municipal administrations execute strategic control (Bıyık et al., 2021). It leads to a significant over–communication system that creates a vast collection of user–generated data used to manipulate traveler behavior and improve system performance (Docherty et al., 2018; Voordijk & Dorrestijn, 2021). This socio–technical evolution represents linked changes in cross–domain areas, such as technology, the economy, institutions, behavior, culture, ecology, and belief systems (Docherty et al., 2018). In a nutshell, it promotes alternative means of transport and sustainable citizens' behavior. So, smart mobility is intended as a dynamic data–driven system influencing urban governance and citizens' lifestyle while simultaneously optimizing transportation networks and enhancing the quality of life. Essentially, the paradigm focuses on mobility (i.e., traveling) and accessibility (i.e., participation) by improving the resilience and safety of citizens and infrastructures. Smart mobility represents a significant momentous in civil and transportation engineering as it fundamentally alters the conception of road construction, traveling, and accessibility.

2.1.2.Smart Roads

Smart roads represent a revolutionary application for integrated mobility and accessibility in the urban context. As a key component of smart cities, they exploit innovative technologies for intelligent and connected mobility. They refer to the physical infrastructure integrated with networks and communication technologies (i.e., Internet of Things, Big Data, Machine Learning solutions, and Cloud Computing) incorporated into roads and transportation roadways (Pompigna & Mauro, 2022). Smart roads have become the backbone of the transportation system by providing added public value to citizens and infrastructures. The quality of transportation significantly impacts the sustainable development of urban life as it increases the citizens' standard of living. For instance, it increases transport efficiency, drivers' and pedestrians' safety, monitoring traffic status and road conditions; furthermore, it cleans energy consumption and promotes sustainability by collecting and supplying green energy (Pompigna & Mauro, 2022). Essentially, smart roads are capable of ensuring operational self–awareness of the technological applications and their information interaction and connection; they are self–adaptable systems with particular attention to energy efficiency while easing traffic and advancing safety and sustainability.

In the last decade, various developed countries have launched experimental projects in the field of road engineering by attracting widespread attention for engineering construction and management. These intelligence applications are extremely adaptable to smart roads. They represent a "promising direction of research and development in the field of road engineering, both in construction and management," which benefits the environment, society, and economy (Zhao et al., 2015, as cited in Pompigna & Mauro, 2022, p. 2). The paradigm of smart roads is rooted around the citizens by connecting the physical and virtual worlds, together with technical applications that identify solutions capable of automatically adapting to different contexts of human life (Pompigna & Mauro, 2022). Smart roads are understood as a self–aware ecosystem, which is able to adapt to the surrounding conditions by monitoring the road conditions in real–time thanks to the adoption of intelligent technologies built on the IoT sensors, cameras, radar, 5–G networks, with the availability of large data on traffic, pollution, weather, itineraries, and policies.

These initiatives are promising investments for developing Cooperative Intelligent Transport System (C–ITS) solutions, promoting innovation, automation, connectivity, cooperation, security, and interoperability of networks and services. Indeed, they represent key drivers of the EU plan, allowing information sharing among users and stakeholders to coordinate actions. As core element of smart roads, C–ITS systems enable data interchange between various transportation system components among human–vehicle–road. The configuration of cooperative communication systems, known as Vehicle–to–Everything (V2X), bridges the physical and virtual worlds through the various wireless technologies that transmit data from Vehicle–to–Vehicle (V2V), Vehicle–to–Infrastructure (V2I), Vehicle–to–People (V2P), and Vehicle–to–Network (V2N). In other words, C–ITS solutions are advanced intermodal transport networks used for data gathering, processing, and storage, as well as competence in planning and evaluating integrated programs and policies at the core system of smart connectivity. The European Union is adopting a systematic approach to facilitate the smartification process of road networks with the implementation of common regulatory frameworks to connect policies and resources at a national and local level. Moreover, numerous operators involved in the members' states of such initiatives have been employing policies and strategies. For instance, the Italian Ministry of Infrastructure and Transport (MIT) approved a Smart Road Decree in 2018, identifying the components and functional standards to create an intelligent urban ecosystem. It establishes guidelines for an interconnected and secure road network ensuring communication among users for delivering real–time data on traffic, accidents, weather, and other relevant information to improve traveling comfort and infrastructure management.

The relationship between Smart Roads projects, with the large–scale processes underway in Europe, suggests a promising direction. It involves an extraordinarily large number of actors from all sectors, to standardize approaches to communications security, interpretation of standards, harmonized definition of services, impact assessments of early projects, and up to large–scale implementations. This scenario attracts various stakeholders, including governmental institutions, road operators, electronics and automotive industries, with a growing interest in redesigning safety and mobility parameters in traffic analysis. Thus, the ultimate purpose is to improve road–safety, reduce transportation costs, and expand accessibility towards interoperability of network security and communication channels (Bouton et al., 2017). In civil engineering transportation infrastructure sectors, the smart ecosystem is equipped with a combination of digital devices and innovative materials applied to the road pavement and platforms that support vehicle loads with capabilities for management and monitoring (Trubia et al., 2020). Hence, Smart Road is an end–to–end concept that involves the whole road network functions and management with the adoption of intelligent mobility solutions.

Digital solutions applied to smart roads boost the future of mobility to a plethora of opportunities for connected road networks thanks to the current advancement in the field of Big Data analytics and artificial intelligence. In the field of smart mobility, there are various fast–moving trends, such as shared mobility, autonomous driving, and vehicle electrification, among others (Bouton et al., 2017; Butler et al., 2020). For instance, the advancement of autonomous vehicles represents a fundamental breakthrough in transport engineering as it improves emissions, operational performance, and safety (Trubia et al., 2020; Ribeiro et al., 2021). However, legislative regulations impede the development of this trend due to concerns about the quality of infrastructure automation. It has shown the importance of achieving efficient and safe intelligent installations in the Road Side Units to facilitate communication with vehicles by collecting and exchanging data and other parameters. Essentially, the digitalization and smartification of roads exploit the users' data anticipating the revolutionary introduction of self–driving vehicles within the next ten years.

The main objective is to achieve higher levels of productivity and efficiency and better individual living conditions and environmental sustainability. In order to create a more sustainable transportation system, the environmental, economic, and social repercussions of mobility must be balanced (Butler et al., 2020). Smart Roads initiatives aim to efficiently use the road capacity by addressing key challenges such as "vehicular emissions, transportation cost, travel time, congestion, safety, accessibility, and social equity" (2020, p. 2). These components represent key criteria to build upon sustainable development. Therefore, the primary challenge is developing high–performance services to shift mobility behaviors away from private vehicles and toward a more sustainable transportation system. For instance, mobility governance supports innovative initiatives to "shift towards shared mobility services" as a "multimodal platform for sustainable mobility services" (Koźlak & Pawlowska, 2019, p. 38). So, road networks have integrated intelligent technologies that allow communication and cooperation among vehicles and physical infrastructures.

2.2. Spectacle of Progress: The Dark Side of Digitalization

Smart city initiatives aim to enhance urban performance, efficiency, and competitiveness with the use of digital solutions in the interests of their citizens and organizations by monitoring and optimizing existing infrastructures and services while fostering collaboration with various stakeholders. The main goal is to make cities more livable and resilient by being capable of adapting more quickly to new challenges for sustainable prosperity and progress. Indeed, smart cities encourage innovative and efficient business models for smarter urban management for creating an interactive and responsive city, in both private and public sectors. Generally, smart cities embrace technological applications with the expectation of improving the quality of life. However, the various notions of smartness are presented as a kind of promise that may overlook potential harms and risks to society. As a result, smart cities are criticized for their "self–proclaiming and self–congratulatory" notions of their smartness (Hollands, 2008, p. 62, as cited in Jiang et al. 2022, p. 1641). Essentially, a complex set of dynamic variables and cross–sectorial implications come into play by impacting the broad community of stakeholders involved, including citizens, government, organizations, and environments. Furthermore, the smart city concept is associated with the narratives, logic, and practices of symbolism sold and perceived within a society (Sadowski & Bendor, 2019). Accordingly, smartness is seen as an innovative container for smart city initiatives and an evaluation metric for urban performance reflected in sociotechnical imaginaries of desirable and attractive futures.

The contemporary 'ideal city' maximizes the efficiency of urban spaces and resources built around the data produced by citizens by developing more interactive and responsive networks and services. Accordingly, data are the core of the political economy and societal progress as the key driver for digitalization and smartification. The smart system is indeed nurtured by data from physical and social sensing (IoT) integration, representing a potential benefit for cities' mobility configuration and management leveraging machine learning and algorithms. For instance, smart mobility performs in a data–driven scenario produced from various sources and devices by radically altering the configuration of the urban fabric. Smart road projects are based on a complex digital platform and network. They are articulated on the road infrastructure as a nervous system supported by innovative technologies. Therefore, it is suggested to consider social and environmental aspects in the effectiveness and sustainability of smart roads solutions by taking into consideration potential risks on the "security of data flow and information storage; privacy and responsibility of individuals; safety and protection of all road users, with particular attention to the weaker ones; new forms of pollution, to the detriment of human health and the environment" (Pompigna & Mauro, 2022, p. 12). Specifically, the main concerns refer to mass surveillance, privacy erosion, profiling and targeting, nudging behaviors, lack of transparency and accountability, digital divide, control creep, and data ownership (Galič & Schuilenburg, 2021). Moreover, the potential harms are linked to discrimination, and marginalization of communities and groups, together with other factors such as income and racial lines.

2.2.1.Participatory Governance

Participatory governance is crucial for the advancement of the process of smartification while ensuring transparency, accountability, and responsiveness. It provides a possibility for citizens and communities to make an impact by participating in decision–making processes, procedures, and projects by strengthening trust in the government to design fair and effective policies. Indeed, citizen participation represents a crucial factor in urban planning strategies and interventions. Consequently, smart governance develops a citizen–centered approach in response to their demands. For this reason, smart cities integrate ICTs to maintain a "continuity of information between government and the provision of high–quality services" built around its main goals in a specific context and time (Ma, 2021, p. 8000). Therefore, smart governance must consider users' data gathered from technologies as a resource to create public value. This asset becomes valuable once they produce actionable insights to monitor and understand beyond the processes for efficient decision–making through data analytics. Indeed, citizens cooperatively and participative support infrastructures and stakeholders (Obaidat & Nicopolitidis, 2016). So, they have become both a consumer and a producer of services and information.

The prospect of participatory governance contributes to democratic legitimacy, although citizens may not necessarily become active. They would participate actively as data providers and end–users only when satisfactory digital literacy is provided and involved throughout all processes. This political orientation benefits sustainability and social resilience; but, it leads to larger societal and ethical implication data–based value creation. According to König (2021), open–data could be sold and transferred to third parties (private, public, civil stakeholders). A smart city collects personal information about citizens' uses and behaviors that optimize administrative processes and operations (i.e., predictive analytics) for planning and managerial decisions. They include marketing initiatives and customer relations through personalized advertisements and development of new services and products.

This complex creation of data–based values in relationships with citizens is perceived as "complicated, time–consuming, and expensive, with a lack of ability at the community level to execute the support programs" (Bıyık et al., 2021, p. 3). Indeed, it addresses ethical concerns about the legitimacy of data (relating to the generation, recording, curation, processing, dissemination, sharing, and use), embodied in the self–decisiveness, independency, and awareness of citizens of being educated in such processes. Furthermore, smart cities are criticized for not being inclusive and equitable as they promised, leading to a critical digital divide and social inequalities (Galič & Schuilenburg, 2021). Governmental services are offered via ICT–augmented systems that could not be accessible by citizens with low socioeconomic status and those from marginalized situations (e.g., refugees, migrants, asylum seekers). As a result, technocratic smart governance may be exceedingly unequal, with imbalanced power relationships, social exclusion, and unfair allocations of costs and rewards. For instance, it may result in hyper–targeting profiling practices and social sorting of vulnerable communities and minorities. In a nutshell, the bottom–up approach of smart governance creates a collaborative and co–produced scenario, underpinning social sustainability and accountability; however, it is associated with a significant influence on consumer choice and individual autonomy with a civic paternalistic perspective of the government on society.

2.2.2. Urban Behavioral Change

Smart cities represent structural and social entities functioning through data–driven analysis and management built on wide–ranging data. Urban planners and policymakers exploit this data flow to encourage a sustainable lifestyle ethically. Hence, they generate extensive data streams employed to control their infrastructures and citizens' behavior, promoting sustainable behaviors and lifestyle choices. The decision–making beyond the collection of big data has radically impacted users' behaviors and how mobility is conceptualized and planned (Del Vecchio et al., 2019). This libertarian paternalistic approach opens up a debate on the importance of altering urban architecture by redirecting citizens' behavior and rationality through policy interventions and sustainable lifestyles. For instance, smart mobility is linked to multimodal and intermodal components of the transportation system, by shifting citizens' preference to more sustainable options, such as car sharing and vehicle electrification to reduce carbon emissions (Pompigna & Mauro, 2022). Indeed, the perspective of the economic model is shifted away from an ownership approach to a shared–economy together with participatory governance.

This phenomenon is known as the nudge theory, according to which it is possible to influence citizens' behavior in a beneficial way to the community without behavioral coercion, not forcing the exclusion of alternative options through subtle and cost–effective changes (Thaler & Sunstein, 2008). Combining behavioral insights with digital technologies develops accurate predictive models. They identify citizens' biases and preferences to systematically hyper nudge them to choose wisely toward a healthy and sustainable lifestyle through personalized offers, recommendations, products, and services. The adoption of innovative technologies highly impacts behavioral economics as a significant contribution to smart city governance. Indeed, they support citizens to adopt a positive attitude and influence to live more sustainably, to reduce their carbon footprint and promote local commerce and civic participation.

While behavioral insights create innovative opportunities for public values, this data–driven nudging raises ethical concerns associated with the inherent paternalistic mission of smart cities associated with extensive surveillance capitalism. Consequently, it treats citizens as passive data subjects whose data are the core of the urban ecosystem functioning. Therefore, smart cities must evaluate the role of nudging strategy to improve the common good and social welfare by relying on democratic participatory governance, online justice and fairness, and transparency (Ranchordás, 2020). Furthermore, the pervasive collection of personal data with sophisticated algorithms to influence citizens' behavior could be problematic from a legal standpoint in the interest of the right to privacy and individual autonomy, accordingly to the principle of transparency, established in article 5 of the General Data Protection Regulation. Hence, Ranchordás (2020) has been critically asking if:

> Is it necessary and legitimate to collect data to nudge citizens? Has only the very minimum amount of data been collected? If the smart city works together with a private corporation to collect and process the data, who owns the data, and what kind of contracts do these entities have with public bodies? Do citizens feel that their right to privacy is being respected when their data is being collected in order to develop nudges that will be employed to change their behavior? (p. 266)

Although data–driven nudges and behavioral insights are well–intended, they manipulate citizens' choices without them fully being aware due to the lack of transparency regarding underlying intentions, including profit–driven purposes. Consequently, it could be argued that the nudge theory does not support the limitations of contextual integrity, according to which citizens should be protected from malicious intrusions that limit their freedom and autonomy (Nissenbaum, 2004). Indeed, it is crucial to evaluate the ethical interests behind such practices by evaluating the impacts on the affected users and considering the data collection context in its function, purpose, and value. Essentially, nudging strategies are based on ideological components that seek to influence citizens' behavior. Whilst they interfere with fundamental rights, such as freedom of expression, the right to information self–determination, and the 'right to be left alone' (Warren & Brandeis, 1890).

2.2.3.Surveillant Assemblage

Smart cities create public value by collecting and analyzing real–time data from physical and virtual sensors that provide advanced analytics through ICTs. The implementation of ICTs in fostering public value refers to the use of big and open data, participatory crowdsourcing platforms and social media, mobile devices, and smart city sensors technologies, among other sophisticated digital technologies and communication systems (Criado & Gil–Garcia, 2019). This data–acquisition system leads to an interconnected value chain of insights across numerous intertwined processes, organizations, and industries. Smart cities communicate users' data to ICTs' infrastructures to "optimize smart grid performance and maximize user benefits" (Li et al., 2021, as cited in Ma, 2021, p. 8005). Hence, big data is the key driver of a city's smartness in its urban development of connecting users, vehicles, and infrastructure (Batty, 2013). The effectiveness of technological applications "heavily relies on data collection, interconnectivity, and pervasiveness" (Eckhoff & Wagner, 2017, p. 489). Indeed, big data creates digitized urbanism processed in real–time with a wide scope. The granularity and resolution of these data are significantly high in their performance, efficiency, and accuracy.

Smart sensors enable monitoring practices by collecting data from subjects and objects in motion. The sensing network is significantly important to perform a crowd–sensing capability incorporated in technologies owned by the citizens to collect relevant data (Soyata et al., 2019). Combining social and spatiotemporal characteristics with data analytics yields a wealth of information about a city's location, effectively converting its citizens into urban sensors (Jiang et al., 2022). The pervasiveness of such technologies has led to data manipulation and control challenges in surveillance capitalism, such as hyper–targeting through data analytics, facial recognition, and individual profiling (Calzada & Almirall, 2020). Sensors increasingly produce big data by generating data flow with precise geo–localization in real–time. Indeed, they dynamically regulate the citizens' mobility based on real–time information and sensing, combining spatiotemporal data analytics, through the use of Global Positioning System–enabled devices and cars, Vehicle–to–Everything network connection, and Closed Circuit Television (CCTV) cameras on roads and intersections (Obaidat & Nicopolitidis, 2016). Moreover, several software employed for smart technologies integrates critical functions (i.e., data representation, fusion, transmission, storage, integration, and prediction) by automatically becoming third–parties owners of the data collected (Soyata et al., 2019). Moreover, these data could be further processed for specific predictive analysis beyond the citizens' needs and interests without them being fully aware of it (e.g., predictive policing, crowd control, public sentiment monitoring). However, data analytics could produce biases and systematically skewed representation of urban life and citizens' interests (König, 2021). Then, it is still necessary to analyze and provide meaning to data and analytical results to draw an accurate scenario of the urban space. Particularly, it still occurs in algorithmic systems as they are designed to offer recommendations and make judgments based on their ability to learn from data and the surroundings. It may result in biases and untrustworthy insights and assumptions (e.g., discrimination, limitation of personal autonomy, hyper nudging), although algorithmic–

supported decision–making plays a crucial role in the analytical prediction for adopting policies and strategies.

These forms of pervasive technologies have become the backbone of a city's intelligence, with greater potential to be instrumented with analytical tools for monitoring and controlling the operational service delivery, including its citizens. It creates a sophisticated matrix of power relations used for control, government, security, profit, and entertainment by sorting society under scrutiny, visibility, mobility, and classification. As a result, this surveillance assemblage operates "by abstracting human bodies from their spatial and temporal context and separating their component parts into discrete information flows" thanks to sensor–based applications and other emerging technologies (Haggerty & Ericson, 2003, p. 606) These data are reassembled upon the convergence and integration of territorial components, while citizens embody a collection of data flow over time and space, by creating a massive output of open–data repository. Essentially, intelligent applications have the capability to monitor and analyze citizens' movements and resources accordingly to a panoptic governance. It undermines the right to privacy, confidentiality, and freedom of expression, although the main goal is to improve their quality of life (Batty et al., 2012). As a result, cities have become self–monitoring and self–response systems. They integrate interconnected and intelligent instrumentations sourcing real–time data from the physical and virtual sensors across various processes, systems, and stakeholders.

2.2.4.Pitfalls of Technologies: Privacy & Cybersecurity

In the context of smart mobility, sustainable solutions present greater opportunities for safety, congestion, energy consumption, environment, and accessibility. In the field of the transportation system, smart mobility enhances the advancement of sustainable safety. It improves the monitoring of the urban environment through the collection of real–time information for in–vehicle assistance systems and future prevention and planning analysis. Cooperative Intelligent Transport Systems (C–ITS) are used to monitor the transportation network for accidents and other impediments to enhance safety by ensuring real–time distribution of traffic and transportation system data to the most appropriate respondent (i.e., police, ambulance, fire department). Moreover, license plate recognition could be used to identify unauthorized or illegal drivers. Similarly, the reduction of accident risks is associated with supported automated components (i.e., driver assistance systems voice recognition) by decreasing driver distraction and improving the perception of the drivers of the environment. Essentially, smart grid applications definitely increase the efficiency of urban performance against various attacks, natural disasters, and human errors.

On the other hand, there are several constraints since big data results in trade–offs between customer convenience, corporate profitability, policy effectiveness, and privacy (Fabrègue & Bogoni, 2023). It has found risks associated with data privacy and security, associated with cybercrime (i.e., self–propagating malware and ransomware threats such as cryptolocker, cryptowall, and wannacry) and unethical decision–

making in automated systems, including personal tracking and surveillance (Habibzadeh et al., 2019; Butler et al., 2020; Majid, 2023). In the context of data, various researchers have been posing important questions such as: “Who decides what data is collected, who it is shared with, and how to ensure that its generation and use does not result in the erosion of privacy for citizens?” (Galič & Schuilenburg, 2021, p. 1422). In this context, securing access to data is only one aspect of protecting individual privacy in smart cities; it is also necessary to address the knowledge that may be deduced from the data that has been collected. As smart mobility highly relies on ICT systems, users’ data must be protected from external permeability and inappropriate uses to safeguard users’ privacy and their personal information (Pompigna & Mauro, 2022). Then, building secure communication IoT systems is crucial against unauthorized users accessing the data flows. For instance, location–based services naturally raise privacy and security concerns as important information about the driver could be leaked due to the unique ID associated with the vehicle. Essentially, the core problem relies on the data–value creation process, especially the data extraction and analysis. It poses critical concerns about users’ privacy, autonomy, and legitimacy over personal information as it becomes complex to safeguard individual control.

Cybersecurity challenges may compromise users' privacy and data flow security due to the usage of cloud services to store metadata. For instance, drivers of smart vehicles may be tracked down as "attackers can inject false routes or simulate other vehicles in the environment to cause collisions" (Eckhoff & Wagner, 2017; Andrade et al., 2020, p. 15). Moreover, third parties may use CCTV and mobile technologies to spy on people and access their personal data. Technologies generate continuous co–production of high–speed data flow transmitted from sensors to the cloud servers. Dataflow management starts with sensing information analyzed through data mining and control (Pal et al., 2018). Data analytics and visualization play a vital role in examining the complex information and knowledge collected from various sources gathered by intertwined networks of devices and technologies. However, sensing nodes’ and their embedded communication modules' limited power availability is the main barrier to efficient and reliable data collecting in smart cities (Soyata et al., 2019). Their applications and systems generate vulnerabilities that originate from the security requirements, such as authentication, access control, and cryptography (Andrade et al., 2020). Therefore, it is essential to designate sophisticated algorithms capable of processing vast amounts of data in a diverse and dynamic environment to perform accurate data analysis and deliver raw data to smart applications. They require flexible and ad–hoc architecture to avoid privacy, cybersecurity risks, and other malicious practices. Then, it is crucial to maintain a secure wireless network with an emphasis on personal data protection through anonymization and pseudonymization. However, it is still complex and hard to achieve because actionable data must remain personal and identifiable information to be a valuable asset for stakeholders. Indeed, pseudonymized, informed consent, and privacy–by–design solutions are suggested to be effective strategies to safeguard citizens’ data while incentives technological growth and advancement.

Ethical guidelines and regulations are also critical to provide the best policing decision–making. They reflect societal values with a sense of belonging and identity, mutual care and support, connectivity and communication within shared value systems in the interests of the citizens' privacy. The interaction with human and social capital through technological solutions is heavily essential to building an efficient and secure communication system between citizens and governments. Urban growth is made by the social capital contributing to economic and social development. Then, it becomes essential to safeguard the common ideals and standards of social behavior represented in those connections. For instance, trust and civic obligation envisage a functioning society based on governance, cultural norms, and social rules. Indeed, social capital is composed of a "cluster of norms, rules, values, expectations, and sanctions" that must cooperate within a civic society (Allwinkle & Cruickshank, 2011, p. 5). Essentially, urban life is governed by context–specific norms that are followed by its citizens. The normative framework proposed by Nissenbaum (2004) evaluates the flow of information about individuals, accordingly to which privacy is associated and controlled by the information flow based on context–specific norms. The concept of contextual integrity underlines the importance of privacy from a broader social perspective. Clearly, a functioning social capital operates as a stimulus for a strong and solid economy. In the European Union, the General Data Protection Regulation (GDPR) aims to protect fundamental rights and freedoms against the erosion of privacy. Implemented in 2018, it harmonizes the regulation on the protection of personal data within the territory and for its citizens. The major attention on data protection highly increased citizens' trust in the digital society and the use of digital services. Moreover, citizens have the fundamental right to autonomously decide the modalities and limitations of data processing via the practice of consent. Hence, trust and autonomy are integral components of achieving effective smart governance. Citizens should not have concerns about privacy and security. They should have the power to decide for themselves, while stakeholders should be transparent on purposes of data collection practices. Essentially, society should not negatively perceive threats to their data autonomy, integrity, and confidentiality.

2.3. Toward an Ethical Governance and Urban Imaginary

The concept of smart cities, with its umbrella of applications, is extensively progressive. It assumes sustainable urban development with the adoption of cutting–edge technologies, resulting in functional and productive economic, social, and ecological management decision–making. Indeed, they gain greater attention and control of the economic and political benefits. For instance, smart road initiatives represent a rapidly expanding sector as a promising market in the next upcoming years. The innovative solutions aim to tackle urban challenges to connect users, vehicles, and infrastructures with a sustainable outlook by adopting intelligent technologies. The current urbanizing world is empowered by technologies, recognized as the core systems to enable intelligence based on interconnected communication.

Smart roads will definitely enrich the scenario of mobility. However, it depends on people and transportation networks that may be disrupted by terrorism, natural disasters (i.e., hurricanes, floods, and fires), cultural events, strikes, and system failures brought on by human error or inefficient management (Ribeiro et al., 2021). Moreover, the scenario of smart mobility is built around a large collective of various stakeholders and alliances (i.e., governments, companies, citizens) that collaboratively develop problem–solving strategies for a proper governance system to maximize a city's socio–economic and environmental performance. For this reason, city governance appears to be a complex process with higher interrelationships among the systems and stakeholders involved in the operations and developments of the process of smartification (Ribeiro et al., 2021; Bıyık et al., 2021). Therefore, it is crucial to take into consideration the relevance of this complex ecosystem. It is multifaceted and multilevel, encouraging collaboration in the private and public sectors of internal management and service delivery.

The progress of smartification cannot be understood without drawing the links and effects on the technical and social components, their principles and concepts, of an urban system. According to Dirks and Keeling (2009), cities are evolving as interconnected hubs based on thriving economic services, while the power is being realigned "with greater influence, but also greater responsibility" (p. 1). The adoption of smart technologies opens up several ethical debates, essentially due to power imbalances. Thus, the political sphere is de–centralized and privatized as the management is in the hands of public infrastructures, while private companies regulate the services, including citizens' data (Ranchordás, 2020; Galič & Schuilenburg, 2021). Consequently, this techno–centric perspective exploits technologies based on market–values with limited citizens' involvement in its decision–making.

Technology is seen as the only effective way to address the complex problems and challenges that urbanization is encountering. Hence, it is a common belief that "the only path forward for cities is making their infrastructure smarter through the use of novel technologies […] as value–neutral, objectivist, rational, and evidence–based tools" (Galič & Schuilenburg, 2021, p. 1420). The researchers speculate on a techno–utopian narrative in the ubiquitous adoption of technologies to manage city services and infrastructures. This narrative implies Morozov's "solutionism" approach as it "presumes rather than investigates the problems that it is trying to solve, reaching for the answer before the questions have been fully asked" (2013, p. 6, as cited in Galič & Schuilenburg, p. 1420). In other words, technological solutionism refers to the ideology of adopting technological solutions to address challenging real–world issues. This perspective is nurtured by the belief that replacing human components with technology could lead to a scenario without repercussions on society and the environment. Indeed, governments and businesses are eager to make processes efficient through technology while not considering alternative means of progress and innovation. In a nutshell, emerging technologies and their applications are increasingly shaped by this techno–utopianism narrative created around the concept of smart cities. They are seen as performative expressions and fictional visions of the societal faith to rely on technology and its ability to resolve problems and reinvent the human condition by delivering power to the communities.

The data–driven paradigm exploits technologies to foster expansion in the future mobility ecosystem. This is possible with effective urban planning, a shift in behavior, cutting–edge technology, encouraging legislation, financial incentives, and the involvement and leadership of the city. Technologies are crucial and highly significant in sustainable prosperity development. Indeed, the key prerequisite of smart city applications is the creation of advanced sensing information and communications systems, which feed an evaluation and modeling system to monitor critical urban parameters for effective management and governance. However, technologies cannot solely be considered the purpose and aim of smart cities (Pribyl et al., 2022). Urban growth “must integrate the equilibrium between nature and the physical environment, and the education of citizens, promoting more inclusive, tolerant, and open cities” (Ribeiro et al., 2021, p. 1). Ultimately, the current paradigm is expected to foster sustainable prosperity for the current and future generations without transforming society into an algorithm–driven ecosystem within a political surveillance approach.

Finally, it is worth mentioning that all decisions and solutions come with a cost and responsibility. It is difficult to forecast the scope and nature of the changes that will happen, especially what they will entail and how they will develop. However, it is crucial to acknowledge the potential impact of these forces on how organizations operate in the current competitive dynamics for value generation and customer value propositions through the regulation of users’ data. This process of smartification and digitalization is an on–going process that “cannot be simply bought” (Pribyl et al., 2022, p. 3). Indeed, the vision for smartness is inextricably linked with infrastructures, mobilizing services, and adopting a policy for modernization and innovation. In the context of smart urban governance, narratives and practices around the concept of smartness should place a greater emphasis on the role that urban challenges play in stipulating the functional support of technological innovations than simply on the problem–solving capabilities of big data, city sensors, and intelligent infrastructure (Jiang et al., 2020). Therefore, smart governance should promote an ethical approach by starting with a sociotechnical perspective, promoting technological innovation in a specific context, without compromising citizens’ right to privacy, while regulating the narratives rooted around the evolution of smartness in smart city initiatives.

3. Methodology

This chapter discusses the methodology approach in detail. The analytical choices made for this investigation will be discussed in this section. The research adopts a qualitative content analysis in a case study research. It aims to explore the users' privacy within the regulatory framework integrated into smart mobility, in relation to the technological application of Smart Roads. First, a general description of the research design, together with a comprehensive rationale, are given. It follows a comprehensive explanation of the case study chosen, namely Smart Road Plan, in Italy. After this, the operationalization is described, followed by the rationality behind the data analysis applying a systematic and informed approach, while including the sampling method and data collection processes. Lastly, a critical analysis of the research design, along with some ethical considerations, are further rationalized.

3.1. Qualitative Content Analysis

This qualitative research adopts a mix of theory–driven and data–driven methodologies to gain a holistic and informed understanding of users' privacy in the policies and strategies of Smart Road in Italy. This study aims to offer effective suggestions for supporting technological progress in the field of smart mobility. Particularly, smart roads represent a form of surveillance assemblage in which citizens are abstracted from their territorial and spatial contexts (Haggerty & Ericson, 2003). They pose various challenges regarding users' privacy and data flow security. This research aims to provide valuable insights contributing to expanding the current literature and providing valuable solutions and practical insights to decision–makers and stakeholders.

The contemporary inquiry is exemplary regarding the privacy and security implications drawn in the theoretical framework. Indeed, their boundaries are not clearly evident in the regulatory context of the various experimental projects. Contrarily, it simply indicates that privacy and data protection legislation must comply with the technological advancement of such a legislative context. However, it has shown that technologies' design (i.e., privacy and cybersecurity) may harm citizens. Moreover, Smart Road Plan is expandable to a broader project in relation to smart mobility and Connected Intelligent Transport Systems (C–ITS) specifications and standards within Italy and European Union. In this market, a regulatory framework has been adopted by the European Commission. Thus, the case study consists of a "detailed investigation of a phenomenon within their context over a period of time" (Hartley, 2004, p. 323, as cited in Kohlbacher, 2006, p. 5). Based on this assumption, it supports a better understanding of the causal links and pathways resulting from a new privacy policy development and implementation of the smart road mobility in Italy.

Given the purpose and scope of this study, this research strategy is appropriated to represent an in–depth and longitudinal investigation of a real–world application of theories and concepts for a practical and applicable understanding of privacy and security in relation to the Smart Road Plan. These aspects must be addressed systematically and objectively as the latent and context–dependent meanings elucidate the complex relationships in a real–life context. Therefore, a qualitative research approach is effective in focusing the interpretations on drawing inextricably links between the data and the theoretical framework, through the development of a systematic coding scheme. Hence, the flexible approach allows the analytical generalization provided by the theoretical framework and practical insights as the legal framework will be analyzed theoretically and thematically by identifying relationships, connections, and patterns among the meanings.

3.2. Case Study Research: Smart Road Plan, Italy

Anas S.p.A. (National Autonomous Roads Corporation) is an Italian–based company responsible for constructing and maintaining motorways and state highways by overseeing road infrastructures and territorial protection under the supervision of the Italian Ministry of Infrastructure and Transport (MIT). Founded in 1928, the leading agency was officially recognized in 1946 to reconstruct the road network damaged during World War II as governed by the Legislative Decree No. 38 of 27 June. In 2018, it became part of the Italian State Railways, the national state–owned railway enterprise, which takes control over the management of the majority of rail infrastructure. Throughout the years, Anas S.p.A. has been strengthening the progressive improvement of road assets, providing constant maintenance and intermodal connections. Currently, it is involved in an ambitious project that enhances connectivity among people, vehicles, objects, and infrastructures with the purpose of realizing the first Italian Smart Road, supported by services for autonomous vehicles. MIT considers the technological component as the key element for such digital transformation towards smart mobility growth, with a direct benefit and public value for citizens and businesses. Since 2016, the Ministry of Infrastructure and Transport has been actively working on policies and strategies for leading the country to economically, socially, and environmentally sustainable progress, as established in articles 9 and 41 of the Italian Constitution, in line with the European political objectives. However, the policy context of the transport and logistics infrastructure sector is fragmented and characterized by a plurality of regulatory instruments. The first implementation of the Intelligent Transport System (ITS), aimed at promoting sustainable mobility, was carried out within the General Plan of Transport and Logistics of 2001 and subsequently in the 2007 Mobility Plan Guidelines. Ultimately, the initiative of Smart Road is governed by the Decree of the Minister of Infrastructure and Transport envisaged by the 2018 Budget Law, No. 70 (in implementation of article 1, paragraph 72), published in the Official Italian Gazette.

Anas S.p.A. is operating a progressive digitalization project involving a 3.000 km smart road network in collaboration with the Italian Ministry of Infrastructure and Transport and the European Commission. The ambitious project involves the highways, namely Orte–Mestre (E45–E55), the Palermo–Catania (A19), the Roma–Fiumicino (A91), the Salerno–Reggio Calabria (A2), and the Catania ring road (RA15), the Great Ring Junction (A90), including those Italian infrastructures belonging to the Trans European Network (TEN–T). However, the first intervention, along the highway of Alemagna (SS51), began on the occasion of the Cortina 2021 World Ski Championships, foreseeing for Milan–Cortina 2026 Olympic Games. Cortina, one of the most well–known and expansive ski areas in the Dolomites, is expected to welcome a considerable flux of visitors for the sporting event. Indeed, the implementation of the Smart Road is based on forecast models of long–term mobility and traffic demand. Then, it becomes essential to offer an integrated infrastructure network for the management of mobility for efficient viability and security in the valley. This investment has a relevant impact on mobility with long–term applications, including sporting events and others. For instance, it allows dynamic parking booking and provides basic parking guidance tools; it also manages the booking and availability of electric charging points; and finally, it integrates with special transport services and the main hotel and reception services. The Olympic Games represent a unique opportunity to invest in infrastructures, accessibilities, facilities, and services for extended gains in tourism, human capital, urban transformation, and cultural reputation.

The development of Smart Road in Cortina aims to optimize urban mobility in the valley. It ensures a fluid vehicular traffic flow by preventing risks and providing assistance to the users. This is possible through real–time monitoring of traffic, road, and weather conditions to guarantee mobility quality and efficiency by reducing environmental impacts and risk of accidents. Indeed, the mission is to provide a performative exchange of infrastructure–user information and dialogue between users in a Road Site Unit thanks to 5G networks, Ultrabroadband, and Cellular–Vehicle–to–Everything (C–V2X), Vehicle–to–Vehicle (V2V), and Vehicle–to–Infrastructure (V2I) technologies. Anas S.p.A. has installed multifunctional poles equipped with high–tech cameras and multi–sensors, namely distributed acoustic sensing (DAS) and distributed thermal sensing (DTS), resistant to temperature variations and thermal shocks along 80 km of the SS51. These cutting–edge technologies constantly monitor the flow of traffic by processing information in real–time to make effective and efficient decisions and predictions. Indeed, the control room (urban dashboards) could proactively predict analytics and useful data in advance and provide them to the drivers at any time. A direct and customized dialogue between drivers and infrastructures is established thanks to an app, developed in collaboration with the Massachusetts Institute of Technology think–tank *Senseable City Lab*. The *GoodVibrations* App is used for monitoring the infrastructure status thanks to the smartphone sensing technique that detects the surrounding's axis–based motion orientation. It collects accelerometric data, together with advanced analytics algorithms and real–time pre–alerts of vibration anomalies, to provide immediate assistance. This initiative encourages constant and real–time communication with the territory among users. These technical solutions generate data used to send messages to drivers' mobile phones or their vehicle's onboard navigation systems. Indeed, the leading factor of this digital progress refers to the constant exchange of information between the infrastructure, user, and vehicle. The driver assistance system ensures the dialogue for analyzing the surrounding environment, assisting the vehicles with status updates, and automating route planning.

Smart Road drives new challenges by implementing further services by 2030. They include traffic flow diversion, intervention on average speeds to avoid congestion, trajectory suggestions, dynamic management of accesses, parking, and refueling areas. The ultimate purpose is to guarantee an adequate infrastructure network that supports autonomous vehicle driving. This new concept of the intelligent road also optimizes electric mobility with eco–sustainability objectives by building strategic green islands, approximately every 30 km. These areas are conceptualized as energy cores for producing renewable electricity adopted with photovoltaic and wind power. These recharging and parking areas are also provided with drones that allow road traffic monitoring and surveillance. However, drones are not activated yet due to lacking a regulatory framework.

The initiative promotes a digital pioneering infrastructure system for acquiring and exchanging mobility–related data to enhance traffic control and safety conditions. The data (i.e., position data, vehicle movement, acceleration and deceleration) are collected by the sensors (i.e., GPS, accelerometer, gyroscope). They deliver customized warnings and alerts, create customized statistics based on such real–time services for management and control of infrastructures and roads. The constant monitoring allows citizens to be informed about their spatiotemporal environments providing user–centric services thanks to cutting–edge technologies, including Road Weather Information System (RWIS), and Automatic Roadworks Extensions Alert System (AREA). Their applications results in traffic control (e.g., traffic detection and forecasting, traffic regulations, dynamic signage management), mobility management (e.g., demand management, infrastructure management, special event management), and safety prevention (e.g., notification of speed limits, reproduction of road signs on board of the vehicle, improper behaviors, weather conditions, notifications of alternative routes, roadworks, accidents).

Under these circumstances, Cortina must guarantee a sustainable development of security policies and strategies against perceived risks and threats. As a prestigious sport–mega event, the Olympic Games attract huge interest and participation worldwide. So, the mass movement of people must be assessed in its density and visibility, considering the specific set of layered national and urban geographies. Indeed, the migration flows of people and objects across borders are strengthened with surveillance and monitoring practices to safeguard one's security in a certain space. The adoption of sophisticated digital technologies supports the prevention of "perceived terrorist threats, spectator violence, and broader risks associated with poverty, social divisions, and urban crime" (Giulianotti & Klauser, 2010, p. 1). Thus, security is the biggest key driver of smart technologies. They provide effective protection and prevention against criminality, and "disorder from tracking, searching, and detecting suspects to proactive crime prevention by identifying crime hot spots and the use of predictive policing (Galič & Schuilenburg, 2021, p. 1422).

As a result, the Olympic Games are the biggest security spectacle in the world, especially since the terrorist attacks of 9/11 that have greatly impacted Western countries' concerns about national security (Lyon, 2022). The competitive event serves as a kind of "superpanopticon," providing constant societal control and activity monitoring of the population due to its widespread appeal, live and virtual media coverage, crowd control, and interconnected network of surveillance solutions. Additionally, political violence and terrorist threats are frequently seen as a "symbolic and political embarrassment, […] with financial risk for host nations and organizing institutions" (Giulianotti & Klauser, p. 4). As a result, it is essential to supervise the population's behavior and tracks their movements in time and space to safeguard national security. Through that, Cortina's urban context and spatiality have been altered in the intentions and aims for surveillance and scrutiny. Thus, Smart Road performs as a surveillant assemblage by providing a considerable production of open data flows for mobility and security.

In the context of urban mobility and security, the first Italian Smart Road represents an innovative digital transformation, both at the national planning level and in industrial development. Smart Road is an expanding sector for a secure and sustainable road network in line with smart mobility principles. This digital transformation of road infrastructures represents a key–leading factor for sustainable, intelligent, and inclusive growth thanks to advanced technologies. It represents a milestone in leveraging digitalization to boost smart mobility toward a sustainable generation of renewable energy sources for autonomous and electric mobility by implementing connected and intelligent infrastructures. This project involves various stakeholders, addressing new technological scenarios, projects, and research as a key factor for the national sustainable, intelligent, and inclusive growth in line with European objectives. Smart Road is the key element of the EU's Cooperative Intelligent Transport Systems plan, which aims to create intelligent ecosystems of roads, enabling real–time and automated traffic management by improving driver's experience, reducing CO2 emissions, and reducing road accidents. It offers a unique opportunity to improve road safety while enhancing environmental sustainability; however, it facilitates monitoring practices due to pervasive technologies, enriching a panopticon networked–mediated form of surveillance. The initiative of Smart Road Plan has become a form of surveillance assemblage in which individuals are abstracted from their territorial and spatial settings in an exchange of data from the citizens to the infrastructures (Haggerty & Ericson, 2003). It is necessary to adopt technological standards for implementing the guidelines and references dictated by the various regulations, to empower prosperous digital progress. However, the objectives set at the National and European level have not yet been achieved. Consequently, MIT has adopted precise technological performance standards in the context of Smart Roads, in line with new infrastructural policies. The mission is to identify the order of priority of specifications while considering infrastructure management, data governance, and how the private sector is heading. This systematic approach provides the centrality of the logical and functional aspects, including the definition of the data and information that could be exchanged between the various functions and the collection and analysis systems.

3.3. Operationalization

This study explores the regulatory framework concerning the case study of the Smart Road Plan. In this context, urban management is highly diversified and institutionalized by multiple stakeholders, leaders, and organizations. Although the project is interested in the Italian legal market, it involves local and international collaborations within Europe. Considering the plethora of regulatory frameworks from various stakeholders in the Italian and European markets is necessary. Indeed, this study investigates regulations, policies, and similar issued by crucial stakeholders involved in this applied smart mobility initiative. Overall, it was found N = 14 units of analysis of at least 2000 words, relatively N = 8 Italian units and N = 6 European units of regulations and policies from the relevant stakeholders and organizations, namely The President of the Italian Republic, The Italian Ministry of Infrastructure and Transport (MIT), The Italian Ministry of Technological Innovation and Digitization (MID), the Italian Ministry of Infrastructure and Sustainable Mobility (MISM), Anas S.p.A., The Italian Connected Car & Mobility Observatory, The European Commission, The European Parliament and the Council (see Appendix A). The combination of their involvement and power management in shaping and affecting the development of the Smart Road Plan represents a significant criterion for the data selection. Moreover, the dataset was chosen by applying purposive and convenience sampling given the influential, relevant stakeholders according to ease of access and proximity to the sensitive political and legislative data. Indeed, the data was retrieved from online archives of the official websites through a keywords strategy in the search bar. Smart Road Plan, as a keyword, was used to lead the first data collection to identify regulations linked with the mobility initiative. Subsequently, they were further selected to their correlation with the keywords privacy and security, accordingly to the research question and the technological progress involved.

The policies and strategies represent guidelines for the assessment of smart governance in relation to the critical components of privacy and security. According to the theoretical framework, they are recognized as crucial challenges in the progressive digitization of roads, which have become information hubs for inter–collaboration in the mobility of citizens between drivers, vehicles, and the environment. Smart roads gather large volumes of personal and sensitive information via advanced information technologies (i.e., IoT, cloud computing, Big Data, artificial intelligence). Relatively, roads are constellations of urban processes integrated with technological progress with relevant consequences on human and social capital regardless of the intention to create an attractive and flourishing scenario. Then, smart roads represent an ideal scenario in which intelligent technological solutions are adopted. Integrated mobility is organized in a productive and effective manner to optimize urban functions and services, increase energy efficiency, and promote social, economic, and environmental sustainability growth. In a nutshell, the theoretical propositions investigated in the theoretical framework concerning privacy and security are inductively explored through the case study inquiry with a data–driven approach. However, the extensive comprehension of the theoretical framework supports a deductive approach with a theory–driven logic to analyzing data. Therefore, a case study inquiry informs the development of theories by underlying the links between the problem and the solution, accordingly to the research question.

3.4. Data Analysis

The regulatory framework focuses on the Smart Road Plan in the Italian national territory, integrated into the European political and legislative context. It includes strategies and policies involved in the development of this initiative since 2010. The broad time frame supports a holistic perspective on the integration of citizens' privacy and security along with technological growth. However, significant attention has been given to the spectrum policy and strategic planning after the introduction of the General Data Protection Regulation (GDPR) in the European Economic as represents a significant milestone in protecting citizens' privacy.

Precisely, the units of analysis are explored by identifying categories relevant to the research question. From the development of a systematic coding scheme, the data are examined by identifying relationships, connections, and patterns. This iterative and dynamic process combines concept–driven and data–driven perspectives in the implementation of a coding frame (see Appendix B). The fundamental core of a content analysis refers to the coding frame that organizes and categorizes information into categories related to the research question. Hence, the coding frame consists of main categories underlying important aspects and subcategories for each meaning investigated. It contains the main features, descriptions, and interpretations that are theoretically and thematically interpreted (Schreier, 2014). It is characterized by mutual exclusiveness, unidimensionality, and exhaustiveness. Moreover, the coding categories are further explained with a definition and a description of the main arguments, providing quotes, where possible.

This level of abstraction of the data is a highly systematic process that contains a solid and valid description of the data by assigning segments to the categories chosen. This dynamic process is applied to latent and context–dependent meanings. Qualitative approach focuses on the meanings and interpretations to uncover details and complexity with a strong concept–driven approach based on the theoretical framework with deductive reasoning. Essentially, the content analysis lays the foundation for an in–depth analysis of the regulatory frameworks starting with a decontextualization and recontextualization of the data by drawing connections and inferences. Firstly, each unit of analysis was analyzed by looking at the integration of citizens' privacy and security with technological progress. Also, it was considered the relationships with the concepts investigated in the theoretical framework. Subsequently, the notions were analyzed together by drawing links and connections with the various regulatory frameworks. This final categorization stage offers a homogeneous representation of the meanings and codes found. Lastly, each stage is performed several times to guarantee the quality and trustworthiness of the analysis by evaluating and improving the coding frame. Once the codebook was finalized, the data were analyzed and interpreted by taking into consideration the latent and context–dependent meanings and implications. A flexible analytical and critical perspective was maintained throughout the whole process for providing valuable insights and patterns.

3.5. Critical Reflections

It is essential to approach the research design with a systematic and rigorous approach to data collection and analysis to ensure the results' validity and reliability. Consequently, these components are critically evaluated in this research design to ensure the transparency and reproducibility of the qualitative content analysis. According to Babbie (2008), validity and reliability are concepts used to evaluate the quality and rigor of research, respectively measuring the accuracy and consistency of the empirical measurements. However, it should be noted that validity cannot be entirely assessed in qualitative research as it is measured in quantitative research (Cypress, 2017). Taking this into account, it could be argued that validity cannot be unquestionably assured, despite being a crucial factor in the context of this study. Rigorous standards of trustworthiness are achieved in the evaluation of the findings. Trustworthiness refers to the degree of integrity of a study in its data, interpretation, and procedures (Cypress, 2017). As mentioned by Lincoln and Guba (1985), this concept relies on four general criteria, namely credibility, transferability, dependability, and confirmability. These criteria were considered throughout the research process.

The case study research provides in–depth and rich qualitative information regarding a real–world application. However, it does not generate findings for a wider population. It may also lack replicability as the data are collected with a retrospective approach within a time frame. This type of inquiry is often criticized for its lack of rigor and reliability, together with the issues of generalizability (Kohlbacher, 2006). Despite the limitations, case studies are seen as a "rigorous research strategy in its own right" as it aims to understand the complex social and cultural phenomenon in a real–life context (2006, p. 3; Puppis, 2019). Case study research provides a generalization to theoretical propositions providing innovative insights into the context and processes of the context studied. It is indeed an empirical inquiry as it investigates "the boundaries between phenomenon and context," even when there are not clearly evident. It provides logical thinking of the data to the theoretical propositions for critical normatively and academically grounded contributions and recommendations to the policy processes, media institutions, and other stakeholders involved.

It is significant to address the role of research reflexivity, as one's researcher uniquely values elements and aspects within the study based on prior cultural, political, and social experiences, beliefs, and judgments. This study is not an exception. As qualitative research heavily relies on subjectivity, the data were evaluated by colleagues to ensure similar and consistent understanding. The evaluation of inter–rater reliability is functional to guarantee rigorousness in the data interpretation based on a common degree of agreement. Lastly, no ethical concerns are found. Therefore, this research design meets the guidelines of the Code of Conduct for Research Integrity, as set forth by the Netherlands Association of Universities (VSNU).

4. Results

In this chapter, the main categories, and related subcategories, of the content analysis will be presented considering the research question. The qualitative analysis resulted in four categories, namely: data privacy, pitfalls of technologies, data protection & security, governance & accountability. The first two categories reflect on issues and threats of the Smart Road Plan, considering the privacy of sensitive data collected and the vulnerabilities of technological progress. The remaining categories focus on data protection and security, associated with strategies and principles within the technological, legal, and social aspects. Lastly, key insights and reflections are drawn. Please, refer to Appendix A to further analyze the context of the quotes reported from the regulatory frameworks accordingly to the letter classification.

4.1. Data Privacy

Smart Roads Plan generates large amounts of static (e.g., geometry, number of lanes, road signs, speed limits, tools) and dynamic data (e.g., reversible rules and arrangements, road conditions, speed control, lane control, ramp metering) concerning the road–side unit to ensure strategic and coordinated traffic and mobility management. The basic data collected refer to historical and real–time information on–road traffic characteristics, including in–vehicle condition/ status, end–user behavior and journey (e.g., traffic volumes/flows, location, presence of accidents and congestion, speed, journey times). Smart Road initiatives are built around huge data flows integrated into different management platforms. Given the plethora of sources, it is particularly important to associate each measure with each data to ensure integrity, also in terms of reliability, updating, accuracy, and completeness, through metadata. However, it poses profound privacy concerns that are not critically addressed in the legal frameworks analyzed. Although stakeholders and governments seem to be aware as Smart Road applications collect personal and sensitive data, they are focused on the effectiveness and benefits of these initiatives. Controversially, the protection of personal data and privacy is an influential component for the successful effectiveness of Smart Roads based on data processing models, integrated with advanced predictive analytics.

On the contrary, it is largely highlighted that Smart Road Plan exploits these data mainly for management and optimization purposes to recognize potential threats to mobility and to enhance accessibility. It reduces journey times and intermodal routes, granting maintenance of the transport networks and infrastructures. Furthermore, the interaction with users (crowdsourcing) is essential to receive data and information from vehicles, "through personal and on–board devices or obtained directly from vehicles using the V2I communication platform and other communication methods," according to the Italian Ministry of Infrastructure and Transport (see D). Indeed, sensitive information is largely and primarily collected through sensors installed into personal devices. While it offers various advantages (i.e., speed, accuracy, low cost), it carries potential risks and challenges associated with data security and privacy. Data could potentially be stolen or improperly accessed.

The valuable and reliable information about mobility aims to promote high–quality services impacting “travel behavior, social inclusion and urban development, environment, entertainment and commerce, growth and jobs,” according to the European Commission (see G). For instance, the continuous instrumental monitoring of the road–side unit infrastructures enhances the promptness of risk analysis and emergency management in the assessment of the state of vulnerability. Smart Road Plan has the capability to identify “located areas at risks or subjects to extreme climatic and meteorological conditions (i.e., earthquakes, landslides, floods),” according to the Ministry of Infrastructure and Sustainable Mobility (see M). It also recognizes illegal behavior (e.g., exceeding speed, prohibited transits, dangerous maneuvers, stationary vehicles or in prohibited direction, serious accidents) with the conformity plate checks. In the context of security and safety, police and civil associations are involved in emergency management (e.g., rescue bodies). On the other hand, security is not often correlated to privacy. It is indeed context–dependent, although it is largely used to describe the effective sides against crime interplaying safety on the urban scale.

The pervasive monitoring of the infrastructure networks results in a state of hyper–connectivity that optimizes the management of the functional standards of the urban fabric. The management and organization of the infrastructural assets involve “non–end users (e.g., authorities and road operators, service providers) and end–users (e.g., road users, natural and legal persons, vehicles),” according to the Italian Ministry of Infrastructure and Transport (see D). These stakeholders collaborate to ensure more connected and safer roads by activating cooperative functions between users and infrastructures. Indeed, infomobility represents a core component as a means of communication and information exchange. It offers dynamic multi–modal information to users by “timely updating of available road and traffic data used for multimodal travel information by relevant public authorities and [private] stakeholders,” according to the European Parliament and the Council (see A). In a nutshell, the mobility data flows are extremely significant in the improvement of Smart Road performance by “comparing current [real–time] data with target data,” according to the Italian Ministry of Infrastructure and Transport (see H). Basically, static and dynamic data are combined to find patterns and insights to identify threats and opportunities, such as “identify[ing] ‘black spots’ for infrastructure safety, effectiveness, and resilience,” according to the Italian Ministry of Infrastructure and Transport (see D, H). Advanced predictive analytics support the performance analysis to “make efficient predictions and strategies using historical data, and possibly other data obtainable from third parties, combined with statistical modeling,” according to the Italian Ministry of Infrastructure and Transport (see D). Hence, analytics could support internal performance and productivity thanks to the evolution of computing ability and the development of artificial intelligence. This predictive practice could recognize patterns, predict outcomes, and weigh probabilities based on contextual data and real–time data from multiple sources. These observations represent the guidance of the performance of Smart Roads as it enables identifying anomalies and inefficiencies to improve the maintenance and management of the urban fabric. However, it poses ethical concerns related to biases and discrimination as it may perpetuate patterns against minority groups and vulnerable demographics.

The successful implementation of cooperative and connected communication systems based on personal data and privacy protection depends on data and information processing models “collected and stored by road authorities, road network managers, and real–time traffic information service providers [at national access points],” according to the European Parliament and the Council (see C). Hence, personal and sensitive data are protected “against improper use, including unauthorized access, alteration, or loss,” according to the European Parliament and the Council (see A). The various stakeholders (e.g., road operators, service providers, public traffic information broadcasters) are committed to disclosing “minimum universal traffic information related to road safety to end–users” to guarantee “fair access, storage, and sharing of vehicle data,” according to the European Parliament and the Council (see B). The current legislative framework supervises commercial agreements with third parties. However, stakeholders are relatively limited to reaching a commercial agreement for the reuse of relevant data; only if they are “aggregate data that can be used, anonymously, for statistical purposes and the possibility of granting advertising spaces,” according to Anas S.p.A. (see N). At the European level, the transmission of the data facilitates the management of the infrastructure assets. The objective is to ensure security with an open data approach that encourages the use, reuse, and free distribution of datasets allowing governments to promote citizen–centric services, particularly for advertising for marketing purposes. As a result, it becomes essential to investigate one’s consent and right to object or the right to be forgotten as a legal basis, together with the legitimate interests in processing data, to ensure a fair legislative procedure in the interests of citizens’ privacy and security.

4.2. Pitfalls of Technologies

The digital Smart Road transformation is driven by advanced technological progress, which is described as the “strongest driver and enabler,” according to the European Commission (see E). Hence, Smart Road Plan aims to improve the safety and quality standards of the infrastructural networks, while ensuring continuity in maintenance through actions aimed at the use of innovative technologies in an open and all–encompassing system architecture with enabling platforms and structures. Adopting Cooperative Intelligent Transport Systems (C–ITS) represents an essential part of the digital transformation toward technologically advanced road infrastructures. According to the European Parliament and the Council, these services provide “accurate and guaranteed synchronization and positioning services, using satellite infrastructures or any other technology that offers an equivalent level of precision” (see A). The significant accuracy of data is also ensured by sensors IoT that enables “constant transmission, acquisition of data, and information to/from the gateway and/or concentrator,” according to the Italian Ministry of Infrastructure and Transport (see D). In a nutshell, these technologies enable vehicles to communicate with each other and/or with the users thanks to the technical conformity of interoperability, which refers to the capability and functionality of information systems to exchange data by granting mutual access. Indeed, the cooperative and connected communication systems highly rely on interoperability, based on “open and public standards, accessible on a non–

discriminatory basis to all suppliers and users of applications and services," according to the European Parliament and the Council (see A). In the transportation network, data exchange between various stakeholders matches in real–time interactions across borders and transport modes at all levels (i.e., infrastructure, data, services, applications, and networks). Indeed, interoperability enables connected and coordinated communication flows among various systems, devices, and platforms with a cross–organizational collaboration approach, achieving higher efficiency and quality with data management by minimizing the time and costs of process data and additional maintenance of systems and software.

However, legal frameworks have shown a relevant fragmented and uncoordinated security solutions scenario that challenges the privacy of interoperability and the safety of end–users at risk. Furthermore, technologies enable pervasive monitoring by detecting "measurements of infrastructural parameters in real–time for predictive maintenance" for improving the "processes of design, maintenance, and diagnosis or prognosis of malfunctions," according to the Ministry of Infrastructure and Sustainable Mobility (see M). The implementation of advanced data–driven procedures is given by "sensory data, combined with historical data, human skills, and simulated learning," according to the Ministry of Infrastructure and Sustainable Mobility (see M). It is indeed recognized the importance of agreed standards on C–ITS system specifications to ensure geographical continuity. They "should not undermine issues of national security or on in the interests of defense," according to the European Parliament and the Council (see A). At the European level, it is highlighted the necessity to "introduce specifications, standards, provisions, and procedures to assess the conformity of their development and dissemination, taking into account technological progress and financial effort" (see A).

Lastly, Smart Road Plan represents an ideal scenario for automated and connected vehicles thanks to the various types of sensors, software for processing data and interpreting traffic situations, learning software for making driving decisions and implementing them, and components for integration with the traditional vehicle. This digital progress encapsulates the scenario of the future of highway and self–driving vehicles as they communicate with other vehicles and infrastructural networks, using real–time traffic and mobility data to forecast potential problems for efficient management. However, the European Commission states that these technologies bring new challenges for regulators and policymakers associated with "road safety, environmental, societal, and ethical issues, cybersecurity protection of personal data, competitiveness, and jobs" (see G). Hence, the European Commission suggests to further analyzing the "societal aspects (i.e., driver acceptance, ethical issues, social inclusion) and economic issues (i.e., impact on economic activities, environmental issues)" of these vehicles (see G). Again, regulation and specifications are major hurdles in their development as they could only operate once certain requirements are met. Particularly, the European Commission is questioning "how to develop a new coherent legal framework for some vehicles that have not yet been built" as it has found particularly important to ensure flexibility along with technological progress (see G).

4.3. Data Protection & Security

It has found six core principles of privacy protection that ensure appropriate security and confidentiality of personal data. These principles are also at the center of the General Data Protection Regulation (GDPR) as guiding fundamentals to address the legitimization of the right to privacy. At the European level, it is suggested to guarantee transparency regards "terms and conditions, using clear and plain language in an intelligible way and in easily accessible forms, enabling them to give their consent for the processing of their personal data," according to the European Commission (see E). Consent is the main lawful basis for data processing, as consumers must have control over their personal data. It must be freely granted and given voluntarily in an informed way. Consequently, institutions and stakeholders must support users to "understand for what purpose the data concerning them are collected and how they will be used," according to Anas S.p.A. (see N). As a result, the consensual permission in the agreement of disclosing personal information is informed and taken on a voluntary basis given sufficient information and understanding of the conditions of data processing.

The principle of transparency and the other key principles are incorporated into the innovative concept of privacy–by–design, namely: purpose limitation, data minimization, anonymization, and pseudonymization. The current regulatory frameworks suggest implementing appropriate technical and organizational measures and standards for data processing. For instance, the practices of anonymization and pseudonymization are configured in the technical design. While, purpose limitation and data minimization are organizational interventions in relation to the required adequate, relevant, and limited data and associated intentions demonstrated by stakeholders.

Under these principles, the current legal frameworks highlight the importance of confidentiality and the right to be informed. Hence, data subjects must be informed about the collection and use of their personal data, precisely of the "data acquisition, the methods governing the collection and potential traceability, and the period of time in which the data has documented," according to the European Parliament and the Council (see C). The right to be informed is significantly important, considering the transparency measures required from platforms and stakeholders. Furthermore, "the collection and storage of sensitive data and the ability to analyze individual and collective behavior" by processing sensitive data in real–time represents a potential threat to confidentiality, according to Anas S.p.A. (see N). Hence, open and transparent communication must be guaranteed to grant users confidentiality and their right to privacy.

In various legal frameworks, intrinsic technical measures are highlighted for data protection and security against improper users, vulnerabilities to hacking, and cyberattacks. The basic assumptions are fundamentally designated on the "set minimum requirements for local security practices (physical controls, personnel controls, procedural controls) and technical security practices (computer security controls, network security controls, cryptographic module engineering controls)," according to the European Commission (see I). Cryptographic technologies are mostly indicated as requirements "concerning the signature algorithm, key length, random number generator, and link certificates" to protect information and communication, according to the European Commission (see I). Furthermore, cryptography is exploited in the Public Key Infrastructure (PKI) as “guidance to assess which level of trust can be established in the received information by any receiver of a message authenticated by an end–entity certificate” using pseudonym certificates, according to the European Commission (see I). These technical strategies are widely acclaimed in the current legal framework of the Smart Road Plan, together with the Building Information Modelling (BIM) “for a standardized information kit in which the data of the entire life cycle contextualized in the territory are cataloged,” according to the Italian Ministry of Infrastructure and Transport (see H). BIM, a digital and three–dimensional representation of infrastructural networks, is extremely essential as the large data flows cross–domain platforms require strategic time management and cost analysis to consider. Improving accuracy, coordination, and efficiency in communication and collaboration among stakeholders is incredibly beneficial. However, it addresses privacy and security risks as sensitive information may be a target for cybercriminals because BIM is increasingly data–rich and centralized in one internal system. Then, performing a risk analysis by implementing identity verification controls and up–to–date antivirus software becomes critical.

Lastly, it has been found significantly important to ensure an international common security roadmap aligned with the technological progress for data protection and security. The regulatory harmonization represents a requirement that facilitates a common protocols framework to bring into conformity robust global standards for avoiding uncertainty and rebuilding reputation. At a European level, Data Protection Authorities aim “to develop a sector–based data protection impact assessment template to be used when introducing new C–ITS services,” according to the European Commission (see E). As a result, these efforts promote an extensive and in–depth national discussion about ethical and legal connotations regarding connected and self–driving vehicles from a security standpoint (i.e., data ownership, circulation patterns and effective use of data, privacy, and confidentiality, protection of a competitive market) for an efficient data use and its processing associated with the use of the real–time monitoring tools involved. Consequently, the development of a strategic plan intends to flourish the innovation of new technologies and standards in the Smart Road applications and services.

4.4. Governance & Accountability

In the context of data privacy and security, it is relevant to define the roles and responsibilities for ensuring accountability and ownership in the view of a legal and social context. In the legal frameworks analyzed, governance and accountability are found critically engaging in defining the legal basis incorporated to cooperation and collaboration with the various stakeholders to better respond to the social acceptance and trust to advanced technologies and personal data exploitation. Definitely, the General Data Protection Regulation (GDPR) represents a significant milestone in protecting the right to privacy. Indeed, GDPR is a turning point regarding data protection and privacy issues as it poses particular attention to protecting citizens from malicious practices throughout the data lifecycle. Before GDPR was introduced in 2018, the

European legal framework refers to Directive 95/46/EC, concerning the protection of individuals with regard to the processing of personal data and their free movement. Subsequently, major attention to cybersecurity and data protection is given by national and local entities, pointing out the potential threats to cybersecurity, integrity, and safety. Indeed, Anas S.p.A., the leading agency, reports that "data are acquired, treated, and used accordingly to the privacy legislation without the possibility of transferring them to third parties, thus guaranteeing the non–discloseability" (see N). However, they still largely focus on the positive asset of digital solutions, despite the adoption of advanced technologies and advanced analytics, in correlation with the capability to monitor, control, and respond promptly and effectively to the management and maintenance of the urban infrastructural networks. For instance, it is interesting to notice relevant attention on crime prevention and control thanks to the technologies and data collected, while little consideration is addressed to the protection against cybercrime threats.

Although GDPR successfully protects citizens' privacy, the current legislative framework is characterized by a particular fragmentation due to the existence of a plurality of normative and strategical instruments, as previously mentioned. Indeed, it is largely suggested to adopt specific technological principles, standards, and specifications for present and future progress. It is important to allow flexibility toward infrastructure management and data governance by avoiding the risk of obsolescence. At a national and local level, it has found majorly underlined the prominence of close cooperation with members states and key stakeholders (i.e., ITS service providers, user associations, transport, and facility operators, responsible national security associations, representatives of manufacturing companies, social partners, professional associations, local and public authorities, and related suppliers and operators). This synergy represents a requirement to develop an efficient know–how governance based on sharing knowledge and experience.

Furthermore, the diverse backgrounds of states and stakeholders could further improve practices associated with measuring and monitoring the quality and accuracy of data, including geo–localization practices. The efficiency of collecting and processing personal data is recognized as a critical asset to developing sustainable prosperity through Smart Road applications, despite their risks and concerns regards privacy and security. Therefore, "users must have the assurance that personal data are not a commodity, and know they can effectively control how and for what purposes their data are being used," according to the European Commission (see E). Under these circumstances, it becomes extremely relevant to support the social responsiveness of citizens in building a positive reputation, acceptance, and trust. The existing governance, therefore, focuses on developing communication and informational campaigns to build the required level of confidence and trust among end–users.

4.5. Key Insights

Smart Road Plan represents a spectacle of progress to deliver a prosperous and inclusive future scenario for its citizens. The public value is understood as a useful means to articulate and understand the regulatory frameworks, including strategies and policies that proactively govern the smart transition. This project significantly improves citizens' safety and quality standards in the long term by ensuring continuity of management, prevention, and maintenance actions. Indeed, it is part of a broader project at the European level (i.e., The 2030 Agenda for Sustainable Development with 17 Goals of the United Nations) as it impacts "travel behavior, social inclusion and urban development, environment, entertainment and commerce, growth and jobs," according to the European Commission (see G). However, these benefits are largely addressed for their positive efficiency and productivity without properly investigating their side effects on societal and ethical issues. The regulatory frameworks thoroughly underline the estimated costs and benefits analysis, but merely from a financial perspective highlighting the numerous opportunities. Similarly, the various stakeholders properly remark on implications and concerns associated with privacy and security by just mentioning and raising awareness. Indeed, the regulatory context lacks an in–depth investigation of related risks and effects on monitoring practices on citizens. For instance, personal data may be used to discriminate against minorities, manipulate public opinion, and develop tailored advertising for marketing purposes. These potential consequences are not clearly stated in the regulatory frameworks but are inferred from the technological applications described, together with the information associated with the theoretical framework. In the context of targeted advertising, it is mentioned that citizen–centric services would be implemented for marketing purposes without elucidating and emphasizing the harms to society. Again, the integral role in driving economic growth is encouraged and preferred to societal and ethical issues.

The technocratic perspective largely dominates the scenario of the Smart Road Plan. Technological progress is described as "the strongest driver and enabler," according to the European Commission (see E). Governments and stakeholders highly rely on technologies and innovative interconnected systems for intelligent mobility management. It is based on information provided in real–time by monitoring devices installed on the road through the use of advanced data processing and decision support software. As a result, the data flow is significantly accurate, geo–localized, and constant to achieve efficient collaboration and precise control over the urban fabric by using data–based decision analysis techniques. These data, classified as static and dynamic, are characterized by different characteristics that should meet appropriate requirements that are not clearly stated in the regulatory frameworks. Given the diversity of data sources ranging from sensors installed in infrastructure to vehicles with sensor functions, it is important that the specifications are applied to the relevant data categories, regardless of the data source and the technology used to create or update the data. However, the collection and storage of sensitive data and the ability to analyze individual and collective behavior by processing key pieces of information in real–time undoubtedly represent a potential threat to confidentiality. Moreover, Smart Road Plan is characterized by a centralized platforms database thanks to the interoperability, which allows systems to connect, exchange, and share information. It definitely increases productivity by reducing the time and costs to obtain accurate data; however, it undermines data security as a centralized platform may be the object of cyber–attacks and other malicious activities. In order to balance interoperability and data protection, the regulatory frameworks evaluate valuable technical and organizational measures and standards for data processing to guarantee fair access, storage, and sharing. The importance of transparency and informed consent is recognized, which are essential to grant accountability and ownership to citizens who could control their personal data. It is mandatory to achieve consensual solutions with a privacy–by–design approach. On the other hand, citizens may not be enough informed, aware, and educated about the data practices and their purpose as data are ubiquitously collected from various personal devices, sensors, and other devices. This hyper–seamless approach may be vague for citizens, considering certain minorities and the digital divide. Furthermore, the practice of consent occurs by default, given the choice to opt–out. This logic must be revised as it could discriminate by excluding those who choose not to engage with certain services, which is also unpleasantly difficult in a smart road scenario.

Citizens are highly concerned about data processing practices and whether their privacy is being compromised in favor of sustainable prosperity development. However, citizens' trust and social responsiveness in accepting this urban Renaissance are fundamentally crucial for the success of the Smart Road Plan. Then, the lack of transparency is not counterproductive for gaining trust and public acceptance. According to the European Commission, critical issues and concerns, including cybersecurity and data protection, must be addressed, "both particularly important for public acceptance" (see E). Integrating these components in a solid and coordinated legal framework becomes crucial as a strategic strength for technological and social progress. However, the current regulatory context is fragmented and uncoordinated, characterized by a plurality of normative and strategical instruments. Indeed, the necessity to rebuild a reputation in legal regulations is recognized. For instance, stakeholders are responsible for developing informational campaigns to reassure that "personal data are not [perceived as] a commodity and [let citizens] know can effectively control how and for what purposes their data are being used," according to the European Commission (see E). Therefore, it is critical to further develop and introduce standards, specifications, and provisions to asset technological progress by designing flexible systems with high information protection capabilities and introducing sector–based data protection impact assessments. Particularly, the General Data Protection Regulation (GDPR) must offer clear guidance and insights around the purpose of personal data collection, how the data is used, and how long the data will be retained in the Smart Road Plan, and in similar cases as it does not provide a dedicated section yet. GDPR represents a significant milestone regarding cybersecurity, integrity, and safety, which must be integrated into the Smart Road initiatives' strategies by creating ethical governance that places the right to privacy at the center.

In conclusion, the Italian and European regulatory frameworks address citizens' privacy and security with the technological progress in the Smart Road Plan by raising awareness of concerns and potential risks while promoting technical and organizational measures. However, the technocratic perspective largely dominates the context of the urban Renaissance without properly introducing in–depth investigation on monitoring practices and data exchange between citizens and infrastructures. Smart Road Plan is positively described for the beneficial efficiency and productivity in a long–term economic growth, without accurately addressing societal and ethical issues. The regulatory frameworks appear fragmented and uncoordinated, characterized by a plurality of normative and strategical instruments. The lack of transparency and legal vagueness damage public responsiveness and social trust, accordingly to which citizens have begun to express concerns about their personal and sensitive data. However, it could be speculated that the real intention behind the lack of meaningful actions is avoiding formal regulation and legal mechanisms to promote competitiveness and attract investments while reassuring the public with informational campaigns. Nonetheless, numerous governments, stakeholders, and organizations seek to cooperate to improve a know–how governance based on extensive and in–depth national discussion about ethical and legal connotations from a privacy and security standpoint. For instance, the Italian Ministry of Transport (MIT) has established the technical support Observatory for Smart Rods and for connected and self–driving vehicles for coordinating initiatives and supporting research with particular attention to safety, security, infrastructure development, and surveillance. Indeed, this process of smart Renaissance is ongoing and cannot simply achieve; even the biggest challenges could be used to identify opportunities to change and improve.

5. Conclusion

The final chapter provides conclusive remarks and insights into the research findings, linking back to the comprehensive theoretical framework, to be found in Chapter 2, and the interpretation of the results, to be found in Chapter 4. It furthermore offers a clear answer to the research question, presented in Chapter 1. Ultimately, some limitations of this study will be addressed, as well as investigating some suggestions and recommendations for future research.

5.1. Conclusive Remarks

This smart Renaissance extends the concept of the 'ideal city' beyond the personal context to a larger community of the urban fabric by integrating citizens and institutions with digital solutions and technological progress (Alberti, 1485). Smart Road Plan aims to improve citizens' safety and mobility through permanent and continuous monitoring by collecting, storing, processing, and sharing a massive scale of data with various stakeholders and third–parties. Advanced technologies promote sustainable infrastructure services that benefit cross–domain sectors, although privacy and security remain crucial challenges. Indeed, the competitiveness and innovation that characterize this initiative may seriously obscure threats and concerns relating to the security and confidentiality of the data. Particularly, it undermines the right to privacy and transparency, which concerns using and applying these technologies in the urban fabric, and the principle of security and resilience, which concerns adopting measures that protect information resources. Therefore, this study sought to answer the question using qualitative content analysis: *How do the Italian and European regulatory frameworks integrate citizens' privacy and security with the technological progress in the Smart Road Plan?*

Smart Road Plan represents a significant investment in mobility in the Italian territory. This initiative is acclaimed for its sustainable prosperity development, especially for the upcoming Olympics Games 2026. It integrates seamless networks to ensure intense and constant production of data and information among the infrastructures, citizens, and their vehicles and personal devices. Technological progress is the core component in upgrading the urban fabric's transportation system. The attractive smartness is driven by a technocratic perspective, obscuring threats to citizens' privacy and security. The benefits and advantages of producing public value alleviate citizens' concerns (Lytras & Visvizi, 2018). However, stakeholders and governments attentively explore the various technologies adopted by sufficiently suggesting security measures. However, privacy implications are not adequately exposed. The uncoordinated and fragmented regulatory frameworks do not consider smart roads as a surveillant assemblage (Haggerty & Ericson, 2003). Indeed, Smart Road Plan is exploited as a highly profitable product without evaluating its holistic scenario. It is not considered part of the urban nervous system (Nam & Pardo, 2011). As the backbone of the transportation system, Smart Road Plan presents significantly more opportunities only if integrated and regulated within the urban fabric. Smart urban Renaissance starts from here.

5.2. Limitations & Future Research

Limitations of this study should be noted to critically assess potential factors and constraints for further evaluation suggestions aimed to be improved in future perspective research. Firstly, this study lacks generalizability and transferability as the case study focuses on a particular real–world scenario located in Italy. Furthermore, the data collection did reach the data saturation point (N = 14) with a heterogenous distribution among the stakeholders between the Italian and European legal frameworks (IT = 8; EU = 6). Hence, the dataset is consistently collected across national and local stakeholders, although the ease of access and proximity to sensitive political and legislative data has been selected it. The purposive and convenience sampling could limit the findings, as they could not be generalized to an extensive population. However, the holistic perspective of the broad time of data collected provides innovative insights and critical connections of theoretical and legislative frameworks for contributing to the technological progress of smartification and the digitalization of urban infrastructural networks. Indeed, the recommendations provided are normatively and academically justified and addressed to support policy processes, media institutions, and other interested stakeholders. Future research should consider investigating the phenomenon in detail in any given country, supported by a multiple case study research design with a comparison approach.

Secondly, this study lacks triangulation in research design. It should capture the complexity of the phenomenon by gaining insight into the research gap from various methodological approaches, particularly because it is based on a qualitative methodology. Indeed, it is highly recommended to conduct in–depth interviews with different groups of stakeholders to provide a comprehensive understanding of the beliefs, attitudes, values, and motivations of the social actors involved in the implementation of the Smart Road Plan. Contrarily, the qualitative content analysis focuses on perceptions, meanings, and experiences of the constructed reality collected (Puppis, 2019).

Thirdly, the analysis of the regulatory and legal frameworks may lack previous background expertise in understanding and interpreting normative conceptual frameworks. Although the existing curiosity and knowledge on privacy and security implications, it is suggested to conduct future research with academics from different fields and expertise to reinforce the validity and reliability of the findings. However, the comprehensive theoretical framework supported the research process in this field, although collaboration and observations from others are strongly recommended to effectively explore the phenomenon, with the support of diverse knowledge, expertise, and insights.

Despite the several limitations of this study, this qualitative content analysis in a case–study research successfully offers opportunities for further perspective. An important area of investigation would be the implementation of the data protection regulations in compliance with the GDPR regarding the development of Smart Road applications, together with the pervasive monitoring of its technological progress. At the European level, GDPR establishes a common standard framework regards privacy and security. Hence, it would be significantly interesting to further analyze GDPR considerations about C–ITS deployment as key to promoting sustainable prosperity in Smart Road applications. In this context, the vast exchange of personal and sensitive data between vehicles, infrastructures, and users must be closely examined across the European legislative guidance of the GDPR. For instance, an interesting perspective would refer to the connected and autonomous self–driving vehicles as representing the next moving–trend in the upcoming years. Despite the attractiveness of this scenario, this study highlights major legal issues connected to this market, associated with regulation and cybersecurity, including also social and cultural implications that are worth tackling. Furthermore, it would be noteworthy to focus on this technological advancement in the context of cybersecurity issues and risks. Lastly, another perspective to further development would be the perceptions of citizens regarding the privacy and security implications of Smart Road initiatives, including their level of education and knowledge in this context due to the attempts of national and local governments to demonstrate the benefits of collecting personal data for support the sustainable prosperity in the urban fabric through informational campaigns.

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Appendix A: Unit of Analysis

The Italian and European regulatory frameworks (TOT = 14 units; TOT/ ITALY = 8 units; TOT/ EUROPE = 6 units) in chronological order.

	REGULATORY FRAMEWORK	ISSUED BY	DATE
A	Directive 2010/40/EU of the European Parliament and the Council on the General Framework For the Deployment of Intelligent Transport Systems in the Road Transport Sector with Other Modes of Transport.	European Parliament and the Council, published in the Official Journal of the European Union.	July 7, 2010.
B	EU Delegated Regulation No. 886/2013 Integrating Directive 2010/40/EU of the European Parliament and the Council with Regard to the Data and Procedures for the Free Communication to Users, where possible, of Minimum Universal Information on Traffic Related to Road Safety to Users.	European Parliament and the Council, published in the Official Journal of the European Union.	May 15, 2013.
C	EU Delegated Regulation 2015/962 Integrating Directive 2010/40/EU of the European Parliament and the Council on the Provision of Real–Time Traffic Information Services throughout the European Union.	European Parliament and the Council, published in the Official Journal of the European Union.	December 18, 2014.
D	Position Paper with Functional Standards for Smart Roads.	Italian Ministry of Infrastructure and Transport (MIT).	June 22, 2016.
E	Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions. COM(2016)/766 final. A European Strategy on Cooperative Intelligent Transport Systems, a Milestone Towards Cooperative Connected and Automated Mobility.	European Commission.	November 30, 2016.
F	Guidelines for the Evaluation of Investments in Public Infrastructures in the Sectors under the Responsibility of the Ministry of Infrastructure	Italian Ministry of Infrastructure and Transport (MIT).	June 1, 2017.

	and Transport, according to the Legislative Decree 228/2011.		
G	GEAR 2030: The Report of the High–Level Group on the Competitiveness and Sustainable Growth of the Automotive Industry in the European Union. Ensuring that Europe has the Most Competitive, Innovative, and Sustainable Automotive Industry of the 2030s and Beyond.	European Commission by the Internal Market, Industry, Entrepreneurship and SMEs (DG GROW).	October 17, 2017.
H	Decree No. 90 (18A02619) on the Implementation Methods and Operational Tools for Road Testing of Smart Road, Connected, and Automatic Driving Solutions.	Italian Ministry of Infrastructure and Transport, published in the Official Gazette of the Italian Republic.	February 28, 2018.
I	Certificate Policy for Deployment and Operation of European Cooperative Intelligent Transport Systems (C–ITS) – Version 1.1 result of C–ITS platform Phase II.	European Commission.	June 1, 2018.
J	2020 Annual Report Pursuant to Art. 4 Paragraph 2 of Decree 9/2018) regards on the Smart Road, Connected, and Automatic Driving Solutions (Art. 20 DM 70/2018).	Ministry of Infrastructure and Sustainable Mobility (MISM) with the Technical Support Observatory for Smart Roads and for Connected and Self–Driving Vehicles.	June 19, 2018.
K	Memorandum of Understanding on Innovation for Autonomous and Connected Driving in Urban and Extra–Urban Areas between the Ministry of Technological Innovation and Digitization (MID) & the Ministry of Infrastructure and Transport (MIT).	Ministry of Technological Innovation and Digitization (MID) & Ministry of Infrastructure and Transport (MIT).	May 18, 2020.
L	Legislative Decree No. 77 on the Governance of the National Recovery and Resilience Plan and First Measures to Strengthen the Administrative Structures, Acceleration, and Streamlining of Procedures (21G00087).	The President of the Italian Republic, Sergio Mattarella, published in the Official Gazette of the Italian Republic.	May 31, 2021.
M	Strategic Document for Road Mobility (2022–2026).	Ministry of Infrastructure and Sustainable Mobility (MISM)	July 21, 2022.

N	Smart Road: The State–of–the–Art Road that Runs with Progress.	Anas S.p.A. by the Operations Department and Territorial Coordination of Technological Infrastructure and Systems.	n.d.

Appendix B: Coding Frame

Coding categories, with associated subcategories, further explained with a definition and a description of the main arguments, providing quotes, where possible.

Category 1 – DATA PRIVACY *Taxonomy of personal and sensitive data focusing on issues related to collecting, storing, and retaining data, as valuable assets and commodities in the digital Smart Road transformation.*
• ***DATA CLASSIFICATION*** ○ *ROAD–SIDE UNIT* ▪ Instrumental monitoring of infrastructure located in areas at risk (earthquakes, landslides, floods) or subject to extreme climatic and meteorological conditions. ▪ Monitoring and tracking goods during transport and between modes of transport to assess the state of vulnerability of the network, risk analysis, and emergency management. ○ *TRAFFIC* ▪ Historical and real–time data on road traffic characteristics ○ *MOBILITY* ▪ Basic data regards in–vehicle condition/status and end–user behavior ▪ Basic data regards in the journey (e.g., traffic volumes/flows, location, presence of accidents and congestion, speed, journey times) ○ *CROWDSOURCING* ▪ Data provided "voluntarily" by travelers, through personal and on–board devices or obtained directly from vehicles using the V2I communication platform and other communication methods.
• ***DATA CHARACTERISTICS*** ○ *STATIC* ▪ Geometry, number of lanes, road signs, speed limits, tools ○ *DYNAMIC* ▪ Reversible rules and arrangements, road conditions, speed control, lane control, ramp metering
• ***DATA USAGE*** ○ *MONITORING* ▪ Real–time traffic information, weather conditions, and infrastructures, including bridges, viaducts, and other road infrastructure.

        - Monitoring illegal behavior for safety reasons (e.g., exceeding speed, prohibited transits, dangerous maneuvers, stationary vehicles, vehicles in prohibited direction, serious accidents).
        - Conformity plate checks.
    - *INFOMOBILITY*
        - "Timely updating of available road and traffic data used for multimodal travel information by relevant public authorities and [private] stakeholders."
    - *MANAGEMENT & OPTIMIZATION*
        - Management of the national infrastructural assets by non–end users of the organizational and management chain (e.g., authorities and road operators, service providers) and end–users (e.g., road users, natural and legal persons, vehicles).
        - Road–side units, traffic, and mobility conditions, including accidents and congestion.
        - Emergency management (e.g., rescue bodies) together with police and civil protection associations.
        - Accessibility and potential threats to mobility.
        - Reduction of journey times and intermodal routes.
        - Maintenance of the transport networks and infrastructures.
    - *PREDICTIVE ANALYTICS*
        - Performance analysis to make efficient predictions and strategies using historical data, and possibly other data obtainable from third parties, combined with statistical modeling.
        - Analysis of current performance by comparing current data with target data
        - Identify "black spots" for infrastructure safety, effectiveness, and resilience

- ***DATA STORAGE***
    - "Data is collected and stored by road authorities, road network managers, and real–time traffic information service providers."

- ***DATA DISSEMINATION***
    - "Road operators, service providers, and public traffic information broadcasters disclose minimum universal traffic information related to road safety to end–users."
    - Guarantee fair access, storage, and sharing of vehicle data.
        - Data accessibility at national access points (e.g., directory, register, web portal, or similar form)
    - Data are not transferred to third parties, in compliance with the provisions of current legislation on privacy.
        - "Service providers should be free to enter into commercial agreements with each other for the re–use of relevant data."

        - The possibility of transferring to third parties only aggregate data that can be used, anonymously, for statistical purposes and the possibility of granting advertising spaces, not activated yet.

- ***DATA PROCESSING***
    - Personal data are protected against improper use, including unauthorized access, alteration, or loss.

Category 2 – PITFALLS OF TECHNOLOGIES

Taxonomy of technological threats in their design and applications as major contributors to privacy and security deterioration, although technologies are described as the "stronger driver and enabler" of the digital Smart Road transformation.

- ***INTEROPERABILITY***
    - Real–time interaction across borders and transport modes, at all levels: infrastructure, data, services, applications, and networks
    - Based on open and public standards, accessible on a non–discriminatory basis to all suppliers and users of applications and services
- ***COOPERATIVE INTELLIGENT TRANSPORT SYSTEMS (C–ITS)***
    - Exchange of data and information between vehicles, infrastructures
    - Granting access to stakeholders, vehicles, and road infrastructure to the relevant data and information to be exchanged
    - Provides "accurate and guaranteed synchronization and positioning services, using satellite infrastructures or any other technology that offers an equivalent level of precision."
    - "They should not undermine issues of national security or in the interests of defense."
    - Fragmented and uncoordinated technological diffusion makes the geographical continuity of C–ITS services in the EU and abroad impossible.
    - Essential to introduce specifications, standards, provisions, and procedures to assess the conformity of their development and dissemination, taking into account technological progress and financial effort.
- ***SENSORS IoT***
    - Constant transmission and acquisition of data and information to/from the gateway and/or concentrator.
    - Detect measurements of infrastructural parameters in real–time for predictive maintenance.

- Implementation of advanced data–driven procedures: sensory data, combined with historical data, human skills, and simulated learning will help improve the processes of design, maintenance, and diagnosis or prognosis of malfunctions.
- Aim to monitor, control, and transfer information.

- ***AUTOMATED AND CONNECTED VEHICLES***
  - "Various types of sensors, software for processing sensor data and interpreting traffic situations, learning software, software for making driving decisions and implementing them, components for integration with the traditional vehicle, which fall within the scope of road testing referred to in this decree."
  - "The societal aspects (e.g., driver acceptance, ethical issues, social inclusion) and economic issues (impact on economic activities, environmental issues) of these vehicles should also be looked at."
  - Bring new challenges for regulators and policymakers associated to "road safety, environmental, societal, and ethical issues, cybersecurity protection of personal data, competitiveness, and jobs, etc."
    - "How to develop a new coherent legal framework for some vehicles that have not yet been built."

Category 3 – DATA PROTECTION & SECURITY

Taxonomy of data protection and security strategies and principles designed to guarantee the data integrity, accuracy, and consistency in its entire life–cycle due to the higher vulnerability to hacking and cyberattacks.

- ***KEY PRINCIPLES***
  - Transparency
    - "Offer transparent terms and conditions to end–users, using clear and plain language in an intelligible way and in easily accessible forms, enabling them to give their consent for the processing of their personal data."
  - Purpose limitation
  - Data minimization
  - Anonymization
  - Pseudonymization
  - Privacy–by–design
    - "Transparent approach that allows users to understand for what purpose the data concerning them are collected and how they will be used, as well as to have a high level of user control over the data itself."

- ***LAWFUL BASIS FOR PROCESSING***

- Consent   - "Consumers must have control of their personal data."

- ***DATA SUBJECTS RIGHTS***
  - Right to be informed
    - "Informing end users of data acquisition, the methods governing the collection and potential traceability, and the period of time in which the data has documented."
  - Right to confidentiality
    - "The collection and storage of sensitive data and the ability to analyze individual and collective behavior by processing billions of pieces of information in real–time represents a potential threat to confidentiality."

- ***TECHNICAL STRATEGIES***
  - Public Key Infrastructure (PKI)
    - Used as "guidance to assess which level of trust can be established in the received information by any receiver of a message authenticated by an end–entity certificate" using pseudonym certificates.
  - Cryptographic requirements "concerning the signature algorithm, key length, random number generator, and link certificates."
  - Building Information Modelling (BIM) "for a standardized information kit in which the data of the entire life cycle contextualized in the territory are cataloged."
  - Set minimum requirements for local security practices (physical controls, personnel controls, procedural controls) and technical security practices (computer security controls, network security controls, cryptographic module engineering controls)

- ***REGULATORY HARMONIZATION***
  - International common security roadmap
    - Regulations as "a model for global standards it will need to rebuild its reputation, particularly in terms of robust enforcement and avoidance to regulatory uncertainty through designing robust regulations."
  - EU Data Protection Authorities "to develop a sector–based data protection impact assessment template to be used when introducing new C–ITS services."
  - Promote an extensive and in–depth national discussion on:
    - Ethical and legal issues related to self–driving vehicles.
    - Security of connected and cooperative vehicles (e.g., data ownership, circulation patterns and effective use of data, privacy, and confidentiality, protection of a competitive market)

        - Definition of interventions of Smart Road initiative (e.g., national cartographic databases, shared platforms) for efficient data use from cooperative vehicles, monitoring tools for automated vehicles
    - Strategic research plan as an instrument for continuous innovation and adaptation to the new standards
        - Automation and digitization (monitoring, computerization of road construction, and traffic management process)
            - Smart Road applications and services
            - Real–time monitoring of the functional and structural infrastructure network
            - Concept of intelligent roads in various fields, including public information
            - "Identification of innovative interconnected systems for intelligent mobility management, based on information provided in real–time by monitoring devices installed on the road (traffic volumes, speed, network congestion status, weather conditions, noise, and atmospheric pollution), through use of advanced data processing and decision support software."
            - Computerization of the road construction
            - Management and use of large data flow to process and integrate different data types to facilitate the extraction of the necessary information.

Category 4 – GOVERNANCE & ACCOUNTABILITY

Taxonomy of data protection that defines the roles and responsibilities for ensuring accountability and ownership in the view of a legal and social context.

- ***GENERAL DATA PROTECTION REGULATION (GDPR)***
    - *PRECEDENTLY*
        - "As regards data protection and privacy issues, the Commission should, where appropriate, consult the European Data Protection Supervisor […] for the protection of individuals with regard to the processing of personal data established by Article 29 of Directive 95/46/EC."
        - "The dissemination and use of ITS applications and services involve the processing of personal data […] in accordance with Union law, resulting in particular from Directive 95/46/EC of the European Parliament and the Council of 24 October 1995, concerning the protection of individuals with regard to the processing of personal data, as well as the free movement of such data, and by directive 2002/58/EC of the European Parliament and the Council, of 12 July

2002, relating to the processing of personal data and the protection of privacy in the electronic communications sector."

- *SUBSEQUENTLY*
  - Particular attention to mentioning cybersecurity and data protection.
    - Transport and vehicle data change the way services are proposed to customers within the privacy boundaries of the GDPR.
    - "Potential threats from cyber security as well as vehicle integrity and safety need to be analyzed and taken into account."
  - "The technological adaptation [and the digital transformation] of the national road network in line with the EU and international framework for the digitization of road infrastructures"
  - Highlighting the positive assets of digital solutions, together with the adoption of advanced technologies and advanced analytics, in correlation with the capability to monitor, control, and respond promptly and effectively to cybercrime threats.
  - "Data are acquired, treated, and used accordingly to the privacy legislation without the possibility of transferring them to third parties, thus guaranteeing the non–discloseability."

- ***LEGAL FRAMEWORK***
  - Characterized by a particular fragmentation due to the existence of a plurality of normative and strategical instruments, at a community and national level.
  - Necessity to adopt specific technological principles and standards.
    - Allowing efficient flexibility to the various technologies and services
    - Avoiding the risk of obsolescence
    - Identify major specifications accordingly to the infrastructure management, data governance, and the direction towards which the private sector is moving.

- ***COOPERATION & COLLABORATION***
  - Close cooperation with member states and key ITS stakeholders (e.g., ITS service providers, user associations, transport, and facility operators, responsible national security associations, representatives of manufacturing companies, social partners, professional associations, local and public authorities, and related suppliers and operators)
  - Create a synergy with various actors, in a single platform, from different backgrounds to encourage sharing of their knowledge and experience for an efficient know–how governance.
  - Necessity to commonly agree on definitions of data quality and accuracy in the data value chain, and their acquisition and geo–localization practices.
  - Necessity to further improved practices associated with measuring and monitoring the quality of data and information

- **RESPONSIVENESS**
  - *ACCEPTANCE*
    - Work on information campaigns to create the necessary trust among end–users
  - *TRUST*
    - "Demonstrate how using personal data can improve safety and efficiency of the transport system while ensuring compliance with data protection and privacy rules."
      - "Users must have the assurance that personal data are not a commodity, and know they can effectively control how and for what purposes their data are being used."