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SUSTAINABLE URBAN MOBILITY PLANS. LITERATURE REVIEW AND IMPLICATION FOR POLICIES.

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ABSTRACT

Urban areas are becoming a leading platform for organizational and technological innovation, testing new financing solutions, and transforming mobility models. Nowadays, one of the major challenges is gap-related to sustainability and sustainable mobility. Sustainable mobility is a long-term strategic plan which focuses on improving the quality of life through safe, comfortable mobility and sustainability. Sustainable mobility plans include a broad range of indicators that influence the formation of smart cities. The thesis aims to outline the principle of sustainable mobility plans and their impact on everyday life. The thesis is based on the literature overview and the tables which are created by the author, proposing to the reader to understand in detail the indicators of sustainable mobility and its relation to sustainable development goals.

Keywords: sustainability, sustainable mobility, SUMP (Sustainable Urban mobility plans), smart city, Co2 emissions, air quality, environment, Information and Communication technology(ICT)

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INTRODUCTION

Significant sustainability challenges in cities are associated with increased freight and passenger traffic growth. Transport is increasing costs, carbon dioxide emissions, and noise. The emissions are supposed to be double in 2050 if no action is undertaken to address air pollution problems. Moreover, European cities are estimated to cost more than 100 billion due to traffic congestion. Local governments are responsible for developing strategic decisions to address sustainable mobility issues. Despite this, most local governments focus on the development of passenger traffic when planning, perceiving freight as the responsibility of a private enterprise (Maja Kiba-Janiak, 2019). The formation of competitive and functional cities requires the provision of environmentally friendly transport infrastructure. A long-term goal in the perception and planning of transport systems in daily life is needed. The fundamental basis for successful mobility planning is to involve stakeholders and the public in implementing the plan. Cooperation between all institutions in the various fields of urban mobility is also encouraged. In practice, one of the frequent problems of SUMP is the little-studied evaluation and monitoring process. The importance of evaluation and monitoring lies in the ability to track the process or perceived impact of the selected measures concerning mobility. In this way, evaluation and monitoring indicators should be established, and follow-up actions should be taken to implement the plan based on the data collected (Jonas Damidavičius, 2019). The direct search for ways to improve sustainable mobility leads to the development of indicators for sustainability analysis. Nowadays, there is no correct approach to the problem, but alternatives are available to maintain a balance in the city. It is necessary to clarify the importance of the city planning process, which directly depends on a variety of specialists. However, each city has its method, which is based on personal parameters. Studies have shown that planning with indicators is most effective in sustainable mobility. Since indicators can generate data for decision making, they can simultaneously track targets set and the productivity of actions (Josiane Palma Lima, 2014).

The purpose of this work is to analyze from a literature point of view the concept of sustainable urban mobility plans and its performance in cities. Significant measures that have been developed by the European Union and its strategic plans to address environmental issues are also taken into account. The work reveals the possible trade-offs that must be made to effectively implement a mobility plan. Besides, the work also reveals innovative terminology as smart cities. It is a combination of digital technology and sustainability in a city. It reveals theories, studies, and examples based on successful “Smart Cities”.

The thesis consists of three chapters. The first is a literature overview of sustainability and mobility. Under this chapter, the transitions from sustainability development to sustainable mobility and explored also indicators for sustainable mobility. The author has created a table of indicators of various sustainability areas to explain their impact on daily life. The terminal part of the first chapter is to deepen into sustainable urban mobility plans from a European Union perspective. The second part of the chapter reveals the Smart city theory. It indirectly analyzes the possible impact of sustainable mobility in Smart city. Furthermore, representing a certain impact of technology on solving sustainable mobility issues. The concluding chapter of the thesis highlights the case studies of a smart city.

Chapter 1. The Sustainable Mobility Issue

1.1 What is Sustainable Mobility?

Over the past few years, the degradation of socio-economic and ecosystem conditions has led to focusing on sustainable development (Elena Giovannoni, 2013). The term sustainable development has gained its roots thanks to the copulation of various ideas from various spheres like justice, conservatism at the end of the twentieth century. Whereas, the report of the "***Brundtland Commission***" ***as development that meets the needs of the present without compromising the ability of future generations to meet their own needs***" described the concept of sustainability. Sustainability comprises three pillars as Environment, Economics, and Society. This approach balances the well-being of the population ("University of Alberta Citation").

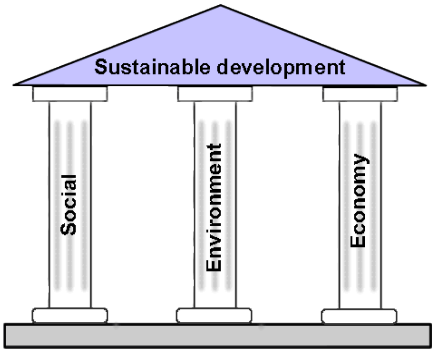

Figure 1.Pillars of sustainability (Project, University of Guelph Sustainable Restaurant, 2012)

Environmental integrity - With increased population growth, the risk of air pollution and natural resources also increases a need.

Social pillar- The social pillar explains the human right to use many resources that exist in nature. This part obliges to satisfy the different needs of the person in the present and the future. The basis of this concept is to leave a better future of keeping resources for further use. We should note is that this is not just about food and clothing, but also about health and education.

Economic development- Explains creating an enabling environment for job creation and services to meet the needs of the population. The key approach is to support creativity, innovation and the ability to compete in the global market (Bansal, 2004).

Sustainable development has created a guideline for long-term goals. An Example, adopting existing issues and addressing the environment, economic and social problems. Meanwhile, using the concept is worth pointing out an issue called capital replacement. The replacement has several types of such as human-created social and natural capital. Strong sustainable development inability to replace natural resources with productive capital. Weak sustainable development means the possibility of replacing natural capital with human-generated (Emas, 2015). The concept of sustainable mobility was introduced in 1992 by the European Union in the "Green Paper." This was a result of a fundamental report "Our Common Future" on sustainable development issues at the global level. The Green Paper observed the favorable effect of transport on economic growth, travel accessibility, trade, and also on costs and adverse environmental impacts (Erling Holdena, 2020). Public policy is different from rational and research methods aimed at solving social problems. Frequently, measures to ensure sustainable mobility are controversial in the political context. Besides, it has been noted that introducing sustainability norms into transport decision-making remains a challenging task. The concept of sustainable mobility requires actions to reduce car travel. This decrease can be encouraged through the use of public transport and a reduction in travel time. However, citizens play a primary role in planning, implementation, evaluation, and monitoring. Along with the development of the plan, there are obstacles to the adoption of effective sustainable mobility policies. Based on

the research, critical barriers have been identified. These are political, technical, legal, economic, and administrative factors that may affect the further carrying out of the plan (Leonardo Herszon Meira, 2019).

One of the definitions from the World Business Council (WBCSD) for Sustainable Urban Mobility:" The vital goal of this plan is to develop safe, stable and comfortable mobility in urban life. By developing a sustainable economic and environmental society through support for entrepreneurship activities by facilitating the movement of goods and people. Moreover, decreasing potential car accidents, lower demand for energy-using. For more effective impact and monitoring of sustainable mobility, several indicators need to be created that will help measure potential problems and their further solutions. Traditional planning remains a proponent of automotive or public transport activities that focus on infrastructures. The essential difference between mobility and sustainable mobility is the priorities set. Sustainable mobility includes the notion of accessibility, not only of transport infrastructure but also of land use (Dominique Gillis, 2015). The city is one of the sustainable forms of modern urbanization. It provides a place where 80% of the world's population will live. According to scientists, a sustainable city should meet the accepted criteria, such as guarantee quality infrastructure for the convenience of residents. The concept of sustainable mobility examines the complexity of cities and the relationship between transport and land. Significantly, sustainable mobility directs society to lifestyle changes, emphasizing attention to the transport movement. Eventually, everything about various changes, society does not accept promptly in a connection, having distrust and fear of the result. Generating a state of mind against negative feedback there is a need to use targeted marketing through media. It contributes to the construction of a dialogue between society and the state. Directing in the precise direction about the benefits of cycling, walking and using public transport. To further the effect, it is necessary to develop a trusting relationship with people and call for a change. Meantime, supporting their input to the development of mobility (David, The sustainable mobility paradigm, 2007).

1.2 Indicators of sustainable mobility

The term indicator or index usually appears in technical manuals. Defining a variable value that represents a functional component of a system. The basis of indicators consists of primary data to compress complex information into a more comprehensible form, transmitting important information to the final version. Indicators can be in areas ranging from daily communication to scientific analysis. The most used indicators are in both political and environmental analysis. Each indicator contains different kinds of messages. However, distinguishing indicator categories have been developed by the European Environment Agency as follows:

1. Descriptive indicators -that identify a position or trend in a structure

2. Pursuance indicators- comparing the state with the accepted norms

3. Efficiency indicators -in the aggregate of interrelated trends

4. Policy performance indicator

5. Indicators summarizing several indicators into a single message

Other parameters of the indicators also include:

- Reducing complexity

- Displaying a clear picture

-Rigorous enforcement under international agreements and their validity

- Observation with systematic update requirements (Henrik, 2004).

Sustainable transport indicators aim to measure progress. This analysis should include relevant information on transport activities concerning socio-economic, environmental and political aspects. Besides, the indicator should prioritize the development of measures and solutions. In doing so, the indicator's characterization ensures that problems and solutions can be identified. In conclusion, the process should implement a rule of sequence and scientifically validated approaches to correctly calculate these indicators.

Consequently, the accuracy, quality, reliability should be achievable in terms of time and cost (Alexandros Sdoukopoulos, 2019).

The multifaceted form of urbanization, as it involves assessing the technological development of vehicles and examining the various impacts in the transport industry. Basing on this theory, that increasing mobility analyze and evaluate the overall level of travelers (Sustainable Mobility, 2007). Often mobility is considering as a definition that applies merely to the sphere of movement. But in reality, the sphere of mobility is unlimited and broad information. The hypothesis of sustainable mobility also addresses the challenges of sustainable development. Typically, it provides a fundamental guideline to analyze the growth of traffic, various emissions to control sustainable mobility (Defining sustainable mobility, 2013). Urban development, expansion of territories, and overpopulation provide negative implications for the ability to move of citizens. It characterizes by increased costs, deteriorating air quality, decreased welfare of the population. Therefore, sustainable mobility compares with environmental, economic and social well-being. It is necessary to identify the frameworks, transport structure, and planning inherent in sustainable mobility. The urban structure comprises three components: movement, localization and social relations. All kinds of land use and integrity relate to a structure of localization. The movement system consists of people and goods, and the transport infrastructure to ensure mobility. Society's mode of operation and activities involves a system of social relations (Salvatore Amoroso, 2011).

The crucial idea of sustainable mobility bases on three concepts, which focus on the well-being of people and the planet. Based on D. Banister's point of view, it divides the list of indicators into four areas: environment balance, economic growth, living standards, and mobility activities. ***Environment balance*** -However, the harm from urban movement is one of the global problems of the city, but there are several types of conventions to prevent the impact on the ecosystem. ***Economic growth***- shows the benefits of mobility in improving the city's financial well-being. ***Living Standards*** - refers to the social aspects related to the health and safety of the population. ***Mobility activities*** - The development of structures and the formation of a comprehensive approach to efficiency. The structure of

mobility comprises the above three principles, which will help in decision making (Dominique Gillis, 2015).

On the road to sustainable development, it is often necessary to discuss every decision taken. The measures taken are designed to provide a solid foundation for effective decision-making, which will take into account the plan preparation cycle itself. The overall strategy for transport and land use offers a strategic plan which, among other policy documents, helps to overcome barriers. One of the qualities in the area of land use is support in solving problems related to transport activities. Appropriate indicators should contain the necessary information to assess land use and transport (Jianquan Cheng, 2007). The Land Use Indicator indicates the area where a certain number of inhabitants live. Each traffic zone generates demand for all other zones according to the number of permanent residents and their permanent travel (Giuseppe Inturri, 2017). The ability to reach frequently explored places with convenience is called accessibility. It depends on two factors: either on location or travel speed. Expanding accessibility is one of the essential steps in the transport sector. It is determined by the territorial division for possible locations, size, and ease of accessibility (Jianquan Cheng, 2007). Accessibility measures require the creation of indicators that provide for the quality of opportunities that can be achieved at a given time and within a period provided to the population. Several types of indicators have a direct impact on accessibility: territorial distribution, transport infrastructure, social layers of society (Giuseppe Inturri, 2017).

However, for the selection of proper indicators, it has to be based on the questions that indicators need to respond. Additionally, the indicator should possess several characteristics like independence, measurability, sensitivity, covering long-term processes, actuality, comprehensive and measurable. In recent times, the selection of indicators was presented in 10 criteria under three categories.

- Representation: credibility, sensitivity, reliability
- Operation: access to data, measurability, ethical attitude
- Policy: relevance of the objective, clarity, interpretation, readiness for action (Hossein Haghshenas, 2011).

Table 1.1 represents the description of the sustainability measurement, codes, area of indicators.

The indicators proposed in the table are divided into three categories.

1. Environmental Indicators -consist of 7 indicators and are defined as the code En1.

2. Economic Indicators- consist of four indicators and are defined as the code Ecn1.

3. Social Indicators- consist of five indicators and are defined as the Soc1 code.

Concerning to the monitored indices, five from the 16 general indicators are intended to improve transport sustainability. The remaining five indicators are developed to address environmental issues. At the same moment, the whole table is comprehensive, as it covers the range of sustainable mobility (Alexandros Sdoukopoulos, 2019).

Sustainability measurement	***Code***	***Area***	***Indicators***
Environmental indicator	*En1*	*Air quality*	*Testing and detection of the emission of harmful substances* (Jean-Pierre Nicolas, 2003)
	En2	*Renewable resources*	*Application of biofuels and alternative energy*
	En3	*Water utilization*	*Annual water consumption (million m^3)*
	En4	*Energy efficiency*	*Depending on the distance traveled and fuel consumption, according to the specifics of the vehicle in use*
	En5	*Ecological footprint*	*Resources consumed concerning the land area used for the livelihood of the population*
	En5	*Solid effluents*	*Processing rate, percentage of waste*
	En6	*Energy Consumption*	*Index of energy efficiency in the transport sector*
	En7	*Land consumption*	*Plot of land that can be used to meet transport needs* (Pavlos Tafidis, 2017)
Economic indicator	*Ecn1*	*Transport costs and prices*	*The annual cost of the road Industry, railway transport starting from passenger to freight, air transport, local Tax, Public parking costs*
	Ecn2	*Investment*	*Share of foreign investment in relation to local investments*
	Ecn3	*Affordability*	*Expenditure on transportation* (Pavlos Tafidis, 2017)
	Ecn4	*Energy Consumption*	*Index of energy efficiency in the transport sector*
Social indicator	*Soc1*	*Mobility*	*Analysis of time spent on the trip and its distance to the final point* (Jean-Pierre Nicolas, 2003)***Cost of public transport****- Calculating with the average indicated price for the road,* ***Fuel Costs****- Depending on vehicle model and distance to destination,* ***Residential Parking****- Prices depend on the location of the property*
	Soc2	*Unemployment*	*Unemployment rate of persons in employment offices*
	Soc3	*Accessibility*	*Health care, medical staff (average of population in place) and availability of hospital beds. The basic services and quality transport for disabled people*
	Soc4	*Trip rate*	*Displays the intensity of urban mobility*
	Soc5	*Public security*	*Rate of killed, injured in road and fire accidents* (Pavlos Tafidis, 2017)

Table 1.1 Description of Sustainable Mobility Indicators (A. Dobranskyte-Niskota, 2009), (Jean-Pierre Nicolas, 2003), (André Mascarenhas, 2010), (Adnan A.Hezria, 2004), (Pavlos Tafidis, 2017), (Deepty Jain, 2017).

The indicators should consider first of all the significant problems concerning the population in the city. Therefore, the presented Table 1.1 describes the areas of the indicators and short evaluation. However, due to the lack of data, it was not possible to develop the remaining indicators as noise level measurements. On the other hand, these problems are easily identifiable in the areas of ecology, economic costs and social norms (Jean-Pierre Nicolas, 2003). At the same moment, the table presents two other areas, both institutional and technological. The institutional aspect is one of the components of social stability. In this part, the institutional part of the indicator responsible for the progress of a sustainable transport system. Thanks to the introduction of alternative methods, investment in research, and the improvement of norms to enhance the operating system of public transport. Technology represents the part without which is connected with modern mobility today. Because it helps to monitor traffic congestion within controlling the overall position of technology (A. Dobranskyte-Niskota, 2009).

The indicators are the results achieved by deep monitoring of the process development. It defines each indicator as goals, objectives, and targets. For the concept of this terminology, an example can be: to resolve problems in traffic jams, necessary to establish indicators by which it will track the progress. The specific goal to reach the destination within the scheduled hours and the tasks to reform the road in case of unpredicted travel behavior. It is significant to note that indicators influence decision-making ranging from the quality of planning to economic impacts (environmental damage and costs). Data collection can help in assessing sustainability and combines indicators with other types of analysis. The analyses can be both statistical and performance reports (Litman, 2019). Ideal indicators should combine features of the urban structure. Which encourages walking and cycling to meet the needs of every city dweller. It is equally significant to use public transport to reduce the number of journeys by car (Vânia Barcellos Gouvêa Campos, 2010).

Urban transport plays an essential role and can meet some half of citizens' needs. As part of the solution to this problem, several potential options have been proposed: 1)

Improvement of areas with an increased degree of residence 2) Optimization of the transit network to expand routes for public transport. However, the structured schemes do not yet provide for promotion in sustainable mobility. Factors that influence success are directly related to land use and are conditioned by the transit system as they link specific areas (Stefano Gori, 2012). In the transport area, the desired results should be clearly stated. In terms of sustainability and quality of life, mobility is not the best influence. Exposure to negative factors such as traffic congestion, excessive time consumption, and inequality can cause environmental and harm to health. Despite the growing interest in revising the strategy for sustainable mobility and capital investment in transport, expansion of accessibility-based planning remains a critical challenge. However, there is uncertainty about the concepts of accessibility and mobility, which leads to the misconception that mobility is an appropriate indicator of accessibility. However, because of accessibility limitations, transport volumes are increasing, and conveyor and people suffer from long distances, costs, and high carbon emissions. Another example is the city, where the limited accessibility of public transport increases car travel and contributes to traffic congestion. But the reason for using cars may depend on longer distances. For sustainable development in the transport sector, emphasis must be placed on accessibility. There are several arguments for the importance of accessibility:

1. In connection with improved accessibility, the potential of the various activities contributes to the well-being of the citizens **2.** The need for spatial expansion planning, while not depending on decision-makers, a significant motivation for sustainability. Indeed, the assessment found accessibility has an impact on strategic goals by preventing major trade-offs (OECDiLibrary, n.d.).

The questionnaire that Hart proposes is about understanding the capabilities of each potential indicator for further planning of sustainable mobility:

- Is the indicator relevant to sustainable mobility?
- Is the chosen indicator understood by society? Is it worth developing?
- Does the indicator comply with the standards and is it considered a reliable source of information?

- Is there a need to link other sectors in the city to get an effective result? (Litman, 2019).

1.3 The transition towards sustainable mobility

The massive transformation in social-technological regimes or meeting needs is the definition of transition. Transition is a complex process and designed for a long period to resist any crucial changes. In the literature, there is a classification of the principal obstacles to sustainable mobility change. The classifications include institutions, players and social performers, and technology. The structure of institutions as laws, funding, and cultural values make progress difficult. Participants and local figures who disapprove of novelty and alternative ways of developing important transition factors. Technologies and infrastructure that serves only those who consider their interest, in this manner blocking all trends in technological, institutional and social issues. The basis of the transition period is built on research on social and technical data. The given data analysis allows for the stimulation and study of transformation progress. To develop regulation of transition in 2000s scientists propose theories of **"transition management "** and **"Strategic niche management".** The theories contribute to analysis and experiences that allow the population to be informed about urban issues (Rob Raven, 2010).

Transition management gets objectives within a sustainable mobility framework. The objectives consider the transformation of the organization's structures. Governance transition uses a set of tools that contribute to the development of policy agendas for intergenerational integration and solidarity. There are four types of governance transitions which has been observed in user behavior:

Strategic- Formation of radical visions to resolve social problems.

Operational- Activity related to habitual actions. Users can construct or change infrastructures.

Tactical- Solutions to the problems of establishing and improving all types of institutions through negotiations.

Reflexive- Activities aimed at testing, analyzing, and solving problems in order of discussions

The transition approach does not guide management. It provides the basis for the progression mechanism for the concept of the process and its various subsystems. The critical concept of transition is sustainability, which calls for a change in the management regime. Besides, the transition approach is consistent with the norms and requirements of sustainable mobility to achieve the aim (Niki Frantzeskaki, 2012).

In the theory of transition, there is a significant relationship between urban infrastructures and institutions. The link formed by the entire system creates a vicious circle. Ultimately, the circle prevents the development of creativity and innovation. The systems form a whole subgroup related to economy, society, and culture. The sustainability of social structures depends on regulatory institutions. To implement the transition period, it is necessary to reform the structure of the system through innovative ideas (Jonathan Köhlera, 2009).

According to research, transitions are distinguished by three crucial features. Initially, the transition is a long term path designed for several ages. Second, transition implies mutual agreement on reform in science, culture, politics, and technology. Third, the final part considers quantitative interest in the transition of governance. It is oriented into the relationship between transition, politics, capability (Nijhuis, 2013). Converting the transition to sustainable development involves transforming large-scale and lengthy processes like changes from one system to another. This hierarchy consists of participants, subjects, and organizations that become sustainable and simultaneously dependent on the path which was primarily selected. One of the well-known methods in the transition to sustainable mobility is innovation. The reason for this is that certain factors influence the desired transition and interactions between users. The order of users should be stabilized by forming new ones for further transitions . Innovation is considering being the modification of behavior and practice with the help of electric machines and car-sharing. The aim is to investigate methods that will support users to facilitate travel. The user represents the principal participant in the development of new transport services. It takes

into account lifestyle, mobility habits and participation in innovation processes (Liridona Sopjani J. J., 2019).

In 2005, a Dutch program for the transition to sustainable mobility was being developed. The program is called **"TRANSUMO"** (Transition to Sustainable Mobility), which describes as competitive, productive and has the least impact on the ecosystem. The program lasted four years and focused on the study of transport mobility while creating managerial and organizational principles for practical application in mobility. The program was multifaceted and studied economics, politics, logistics, and design on an equal footing. TRANSUMO's main contribution to sustainable mobility is divided into four areas:

1. Land use planning and transport development are some of the key processes. While land management planning is creative, transport development on model-based. One of the challenges is the quality integration of the two areas in favor of each of them

2. Reliable transport from the supply side to the demand side. Providing a quality and smart vehicle for the convenience of citizens

3. Transportation and logistics regulations - To date, programs are being developed to improve the performance in the areas presented. Research in ICT is being carried out on implementation in sustainability.

4. Step-by-step optimization of transport - An achievement of the result utilizing correctly set priorities and involvement of the client in the process of payment for the type of service (Jo van Nunen, 2011).

1.4 Urban Mobility Plans: The EU approach

One of the many important aspects of EU activities remains the creation of a common transport market. Providing freedom in the service sector and opening up free markets, in the case of a transport market, the creation of competitively capable conditions for internal transportation is essential for the further development of infrastructure. In this regard, it is important to build harmonious conditions for both administrative regulations, tax, and

social environment for the transport services. An example is the abolition of internal borders, the reduction of prices for vehicles, the simplification of laws in the movement of people, and goods. On the other hand, the transport industry faces global challenges, both environmental and social. Therefore, the role of "sustainable mobility" is becoming an essential issue today. Regardless of the efforts made, the transport system is still struggling with sustainable development. One of the reasons is the greenhouse gas emissions generated by transport. The white paper "Roadmap to a Single European Transport Area-Towards a Competitive and Resource-efficient Transport System" contains suggestions for improving the environmental situation (Esteban Coito, 2019). Initially, the European Union was concerned about foreign policy issues or building a political relationship with member states, instead of focusing on common transport problems on a wider-level. It severely limits problems related to the consideration and enforcement of constitutional norms. The need for a common transport policy influenced the development of the White Paper in 1992. At the strategic level, there are two key regions for transport policy. The first region related to the administrative aspects of competition and monopoly regulation. The second region is to improve the infrastructure for establishing relationships between countries (Fleischer, 2015). In research on transport policy, The White Paper represents a crucial step in the development of common transportation. The White Paper has caused problems that have appeared in certain restrictions on the provision of services that result in barriers to trade. In 1975, the European Court of Justice recognized that the above limitations were incompatible under the Rome Treaty. As a result, regulations relating to infrastructure investments, economic activity through market access, and the harmonization of social and technical requirements began to emerge at the European level. With the introduction of environmental issues into transport policy, a novel concept of "sustainable mobility" has developed. Presenting the peculiarity of interaction between the transport sector and ecosystem in the regulation of atmospheric emissions and noise level (Liana Giorgi, 2002).

Urban areas are becoming a leading platform for organizational and technological innovation, testing new financing solutions, and transforming mobility models. The EU intends to introduce innovative ideas into local policies for both transport interpreters and

citizens. To further ensure a transport system at the European level, through interconnection and integration. Furthermore, sustainable mobility is becoming increasingly important in relations with EU members. With a successful Action Plan, stakeholders have the opportunity to develop a global society aimed at meeting citizens' needs, improving the quality of life and sustainability. The proposed measures are based on six themes that bring together the common objectives of the European Union.

1. The promotion of integrated policies -Implementation of this policy allows for an optimal comparison of transport infrastructure, especially the regulatory and communication problems between cities (districts, regions)

2. Emphasis on citizens – Providing high-quality public transport that has the characteristics of safety, reliability, and accessibility

3. Increasing the greening of transport- A green policy on vehicles has been implemented in most cities. The policy implies the importance of environmentally friendly cars and the use of clean fuels. Also, it stimulates the economy to pay everyone who pollutes the air

4. Increased funding -To fully benefit from mobility, appropriate investments in technology, vehicles, and infrastructure are often required

5. Sharing information and skills- The EU will provide the necessary cooperation assistance to those concerned. It will consist of the collection, comparison of data and information.

6. Improvement of mobility -Building a sustainable transport infrastructure requires integration and interconnection between vehicles. It also requires reducing the demand for car use and increasing walking and cycling (COMMISSION OF THE EUROPEAN COMMUNITIES, 2009). Worldwide, the trend towards private vehicles as a preferred to use in modern urban cities. This trend leads to the consumption of energy in large quantities and the release of carbon into the atmosphere. As a result, the phenomenon has increased dependence on the infrastructure of motorized transportation. As noted earlier, mobility implies the total amount of individual motion, given that as the movements, time and distance increases to the designated arrival point (Alejandro Leo, 2016). Urban mobility

utilizes several types, all known as public transport services. However, mobility does not consider one-way traffic which swings only the transport sector, it equally supports a direct relationship with land use planning (Accessibility is at the core of urban mobility, 2013).

The Green Paper "Towards a new culture for urban mobility" was approved in September 2007. It can facilitate the transformation at the legislative level and will ultimately be presented in White Paper.

One of the most preceding Green Paper examples is performed as:

- Formation of Capital Markets
- Healthcare for mobility
- Retail services (maximum customer satisfaction) (European Union law, n.d.).

Due to the increase in movements in cities, some constant traffic jams are inconvenient for citizens. The chief threat is that the percentage of air pollution and delays increase with each time. As a result, 70% of hazardous air pollutants are produced by cars and 40% of Co2 by urban vehicle. To date, Green Paper has been developing and actively utilizing methods to improve and solve several problems as providing safe and reliable transport, on the way to green cities and the introduction of smart transports (COMMUNITIES, COMMISSION OF THE EUROPEAN, 2007). Urbanization and socio-economic development are one of the principal reasons for the need for Sustainable Urban Mobility Plans. According to statistics, over 75% of the population of Europe live in cities because of the increasing flow of private vehicles. However, the need for mobility produces a direct impact on the quality of life of citizens. As there are problems with the space for recreation of the city residents and the lack of parking for the general use of vehicles (Ana Bastos Silva, 2009). In 2013, to solve urban mobility issues was generated a Sustainable Urban Mobility Plans by the EU. The plan represents a key tool in the development of mobility and transport. An updated version of the plan explores methods for finding the solution to political, social and environmental sustainability (Riejos, 2019). This policy includes certain objectives that must achieve with the support of collective interests and agreements

between countries. The Plan of accepted laws that serve as a bridge between different industries and people's mobility needs. It comprises six critical topics such as:

1) Rationalization of urban mobility 2) Public Transport Improvement 3) Focus on Citizens 4) Support in Implementing Policy 5) Finance 6) Skills and Knowledge Exchange

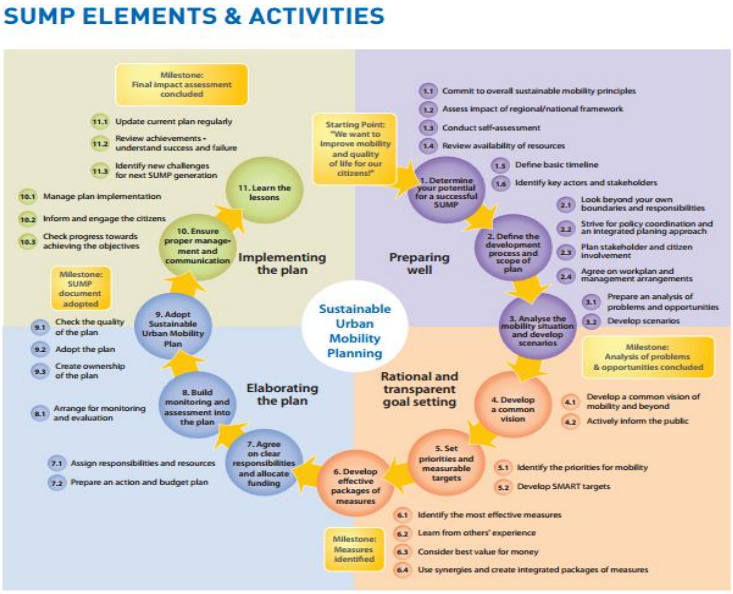

Figure 1.1 Cycle of Sustainable Urban Mobility Plan (Rupprecht-Consult, 2012).

This concept is not a unique way to resolve the difficulties of transport activities, however, it is worth paying attention to the regulatory framework and practice that will solve the problems of transport in urban environments more rationally. To perform this, need to rely on these attributes:

- ***Joint Participation***- all stakeholders in all the tasks set ensures the equality of each participant regardless of their gender
- ***Ensuring sustainable development*** - Balancing environmental, social and environmental growth

- ***Comprehensive set***-out between the political industry and authority. It can be as mixing between the transport sector and the development of the economy
- ***Focus on the development of Sustainable Development*** - meeting the goals in the short term
- ***Economic Review*** - The Importance of Controlling Costs and Profits in Different Sectors of Activity (DANA SITÁNYIOVÁ, 2017).

The SUMP cycle presented in Figure 1.1 describes 11 basic steps and 32 actions created along the logical chain. Start position: "***We want to improve mobility and quality of life for our citizens***". The sustainable mobility plan is divided into four main parts:

1. ***Preparing well***- identifies the strengths for success. The phenomenon consists of a clear viewpoint, the concept of mobility and an overview of present resources. This is followed by describing the stage of the process by looking at the relationship between management and the citizen, developing a plan and defining responsibilities. This part concludes with a mobility analysis and further steps to identify the weaknesses, opportunities, and benefits of the plan
2. ***Rational and transparent goal setting*** - A rational task definition is responsible for developing a general vision and sharing with society. This is followed by the development of priorities and their measurable goals and the creation of SMART targets. In the concluding part, it should provide a suitable indicator for measurement based on the experience of others and the value of money
3. ***Elaborating the plan*** - The development of the plan defines the objectives and prepares a budget plan. The quality of the plan and its further implementation are then monitored
4. ***Implementing the plan*** - The implementation of the plan is based on ensuring the proper approaches for communication and learning the lesson (European Commission, 2013).

Additionally, an updated version of SUMP was introduced in 2014. It touches the updates on essential goals which are an environment, health, social and economic stability, and quality of life (Elisabete Arsenio, 2016). It sets the above goals as locally and the

application of all the targets in unusual surroundings may not be like each other. To assess each aspect of SUMP, policy integration needs to take into account a general overview rather than every factor. For the unification of all aspects of SUMP that offer a sophisticated version of the scheme to achieve the city's goals. The basis of this scheme is the "Urban Mobility Package", which was introduced in 2013. The package presents strategies for the functionality of city districts, offering practical benefits for enlargement plan of action in collaborations with areas and convenient sectors of urban government (Kukely György, 2016). Consideration of the Sustainable Mobility Plan requires a variety of methods of analyzing many vehicles, from the public to non-motorized modes of transport including parking. It is not an additional package of documents but is a deepening of the existing plan (Rupprecht Consult – Forschung und Beratung GmbH). Significantly to develop the plan also in the commercial sphere, there is a need for an expression that will reflect the critical purpose of the concept. The final phrase was given to the European Commission by Eltisplus with the following formulation as:

"If you plan cities for cars and traffic, you get cars and traffic. If you plan for people and places, you get people and places"

Fred Kent

This phrase underlines the attention of ordinary citizens and stakeholders to increase urban mobility. Calling for action and success for the benefit of the people rather than the city itself. Primarily, reformers of the foundations of the Sustainable Mobility Plan have been considered countries like France and the United Kingdom. To implement the Sustainable Mobility Plan, it is desirable to contact stakeholders, decision-makers and implement a specific concept. Almost always, the development and implementation of the plan require not a small cost. But it is important to note these costs have a place to be, so it provides guarantees for a bright future society. SUMP includes benefits like **Improving the quality of life**, **Environmental and health care, Affordable and improved mobility.**

Improving the quality of life- SUMP's quality of life is interpreted as the realization of alternative spaces for the people and problems with resolving emissions and noise that contribute to the deterioration of the air

Environmental and health care- The Sustainable Mobility Plan has a positive impact on human health and the environment. Taking note, it considers the possibility to establish a climate change situation

Affordable and improved mobility- The improved and affordable mobility draws attention to the fact that the development of all SUMP projects implement to meet the needs of mobility and services of urban areas (Rupprecht-Consult, 2012).

The Figure 1.2 demonstrates the connection between sustainable mobility indicators and sustainable development goals. For a more coherent concept, the author has created a coding with the help of which indicators can be clearly defined.

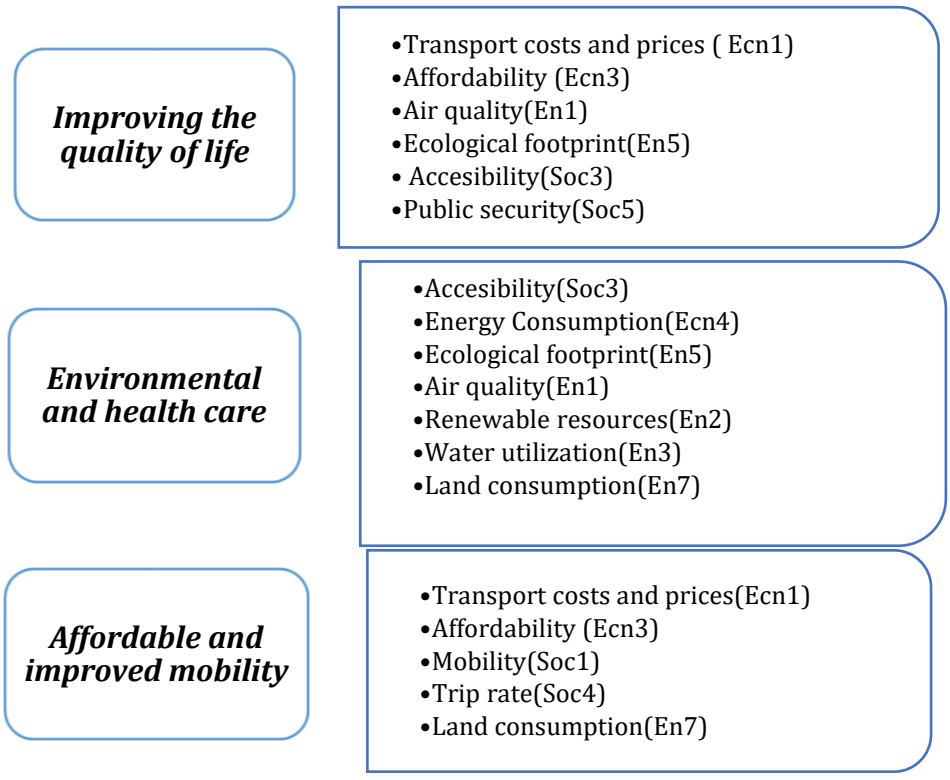

Figure 1.2 The sustainable mobility indicators connected to sustainable development goals

Chapter 2. Smart city

2.1 What is Smart city?

In ancient times, the city was representing a point of human progress. The city was considered a hearth of culture, production, and power. Currently, the city assumes the other appearance as "Smart City". It is significant to discover the essence of the metropolis, to understand better a concept (Bhagat, 2015). Cities have always dominated position in the impact on the ecosystem, economic and social areas. The deterioration of the urban environment is caused by emissions from the supply of goods which intensify present problems. By nature, the city represents the most critical consumer of all kinds of resources. Because of this, the municipalities started developing a plan to solve global problems. Accordingly, the development of plans to improve transport infrastructure as well as land use. Especially, providing high-quality public transport can help with employment and increase the economic growth of the city (Vito Albino, 2015).

The development of "smart cities" began in the 90s along with the expansion of telecommunications services. Frequently the idea of "smart city" is regarded as a novel kind of technology, although it has a broader concept. The initial project to launch innovations in Smart Cities focused on three industries: ICT (Information Communication Technologies), mobility and energy. One of the differences between Smart Cities and simply technological ones that combines social and environmental aspects as the achievement of goals using ICT (Fernandez-Anez, 2016).

Smart City is a kind of leap reflecting the development of urban technology and divided into three categories. A smart city can be described as ***"instrumental***.". It involves the collection and processing of information with the help of unique devices and mechanisms. An ***interacting city*** subtends all received information into a singular computerized form capable of exchanging data among various municipal services. The ***governing city*** is also recognized in the literature as an "intelligent city". Its specific feature is in self-expression, self-marketing to form an image for creative and business representatives. A city is also a tool for the visualization and integration of all data to solve management problems

(Sarbeswar Praharaj, 2019). The basis of modern research in the field of "a smart city" is the study of issues related to stimulation and technology structure. Because of the structure and stimulation of technology, the emphasis is placed on the availability and accessibility of systems. Technology is becoming progressively important in human life. Meanwhile, having a positive impact on the lifestyle of citizens. The Smart City program is gradually evolving from intellectual places to the transition of network residents. The first step towards urban digital infrastructure is the introduction of wireless communication. The set of attributes for "a smart city" consists of service-oriented systems, technological equipment and from available access points. The ubiquitous computer network serves as the core element in the digital city process. The Smart City infrastructure offers interconnected web-based service systems that help transform critical processes for government, both external and internal (Taewoo Nam).

However, the concept of a smart city differs from country to country in terms of socio-economic circumstances. This is because the idea of a smart city has developed on certain requests of the urban area. At the moment, there is no definite definition of a smart city (Anthopoulos, 2019). The European Commission offers its concept of a smart city. According to the European Commission, Smart City is a place where traditional networks accepted digital communication technologies to improve efficiency for the benefit of residents and businesses. SC also influences the environment to manage resources and reduce emissions. This includes renovated water, waste treatment and improved transport systems for heat supply in urban municipalities. Besides, it implies the necessity to meet the needs of each resident by providing responsible administration and protected public spaces (European Comission, n.d.). One of the radical reforms in the development of sustainable urban regions is considered to obtain the promotion of the Smart City concept. The point is Smart Cities form a management structure to manage resources wisely. To promote a Smart City, the role of participation is significant. The program equally appreciates cooperation with citizens as one of the stages of plan. The fundamental idea of an intelligent city is to guarantee safety, provide services and support an enabling environment for business. Smart City is not a traditional type of service or technology, on the contrary, it can be interpreted as a modern model where the government formulates

the needs of citizens (Virginia Barba-Sánchez, 2019). The basis of a smart city is a comprehensive approach to the management and improvement of the city. "Smart City" provides a balance of economic, social and technological components involved in the state of the urban environment. One of the discoveries in innovation, coming from the concept of "smart city." The development of methods focused on the interests of citizens and their interaction in urban activities, which essentially becomes an element of "smart strategies." Taking into account the considered parameters of definition from ***Assessing Smart City Initiatives for the Mediterranean Region (ASCIMER)***: "An integrated system where social and human capital is closely interlinked with each other is a sign of a smart city. It aims to develop and ensure a high standard of living, oriented towards cooperation with urban institutions" (Markus Helfert, 2015). Nevertheless, to develop a smart city, it is necessary to have social and environmental elements complementing public value through creativity and innovation. One of the features of the SC elements is the use of ICT services. For the well-being of cities and the sustainability of resources, towns must benefit from innovative technology. The proposed solutions with the use of technology are designed to contribute to the development of environmentally-friendly transportation, safety, energy- savings and minimization of the "carbon footprint." The emphasis is placed on innovations that allow for the identification, processing, transformation, and movement of data. Among the innovations are:

1. Communication networks - It contains logical and material resources that are declared by servers acting as the city's intelligence.

2. The internet of things -Sensors will be able to record data to quickly respond to the city's challenges. The term is also associated with embedded systems in the technologies

3. Big data - One of the massive volumes of information is generated in cities. Characteristic features of large dates are speed, variety, and volume.

4. Cloud and Edge Computing - This component is necessary to meet the needs of data processing and storage. As the recycled data should be transferred to the city municipality to support the decision-making process (Virginia Barba-Sánchez, 2019).

2.2 Specific contribution of sustainable mobility to smart city

Despite the application and regulation of safe transport over the past twenty years, it remains a global challenge around the world. As the increasing demand for transport services automatically increases the percentage of energy consumed (associated with emissions) and affects congestion. Pollution reduction policies should focus on the city, as it is a strategically important place for the movement of citizens. It is assumed that the implementation of the Smart City concept will reduce emissions and have a positive impact on sustainable mobility (Jakub Zawieska, 2018). The key part of a smart city is sustainability. Since the relevant structure of leading indicators should contain the primary documents adequately prepared by the EU, aimed at rational use of energy to solve the tasks (Ferrara, 2015). Indeed, to achieve sustainable development of SC, it will be necessary to combine efficient transport systems in an integrated manner. The initiative of a smart city is the relationship between social and human capital. To improve the economic condition and lifestyle of its inhabitants. Sustainable transport is considered as one of the main mechanisms in developing a smart city. The driving task of a smart transport structure is to reduce exhaust emissions by providing energy-efficient transport. Sustainable transport is responsible for planning and managing all transport services involved in mobility. In particular, from traffic lights to trains. Apart from that, electric vehicles are an alternative form of transport in a smart city. According to the European Union's White Paper on Transport, all cities will have to abandon fuel vehicles by 2050 (Dastan Bamwesigye, 2019). Consequently, the integration of a smart and sustainable city at the same time has a positive impact on mitigating the effects of economic congestion due to energy costs and a shortage of renewable resources. It is argued that smart cities can become "industrial cities" where renewable resources can play a key role in the economic context. Naturally, the main characteristic of a Smart City is that it reduces carbon emissions in public places. One of the advantages of renewable resources is the predominance of other resources of energy, such as gas and oil, which always has financial assistance from European countries.

In particular, it creates distortions in market functioning despite the benefits of promoting renewable energy and limiting gas emissions, which imply environmental protection. Examples include instability in oil and gas prices, the development of new technological methods for extracting different types of oil and gas, and strained relations between countries that extract all fossil resources to predict a possible economic crisis. It is questionable whether existing energy can be stored for the long term and if this can be measured in time. Based on research, the parameters of a smart city can be divided into six categories:

1. Smart Life - Favorable vital conditions, in other words, quality of life that includes health, housing, and cultural heritage.

2. Smart Environment - A policy designed to reduce emissions and ensure environmental protection. Stimulating sustainable resource management and increasing attention to the ecosystem

3. Smart management - The opportunity to provide public and socially oriented services, involvement in the decision-making process. Undoubtedly, having a certain position in politics

4. Smart mobility - Support for the development of safe and innovative transport systems in a national and global level

5. Smart economy - The perception of competitiveness, production activity, acceptance of innovation and flexibility of the labor market

6. Smart people - Activity in the attraction of social life, wide worldview, human capital, and high qualification. The primary goal of a smart city is to establish public policies to improve urban life (Ferrara, 2015).

For efficient management of the transportation system, a process of transition to "smart transport" is required. It involves creating an infrastructure that will improve the vehicle system through technological innovation.

To increase transport sustainability, there are three methods :

- Improvement of available transport facilities
- Moving towards sustainable transport
- Optimal land use planning

These measures are partial tools on the way to sustainability as it is related to urban design, within the framework to all type of transportation. The idea makes it possible to involve public and non-motorized transport in the implementation. It is worth noting, that if cars are abandoned in favor of bicycles, this will have a beneficial impact on the environment and road safety (Irina Makarova, 2017). Introducing the concept of sustainability directly into a smart city demonstrates the value of the aspect and contributes to the transition to “smart activity”. Besides, projects are designed to make the city stable and more “intelligent”. The proposed projects must be profitable, productive but also improve the well-being of citizens. From this point of view, the city represents a significant contribution to the socio-economic development and protection of resources set at the local level. Despite its beneficial impact, a SC established based on the principles of citizenship can have contradictions with the politicians who make decisions. As a result, SC development depends on an enabling environment that brings together the entire population and other stakeholders who are focused on a specific position and action (Janaina Macke, 2019).

2.3 Technologies to solve sustainable mobility trade-offs

Technology has made a significant contribution to shaping society, the environment, and the economy. Moreover, it has two sides at the same time as it creates constantly new challenges and the solution to many problems. Technology transformation is closely linked to the development of socio-economic areas as society and institutions have developed simultaneously. Technological change can be controversial, as it can be a means for social activism and collaboration, and it can also be a source of controversy (United Nations, 2016). The introduction of development technology has given rise to the improper hope of

resolving problems. However, it led to the consequences of losses in natural resources. The presentation of technology as a means of combating urban problems is promoted by the producers of technologies, start-ups, and other companies. In this way, it formed a novel idea of correcting impractical urbanization and choosing energy resources using modern technologies. Based on this idea, it appeared "intelligent city" and then a "smart city" concept. SC are perceived as populated areas that adopt innovative technologies to address issues related to urbanization. According to one researcher, creating strategies that are linked to ICT technologies will help to address the challenges of a sustainable city (Tan Yigitcanlar, 2019). Technology offers cities the opportunity to determine the needs of citizens while making urban areas environmentally friendly and profitable. Five recommendations were presented at the Smart City Expo World Congress for sustainable mobility:

1. Gaining public rights and authority to be involved in planning - Citizens can be aware of planning progress and facilitate citizen participation in strategy formulation

2. Assist developers in identifying mobility needs- Applying data gathering, processing methods generating effective visualization tools enable residents and planners to optimize street lay-out, transit, and zoning.

3. Integrated use of technology as part of sustainability goals - The focus of cities should be on applying technology to various solutions. There is a need to increase the number of electric and hybrid vehicles without creating other problems like traffic jams and accidents.

4. Improvement of travel conditions- To improve transit operations, it is critically significant to provide citizens with reliable information about departure time in online regime

5. Rethinking bicycle theory -It is important to understand that, despite present technologies in transportation, the bicycle will remain among the technologies of the future. They are a reflection of modern lifestyles (Network, 2017). Air and road transportation is one of the largest demand in the transport sector. Given that, they are one of the negative types of transportation, as they are the most polluting. A critical reason for pollution is a large number of private vehicles and the increase in freight traffic.

Undoubtedly, to reduce the environmental harm caused by vehicles, it is possible to improve existing technological developments or by forming new technologies. Technologies fall into two main categories, depending on the methods by which damage can be predicted:

1. Integrated technologies - designed to deliverance harm through the correction of the processes

2. End-of-pipe technology- used to filter carbon monoxide fume before they damage the ecosystem.

Currently, some cars consume hydrogen, which prevents air pollution. Significantly, only a few units of vehicles do not have negative impacts. Precisely, compromises are forced to be made to achieve environmental goals. For example, reducing exhaust fume can simultaneously lead to noise problems. Besides, the consumption of more fuel may cause unintended long-distance mobility due to low costs. Technology can help to resolve short-term air pollution problems but has no power in solving the quality of life in an urban environment. One of the alternative solutions to avoid certain trade-offs can be to adopt technologies that combine transport areas with others like architecture, energy and land planning (Geenhuizen, 2002).

Given Table 2 provides basic technologies in sustainable mobility and their possible trade off.

Technologies	*Trade-offs*
Integrated technologies	The consumption of more fuel may cause unintended long-distance mobility due to low costs (Geenhuizen, 2002)
End-of-pipe technology	Reducing exhaust fume can simultaneously lead to noise problems The consumption of more fuel may cause unintended long-distance mobility due to low costs (Geenhuizen, 2002)
Energy-saving technology	Cost of operation and investment Interval of service delay Price for equipment and limited types of base stations (Yan Chen, 2011)
Electric vehicle	Costa and batteries deteriorate due to aging mechanisms Limited distance (Eduardo Redondo-Iglesias, 2019)

Table 2 The Technology and its trade offs (René, 2009).

Technological developments in the transport sector are the most preferable due to minimal influence on the government. But clearly, there is a contradiction. To achieve perfection in market conditions, they should be perceived as benefits for suppliers and potential buyers. However, if enhancement forms of vehicles help to reduce production costs, they also contribute to extra harmful modes of transport. One of the primary roles of technological development and policy is the strategic cooperation in the field of the environment and transport areas. Another divergence of opinion in the environmental interests of countries, customers, and producers. These contradictions point to a certain degree of technology caution concerning the transport field. Frequently, when large-scale facilities are constructed, transportation for cargo ships faces material and technological challenges. In contrast, when technologies are present to the public, there are difficulties in operation.

The presence of difficulties in making decisions and an enormous number of stakeholders involved hinder the growth of innovative technologies (Gerlings, 1999).

Chapter 3 Best practices of smart mobility into Smart cities.

Case study Porto

One of the long-term objectives of the municipalities is to modernize inhabited areas into accessible and prosperous residences. Numerous cities have begun implementing a "smart city" to achieve this goal. However, the definition of a Smart City is considered ambiguous as there is a framework to guideline cities and local authorities to take a general view of the progress of the city (Tan Yigitcanlar, 2019).

Difficulties in building a "smart city" are due to the lack of appropriate infrastructure in terms of connectivity. For a Smart City, it is necessary to have an accurate structure with parameters. Any defect will lead to a failure of the system, thus the appropriate duplication of the plan is important. The active participation of local authorities and the adaptation of the population to changes is significant. The founder of Smart Cities is in Portugal. The Smart Cities World Expo, which took place in May 2014 with the participation of the town of Porto, has contributed to the creation of a national network of "Smart Cities" consisting of 25 cities that will soon be smart. In the following years, as part of the Grow Smarter cities program, Portu joined the 5 cities where the EU was going to invest in the concept of "smart cities". Information and communication technologies will be used as a means of solving problems. The first urban activity in the field of smart cities started in 2004 in Porto. The city authorities launched a digital revolution which was the Porto Association. It is estimated that by 2050 about 75 percent of people will be living in cities. Porto is a member of the Open and Agile Smart Cities and FIWARE program. The program implies the consolidation of all the data obtained by the city. In conjunction with the City and the University of Porto, they have created the project "City of the Future". The goal is to receive and combine data from 75 mobile stations. For example, the collected data from all city institutions will be connected to a unique platform where residents could cooperate with city services. Also, a local company in Portugal has developed special points that can be

connected to taxi and public transport to collect data online. The information is then processed to help identify vehicle problems, speed, and level of pollution. The company has also provided WIFI points to improve the quality of travel. Sensors will also be installed on the waste bins, which will indicate the level of the full container, that the garbage truck does not have to reach the empty bins. The sensors will be WIFI-based and will contribute to reducing fuel costs and ecosystem pollution through a router that will regulate the travel of vehicles. Porto has its long-term plans for the future as a reduction in CO2 of more than 45% by the current year 2020. The city foresees the introduction of environmentally friendly cars to combat air pollution and infrastructures for recycling additional waste (Aniket Singh Solanki, 2019). The strategic plan for the smart city of Porto is compatible with the sustainable energy strategy. In the process of restoring the city's neighborhoods, it is critical to take into account the energy conservation of the premises and the transformation of the city's behavior through involvement in the decision making process. Until now, the City of Porto has envisaged raising funds to improve the urban ecosystem. With funding from the Jessica Holding Fund of 130 million euros, the City of Porto has significantly improved its well-being and sustainability (Calçada, 2019).

Objectives of case study **Porto city**

- **Sustainable energy**
- **Data protocol for quality of life**
- **Alternative fuel driven vehicles**

Case study New York

One of the most populated cities in the United States is New York. At the international forum "Smart City Expo", it was awarded as "Best Smart City 2016." The city has implemented a large number of plans to transform into a "smart city." The project involved collaboration with residents and the government. To improve the lives of citizens, the action plan was built on several segments (waste management, clean air, water management, and energy saving). Because of the large volume of waste, it is recycled in two groups - private and public. Public responsibility for waste includes administrative and

residential buildings. Private organizations have to pay for their waste. New York City is implementing several various measures to improve waste management, in particular increasing the volume of waste recycled and removing barriers. As well as gaining access to recycled waste for energy generation. As a given example of the city Porto, New York has created a "smart bin" as part of the initiative. These bins consist of sensors to monitor the level of garbage and have a special solar-powered compactor. The research on air quality began in 2008. Nowadays, 75 temporary control stations monitor the air condition in parallel with eight continuous monitors, which should report information within 15 minutes. The program has addressed one of the primary causes of pollution, which was found in 1 percent of New York City buildings. Subsequently, the city was able to reduce emissions by more than 70 percent and implemented several mitigation measures. Later on, an Automated Meter Reading scale was developed to track water consumption. There are two methods to consume water wisely. These are "Rainwater Harvesting" and "Greywater." Residents must limit rainwater emissions into the sewerage system to prevent leakage. The Greywater method assumes portable fountains that have been installed to supply water to the streets. For saving energy, have been installed LEDs on the streets and can last up to 20 years. The advantage of LEDs is to provide quality lighting and reducing the adverse impact on the environment (Jigar Shah, 2019).

Objectives of case study New York city

- **Quality of life**
- **Clean air**
- **Waste management**

Case study Amsterdam

From the point of view of the global economy, the city of Amsterdam is one of the key places. The location of international companies in the regional branches actively attracts foreign employees residing in the town and its surroundings. The city government in cooperation with enterprises and housing organizations implements plans to restore

strategies since the 1990s (Vallicelli, 2018). A variety of activities have been implemented during the planning process. The Smart City Strategy of Amsterdam was integrated with the city structure and built according to the priorities set. The core focus of the strategy to confront climate change by reducing CO2 emissions. This goal was outlined and agreed upon in the general concept objective and priorities proposed in the new Amsterdam Climate Policy. The ultimate objectives of the strategy are to be achieved by 2025:

1. Taking advantage of opportunities to promote sustainable economic development based on technology, encouraging a sustainable way of life by modifying the behavior of citizens **2.** Enterprises to reduce carbon dioxide emissions and decrease energy loss (Luca Mora, 2017). The foundation of Smart Amsterdam consists of a partnership between the government and entrepreneurs, residents and research institutions with over 70 partners. The core objectives of the project are quality of life, mobility, and community facilities. The concept needs to be implemented in 32 territories around Amsterdam with a focus on the availability of network and energy supply. At the initial stage, projects will be tested and those who gain excellent results will be implemented in larger areas of the city. The "Climate Street" Project is one of the well-known projects in Amsterdam's Smart City. This project aimed to establish energy-saving and smart technologies in the streets and public places. The project results revealed an 8% reduction in air emissions and a 10% saving through green energy. A modern "West Orange" project developed in the context of energy saving. The plan established an innovative system for 400 households to control energy consumption. The energy system is equipped with a wireless scoreboard connected to energy and gas meters. The goal is to reduce energy consumption by 14%. As a result of innovative discoveries Amsterdam Smart City won several titles of "World Smart Cities Awards 2012" and "European City Star Award 2011" (Angelidou, 2014).

Objectives of case study **Amsterdam city**

- **Reducing emissions of CO2**
- **Promote sustainable economic development through ICT**
- **Energy saving**

Case study Barcelona

Smart cities have a positive impact on the daily lives of residents, but smart strategies focus on top-down initiatives. The idea of Smart Cities is widely spread in political circles, regardless of the needs of citizens, usually transformed into strategies designed and implemented by public institutions. Frequently, citizens are perceived as testers and consumers rather than as initiators of technology and production. An example of a smart city will be in Barcelona. The city was awarded the "European Capital of Innovation" in 2014. Before the award, the metropolis's municipality had embarked on a large-scale project called "Barcelona as a city of people." It adopted modern technologies to ensure the economic development and prosperity of the city's citizens.

The base of the project consists of five areas:

1. Development of a sustainable city which implies the use of electric cars and energy-saving.

2. Availability of data collection

3. Promotion of cooperation between universities, research centers, and social organizations

4. Social Innovations

5. Providing intelligent services based on information and communication technologies

In the following years, Barcelona has developed a new sustainable ecosystem under the name "ICAPITAL". It draws on the support of private sectors, public institutions, and citizens of the urban area. Barcelona is a city in which the urban outlook has improved considerably over the past 10 years. It is also recognized as a successful megapolis for its business development, quality of life and ecosystem. In spite of the current crisis, the city has managed to maintain a favorable atmosphere for local development. ICT integration and investments in the reconstruction of the city infrastructure began in the 1990s also to adapt to modern needs. To be specific, provision of WIFI, development of sensor transducer designed for open access for various purposes. In some districts, the city governors invest in the creation of new facilities through an infrastructure development

plan. The goal of the renovation of the districts was to involve large enterprises in areas related to technology and knowledge. On the other hand, it was supposed to apply a creative approach through improving the communal territories. For example, water supply system, communication, centralized waste collection, and movement. The municipal administration of the city of Barcelona has launched projects at visible management. It focused on the collection and exchange of data in open access. This increases transparency although it identifies and addresses the needs of stakeholders and enhances economic growth for business development (Ignasi Capdevila, 2015).

Objectives of case study **Barcelona city**

- **The use of electric cars**
- **Energy saving**
- **Social innovations**

Case study Bogotá

Colombia is one of the developing countries facing new challenges in health, poverty and the economy, which require innovative programs. But the city of Bogotá is one of the exceptions in the smart city area. Thanks to a study commissioned by Nokia, "Smart City Playbook 2016" has been recognized as the city of Bogotá .The main characteristics of Smart City Bogotá are:

Residents-Analyze learning as one of the important factors in influencing Smart Cities, thus divided into two phases:

1. The "Living Digital Plan for People" program, developed by the Ministry of Information and Communication Technology

2. Development of Colombo-School Platforms for the development of educational schools

Quality of life - This part means quality health care, safety and technology development. For example, Bogota has a "District Plan for Health, Science, Technology, and Innovation for Healthcare. It aims to share knowledge and experience to develop all areas of sustainability

The Government –The city of Bogotá has a special platform as a source of innovation and the right to participate in solving the city's problems through technology. The platform has also been awarded the title of "Digital Government" in Latin America

Environment- City has developed an entire air control network and has the property of collecting data on pollutants

Mobility -Despite frequent traffic congestion, the city has created a technology implementation plan to address important aspects of mobility. There are bicycle lanes and a traffic control point by tracking. The city has started using an intelligent system for the convenience of citizens and tourists. An example would be electronic tickets for public transport in conjunction with an application that makes it possible to plan a whole day's route (Ricardo Alirio Gonzalez, 2019).

Objectives of case study **Bogotá city**

- **Quality of life**
- **Air control network**
- **Sustainable mobility**

Given Table 2.1 represents the overall ranking of case studies. There is also an index of air quality (AQI). AQI is a measure of air quality reports for daily life. The level of indicators is scored on a scale of 0-300 and consists of certain color categories. For example, from 0-50 color is green. It indicates a level of pollution is not dangerous, and the air quality is satisfactory. From 51-100 color yellow. To average acceptable air quality but, certain types of pollutants may present a health concern for a small number of sensitive people to air pollution. From 151-200 the color red indicates unhealthy, and higher the level of the rate contamination the more dangerous it is the city to stay (Environmental Protection Agency, n.d.). Congestion level or Traffic index - is an indicator of jams encountered by passengers. If the congestion rate is between 0-15%, the most impressive result is the city has no traffic problems. 25-50% is satisfactory, but there are problems with traffic jams in small amounts. If the rate is between 50% and higher, the city is constantly more jammed and reduces the level of sustainable mobility (TOMTOM, 2019).

Country	*City*	*Size of city*	*Population*	*Air quality index*	*Smart city index*	*Traffic index*
Portugal	Porto	41,42 km^2	1,312,947	37.57		31%
USA	New York	783,8 km^2	8.5 million	54.25	38th place	37%
Netherlands	Amsterdam	219,3 km^2	1,149,000	31.88	11th place	26%
Spain	Barcelona	101,9 km^2	5,586,000	64.22		29%
Colombia	Bogotá	1.775 km^2	10,978,360	69.19	98th place	68%

Table 2.1 The overall ranking of case studies (Numbeo , 2020) (SmartcitiesWorld, 2019), (TOMTOM, 2019)

CONCLUSIONS

With the increase in passenger and freight traffic, there are significant challenges to sustainable mobility. On one hand, they increase the economic potential of the city. On the other side, the increase in costs, noise, and carbon dioxide emissions. The critical problem in sustainable mobility is air pollution. The emissions are supposed to be double in 2050. The responsibility for solving the problems lies in the administrative municipalities. However, The European Union has established an Action Plan to meet the needs of citizens. Since the fundamental objectives of the plan are improved health and environmental care, mobility, and quality of life. The strategy consists of eleven steps linked in a logical chain. The process is described from developing, through the goal setting, elaborating and implementing the plan. It should be noted that there are also barriers that prevent a plan from being rationally implemented.

The work is based on a literature review, and data were selected from the 2000s to the 2019 year. The work emphasizes the relevance and vitality of the chosen topic. The thesis

equally describes a smart city. It provides a combination of broadly accepted sustainability goals with ICT. Smart Cities are designed to address social, environmental, and natural resource problems. The paper provides five examples of Smart Cities' towards sustainability and uses a table for overall ranking at the Smart City level.
The author's recommendation is to develop an intimate relationship between society and governance. This aspect is still one of the critical issues in the implementation of the sustainable plan in developing countries. It is necessary to work in the same way about aspects of accessibility and land use. Trying to expand territories and provide frequent public transport. Because of the lack of concrete ideas about a sustainable mobile plan, it is necessary to extend the analysis and discover the possible trade-off. Since everything is contradictory, it is necessary to discover alternative ways that will have a less negative impact on the environment and mobility.

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