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Future Vision For Improving Riyadh City To Become A Smart Mobility City

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Abstract:

Smart Mobility aims to afford mobility to people in cities and to find advanced and maintainable means of transport, such as the improvement of public transport fuels that are safe for the environment, supported by leading technology and proactive behavior of citizens (Neirotti P., 2012) Riyad city is suffered from traffic congestion, according to The Report 2021 of Ministry of Interior, KSA, the economiccost loss resulting from traffic accidents in the Kingdom of Saudi Arabia is nearly valued at about 21 billion riyals annually. Thus, implementation of smart mobility relieves to make the movement of goods and people easier, in addition to reduce traffic accidents and their catastrophic consequences and it aims to adoptmeasurements that are able to guarantee traffic safety. The research approach is deductive to improve the situation of the sector of mobility in Riyad city through theuse of real data. This studycomes up with a number of recommendations to achieve smart mobility in Riyadh city. The findings of this study indicated that the mobility system of Riyad is sustainable as a result of therise of smart mobility. On the other hand, the government of Saudi Arabia has already started to performsome projects to achieve smart mobility.

Keywords—Smart Mobility; Smart City; Smart mobility eco system; Riyadh City

INTRODUCTION

Many countries have adopted the concept of Smart City in order to satisfy all the needs of people. Actually, KSA is one of the countries that are going into a radical changethrough transforming a number of cities into smart cities (Doheim, R. M., Farag, A. A., &Badawi, S. 2019). KSA has recently practiced and employed a continuous approachfor development that is able to find a significant changein the formulation of smart cities (Aldusari, A. N. 2015).Since it is easier to find a high quality service, amenitiesand higher standards of infrastructure in cities,82%of the people in Saudi Arabia live in cities and they are satisfied for this. (Doheim, R. M., Farag, A. A., &Badawi, S. 2019). Riyadh is taking a serious step in setting up new smart city node. There are many recent and modern studies about Smart Cities all around the world, at the same time; it is very rare to find a study about Saudi Arabia regarding this issue.In reality, Saudi Arabia depends on petrol fuel for transportation, now there is a lack of smart

mobility. Saudi Arabia must start to implement the smart city concepts such as, Resilience Cities, Smart utility, smart mobility, and Smart Building (AlSelami, F. A. 2021).

The concept of Smart City has appeared as a solution for the complicated urban issues that are led by global companies of technology. Under this light, Saudi Arabiaaids the inventiveness of the smart citiesthrough all the possible means (Doheim, R. M., Farag, A. A., &Badawi, S. 2019). A Smart City is an urban zonethat depends oninformation and communication technologies,business models, and many solutions that aim torisethe operational efficiency, through sharing information with the public toimprove both of the citizen welfare and quality of services (Brčić, D., Slavulj, M., Šojat, D., &Jurak, J. 2018).

The most important concept in Smart Cities is the Smart Mobility. Through using various technological solutions in all of the fields of transport and the science of traffic, the opportunities for applying technology into the sector of transport is more and more growing. The development of information and communication technologies form the pillarsinSmart City development (Brčić, D., Slavulj, M., Šojat, D., &Jurak, J. 2018). Smart mobility is an important aspect in the ecosystems of complicated smart cities. It is considered as key factor in allowing cities to beintelligent, thisemphasizes the importance of illustrating the motivations that improve the intelligence of cities (Aljoufie, M., &Tiwari, A. 2021).

1. Smart City

1.1. Smart city concept

Intelligent and Creative Citiesare concepts that might seem very near to the concept of Smart Cities. The difference between these concepts is not obvious (Dudzevičiūtė, G., Šimelytė, A., &Liučvaitienė, A. 2017). Historically, Intelligent City is the concept that appeared at first. It refers to top-down approaches in line with the main focus of technologies and the strong emphasis regarding thedevelopment through technology (WALRAVENS, 2015). Smart Cities have combined all the conditions of infrastructures such as communications, airports, rails, bridges,roads,and tunnels (WALRAVENS, 2015). The concept Smart City has appearedas a help for to the urban difficulties and challenging issues that are very complex. In other words, smart cities have come out by global companies that depend on technology. In this context, Saudi Arabiaaids the inventiveness of smart cities through all available and possible means (Doheim, R. M., Farag, A. A., &Badawi, S. 2019).

In the 1990s, the term Smart City was used for the first time. At that time, the focus was on the importance of new Information and Communication Technologies ICT applications for the modern infrastructures of the cities. Further, the focus was onhow a city can be built and prepared to carry out information technologies (Albino, V., Berardi, U., &Dangelico, R. M. 2015). According to Toppeta (2010), a smart city strives to combine ICT and Web 2.0 technology with other urban planning methodologiesto find solutions that are efficient, intelligent and innovative in order to contribute in increasing thelivability and sustainability of its citizens. To identify the practices that are used in the nation or worldwide regarding theSmart City, it is important to recognize the meanings and illustrations of these practices. Lately, there are some concepts that are similar to the concept ofSmart City, such as intelligent, virtual, digital, or ubiquitous city. Actually, these terms are not comprehensivesince each

term is a holistic approach thatrefers to one smart practice and pays attention on a certain aspect. Actually, the concept of Smart Citycombines all of them (Doheim, R. M., Farag, A. A., &Badawi, S. 2019).

Various technologies have developed such as the field of information technology. The field of information technology is recentlyfilled with the concept of Smart City (Sunardi, H. I., Sulistyo, S., &Mustika, I. W. 2020). The concept of Smart City and its strategies are looking to improve the present services in cities through making the current infrastructure more suitable, encouraging the participation of citizens, and enabling the sustainable development of the urban environment in the future.(Brčić, D., Slavulj, M., Šojat, D., &Jurak, J. 2018).There are two main trends that candefine the term in a theoretical method; the first one only looks for a set of definitions that only clarify theurban aspect regarding technology and ecologywhilst leaving apart the other aspects of the city and providing a wide-ranging approach for the urban organizing and managementin terms of all the aspects of the city (Doheim, R. M., Farag, A. A., &Badawi, S. 2019).The second trend clarifies the concept of the smart city in a general method;itfocuses on the linkage and the relationship of all thecharacteristics and aspects of the city such as social, institutional, urban, etc. It alsoreflects a completemethod to control the urban problems through employing the use of the modern technology in order to make an urban ecosystem (Correia, L.M., Wu¨nstel, K., 2011). The conceptual innards of a smart city can be divided into three categories: institution, people andtechnology. Ifthe investments in these areas of development lead to a sustainable growth and enhance the quality of life,a city can therefore be considered as a smart city (Colldahl, C., Frey, S., &Kelemen, J. E. 2013). Thus, smart cities can be described as places that are forward thinking in all the parts of people's lives, such as, economy, living, environment, governance, and mobility (Giffinger. R., &Pichler-Milanović, N. 2007).

Normally, a city is considered a Smart City when it is capable of collecting and investigating mass quantities of statistics fromextensive groups of industries; from urban planning to garbage assortment. In a Smart City, a composite network of interrelated sensors, software, and devices must be created and well-maintained (AlSelami, F. A. 2021). This should permit the city forhaving a maintainable and a proficient atmosphere for its residents. Many kinds of technologieshelp in sustainingsmart cities, such as: IoT – Connected physical devices using the Internet of Things network,GIS – Geographical Information Systems and ICT. All of these technologies work togetherto collect and contextualize massive counts of statistics that can be utilized to grow and enlarge the components and schemes that are running inside a city (Doheim, R. M., Farag, A. A., &Badawi, S. 2019). Smart mobility in the urban environments is known as one of the most interesting fields of research that deal with the context of Smart City since people all around the world concentrate on cities.

1.2. Smart Mobility

The fastgrowing of urban population with high demands on life quality has formed a necessity for enhancements in all scopes of infrastructure and subsystems in cities. The increasing demand of mobility by citizens leads to difficulties such as pollution andcongestion. For a well-structured transformation, the city needs to have a long-term vision that is usually characterized by an Urban Mobility Plan to ensure smart solutions to come to sufficient outcomes (Maldonado Silveira Alonso Munhoz, P. A., da Costa Dias, F., KowalChinelli, C., & others, 2020).

The concept of smart mobility is becoming an important issue, since traffic jamis caused by the increasing of the number of people who prefer to use various road infrastructures to travel to work, school or any other place. This results in imposing extra charges that make all activities more expensive andimpends the development. (Neirotti, P., De Marco, A., Cagliano, A.C., Mangano, G., Scorrano, F.,2014) The Smart Mobility is a concept that has various old and modern data, and with the help of ICT, travel time is optimized, resulting in reductions of space usage, road congestion, emissions of harmful gases and road accidents (Brčić, D., Slavulj, M., Šojat, D., &Jurak, J. 2018).

Smart Mobility is a wide vision and it is usually known as the most necessary choice for maintainable transport systems (Tomaszewska, E. J., &Florea, A. 2018). The concept ofSmart Mobility and its systematic origin can be found in the smart city paradigm (Albino, 2015; Neirotti.P., 2014). Benevolo, C., Dameri, R. P., &D'auria, B. (2016) described smart mobility as a group of harmonized actions that increase theeffectiveness,the efficiency and the environmental sustainability of cities. The main feature of intelligent can be described as being connective. In other words,it relies on enormous data that gives users a chance to share, acquire and analyze all traffic information in real time. At the same time,this isconsidered as a determinant issue of the dynamic management at the level of local government (Pinna et al., 2017). Vanolodefined Smart Mobility as a "local and supra-local accessibility, availability of ICTs, modern, sustainable and safe transport systems" (Faria, R., Brito, L., Baras, K., & Silva, J. 2017). In this methodology, intelligent mobility must fulfill the entire passenger-transport management system through tracking applications and logistics, parking management and car sharing services (Yue, Chye, & Hoy, 2017).

Smart Mobility offerswell-organized, clean, and reasonable network of transportationfor the inhabitants, such as data and goods. It gets advantages from the available technologies for providing planners, users, and transport managers with the information that they need. It also allows the improvement of multimodality through enlightening the cooperationvarious styles of transportation (Giffinger. R., &Pichler-Milanović, N. 2007).Regarding this illustration, Saudi Arabiastrugglesin facilitating the movement of the goods and the commuters, in addition to adopt somesafety measurementsthatguarantee traffic and decreases the number of traffic accidents and theircatastrophic consequences. Furthermore Saudi Arabia works on reinforcing the pilgrims' experience with a strong network of transportation system whichis able to facilitate the access of pilgrims and helpsthemin performing their visits in a comfortable way. Actually, this goal contributes in a great wayto achieve the other aspects of the concept Smart City, especially for smart living, smart environmentand smart economy (Doheim, R. M., Farag, A. A., &Badawi, S. 2019).

1.2.1. User groups for smart mobility services:

User groups for smart mobility services are: City governments: Generating economic growth from the development of an economic sector focusing on technology, data and information (Aoun, C. 2014).**Transport operators:** Balancing the request and the supply to secure the improved functionality, allowing a more well-organized usage of transportation resources, promoting alternate styles of travel and securing an environmentally sustainable outcome for transporting systems in urban areas. **Urban planners:** Improving future infrastructure planning and transportation service provision on the basis of

modelledand real data about the traveler's demand and activities.**Travelers:**Improving the experience of commuting in urban areas and improving the reliability of times ofjourneys and the costs regarding the citizens and the businesses to create a more respectful and livable city.

1.2.2. Smart Mobility Concepts

Smart mobility builds on the concept of Intelligent Transport Systems (ITS), are based on making atraffic control and special places a special access and low CO2 emissions,throughreducing the amount of cars in the designated areas of the cities.Furthermore, they look toraise the safety of traffic participants and to enhance the effectiveness of the transport system. This is done indirectly in order to protect the environment through reducing traffic jam, increasing the efficiency of energy, reducing air pollution,and through promoting the development of related industries (Ujwary-Gil, A., &Gancarczyk, M. 2020).

ITS sheds light on joining devices withdigital technologies, as well as, vehicles, and infrastructure in order to have a better traffic management. The concept of Smart Mobility expands on ITS in order totake ina communicative assets (vehicles, infrastructure and other objects), mobility data platforms and shared mobility services taken altogether the various intermeshed components of smart mobility that have the potential to improve mobility outcomes and to reduce negative externalities that has a relation to the activityoftransportation**(**Lyons, A. C., &Kass-Hanna, J. 2020)**.**Regarding smart cities, smart mobility connotes the beneficial application of digital technologies to improve the outcomes ofmobility **(**Ibid)**.** "Diagram 1" represents four concepts of Smart Mobility.

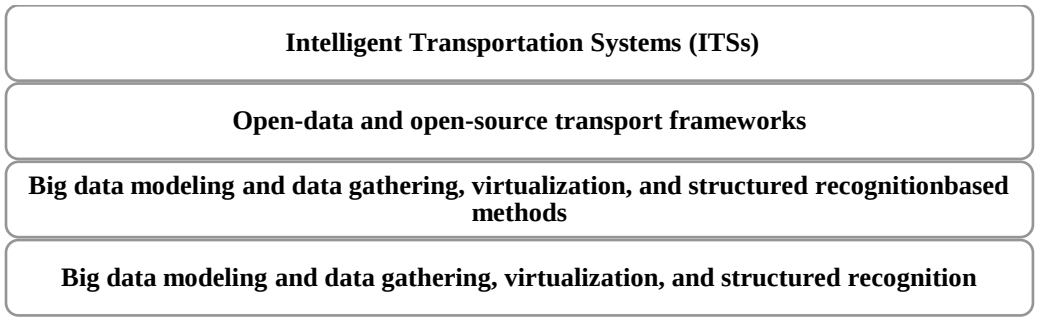


Diagram (1): The Main concepts of Smart Mobility, source: (Author,2021)

- **Intelligent Transportation Systems (ITSs)** are considered as unconventional intermodal transportation networks that areused for smart cities. ITSs aim toincollect data, store data, processing and they provide the needed knowledge in the development, implementation, and valuation of the strong initiatives and strategiesregarding smart mobility. Urban areas are connected to the groundbreaking ideas that are permitted byIoT, as per the common idea of smart connectivity (Bazzan, A. L., &Klügl, F. 2013).The most important elements in smart cities are the citizens, their security and safety.

- **Smart Mobility applications** like road traffic management, smart parking and street light control are starting to be positionedall around world. Thisprovides thecities of many benefits, good quality of life,it also reduces the expenses and produces a well-organizeduse of energy. Howeverenhancing mobilitychallenging, the reduction of traffic jam in cities and the help to reduce traffic jam by integrating smart technology into transportation can make our cities more livable (Sanchez-Iborra, R., Bernal-Escobedo, L., & Santa, J. 2020).Information Infrastructure:Collectinginformation,applications,

access to portable devices and the internet, traffic management system, resident information system (Ibid).

• **Open-source transport and open-data are frameworksthat are used to model mass transit connectivity, collect mass transit routing data**, **develop and mimic bicycle sharing schemes,** givea real-time of otherroad information,software, procedures, traffic accident detection and support systems integrate hardware, and facilities for real-time detection of traffic accidents and rapid assistance to the injured (Maldonado Silveira Alonso Munhoz, P. A., da Costa Dias, F., KowalChinelli, C., & others. 2020), Tracking and documenting traffic safety data by providing maintenance systems with data on road through operating conditions and equipment such as better long-range night vision cameras, sensors and drones, can increase the system's ability to determine the context and severity of accidents, helping reduce their impact on the victim's life and conditions traffic (ibid.), travel time performance. Open data application can be used by authorities and supervisors in urban countries to achieve cost effective designs and implementation. Urban areas collect valuable information and generate massive amounts of data for development, invention and decision-making (Nallur, V., Elgammal, A., & Clarke, S. 2015).

- **Smart Parking systems**are expected toprovide assistance in the transformation of parking management through providing a useful solution to the restrictions of mobility. The Smart Parking Systems include five major categories (Faria, R., Brito, L., Baras, K., & Silva, J. 2017).•E-parking – It provides other choices for clients to ask about the available or the reserved space for parking at the required parking place or facility to guarantee the availability of the parking spaces oncethey arrive at the parking facility. The system can be used or accessed through variousmethodologies such as text messages or the Internet. • • Parking Guidance and Information System (PGIS) – This offerslively information that is related to parking within the controlled areas. These systems contain traffic monitoring, communicating, processing, and static/dynamic message signal technologies. Transit Based Information System – This looksfor directing the user to the facilities ofriding and parking. It also provides real-time information on the status of each and every parking place and public transportation such as schedules of time and the status oftraffic in the public. These systems allow the users to share information regarding traffic routes, schedules of time, and the itinerary planning. • Automated Parking – It involves the use of a computerized mechanism that can place the vehicle automatically in apreviously chosen place. The mentioned systems aim to reduce the space of parking. (Ibid).

- **Smart Traffic Lights** It is a system ofvehicle traffic control that mixes the ordinary traffic lights with various sensors by using the artificial intelligence to guide the vehicles and people who walk in the streets. The traditional traffic light control system runs on afixed hourly basis. In other words,the traffic lights timing cannot be changed in terms of the change in theflow of traffic. In reality, this is one of the major problems in modern urban areas and has a clear impact on theenergy consumption, vehicle emissions, management of traffic flows, as well as on urban noise. Many traffic lights in modern cities complicate the planning of the problem and at the same time this calls for an effective solution that can improve lighting cycle programs (Silva, C. M., Aquino, A. L., &Meira, W. 2015).

• **Big data modeling and data gathering, virtualization, and structured recognition-based methods** these methodologies are used to satisfy the commuter's needs, traffic control, and moves intourging behavior. The scale of collected data has increased tremendously through the introduction of modern IoT apps. This scenario can be applied for many reasons. It might be used to predict the movements in areas that containa high population. In the traffic-related scenarios, the most popular applications with huge data sets are cooperative and share platforms that enable the improved efficiency and the control with the use of pre-existing traffic control resources (Irvin, R. A., &Stansbury, J. 2004).Supporting the Management of Road Traffic through the Car data Retrieval framework agreements of the citizens to take a role in the collection and the uploading of the related traffic and environmental data. This can be accomplishedby the use of the technological features of modern cars, wireless devices, and crowdsourcing. Kinematic and environmental conditions data are conducted to remote servers that are devoted to the organization and road congestion detection and prediction. (Campolo, C., Iera, A., Molinaro, A., Paratore, S. Y., & Ruggeri, G. 2012).**Smart Car** is consistent with the communication of the bus vehicle and it uses special hardware to repossess data from the external sensors. Its software core is built on a mobile application that is specifically developed to work on smartphones that apply the use of Android. (Porru, S., Misso, F. E., Pani, F. E., & others.2020)• **An Arduino board**thistakes inputs from a lot of sensors. Its major role is data collectionand performing the data preprocessing. The Arduino platform was managed and found to present a variety of wired and wireless means of communication (Mangiaracina, R., Perego, A., Salvadori, G., & others. 2017). • **A smartphone** is used for thevisualization and transmission of data. The smartphone application saves data from the Arduino board and displays it to the users, after that it packages and transforms the data to serversremotly (Ibid).

• **People empowerment to have inputs and views, as well as to engage in the process of decision-making.** Cities and neighborhoods allow the opportunity to work with their residents for safer and smarter mobility for the commuters a long with the new visions of the community governance and involvement. This can be used to track the road construction and the maintenance; it also accounts for the road incidents, and evaluates the safety and security issues (Khisty, C. J. 2000). It is expected that with the arrival of 5G, the infrastructure might assess with improving the safety of theroad with a comprehensive vision of traffic and roads in a real time. Intelligent route planning is also considered as a service that is relevant andallows to find the shortest and the safest routes for certain destination or even suggesting alternatives that are taking into account user needs or preferences (Sanchez-Iborra, R., Bernal-Escobedo, L., & Santa, J. 2020), reducing the excessive occupancy of the pedestrian, and to collect vehicle-sharing information that contains two types of vehicles; the first one is Vehicle-to-Vehicle (V2V) – which is known as an automobile technology that is made to allow cars to "talk" throughenabling a wireless transmissions of data among the vehicles. This technology aims to stopthe accidents through allowing vehicles in transit and to send position, speed, and other data to eachother over a Vehicular Ad hoc Network. (Faria, R., Brito, L., Baras, K., & Silva, J. 2017), while the second one is Vehicles-to-Infrastructure (V2I) – is a series of technologies can directly link the road vehicles with their physical surroundings, first and foremost to improve the safety of roads. That is, technology, like sensors and microcontrollers, that allow cars to interact with the infrastructureelements.(Ibid).

1.2.3. Smart Mobility Approach

The smart mobility approach is the most important approach since it is known for being (the potential for the optimizing of the present city infrastructure, services, and urban behaviors through the inclusion and the utilization of the moderntechnology). Smart mobility comes under two approaches. The first one is the alternative fuels and the propulsion vehicles (including electric, hybrid, hydrogen, fuel cells, and Compressed Natural Gas (CNG) vehicles). The second one is the incorporation and the involvement of ICT into the traditional road transport and the sector of automobile; this gives it a chance to create new methodologiesand habitsof travelling (Benevolo, C., Dameri, R. P., &D'auria, B. 2016). These are considered as automatic and self-directed features in vehicles, combines and connect vehicles, users' apps for sharing the cars, or sharing rides, buying tickets, sharing the parking, sharing navigation, and all types of related information (Ibid). Finally, there is an Intelligent Transport System (ITS) that includes theinfrastructure of thetechnologies of transport for collecting the needed data, studying it to invent dynamic smart traffic systems that are able to monitor and accomplish the requirementsfor and supplythetransportion (Ibid). As shown in "Diagram. 2" represents more areas of interest regarding the smart mobility.

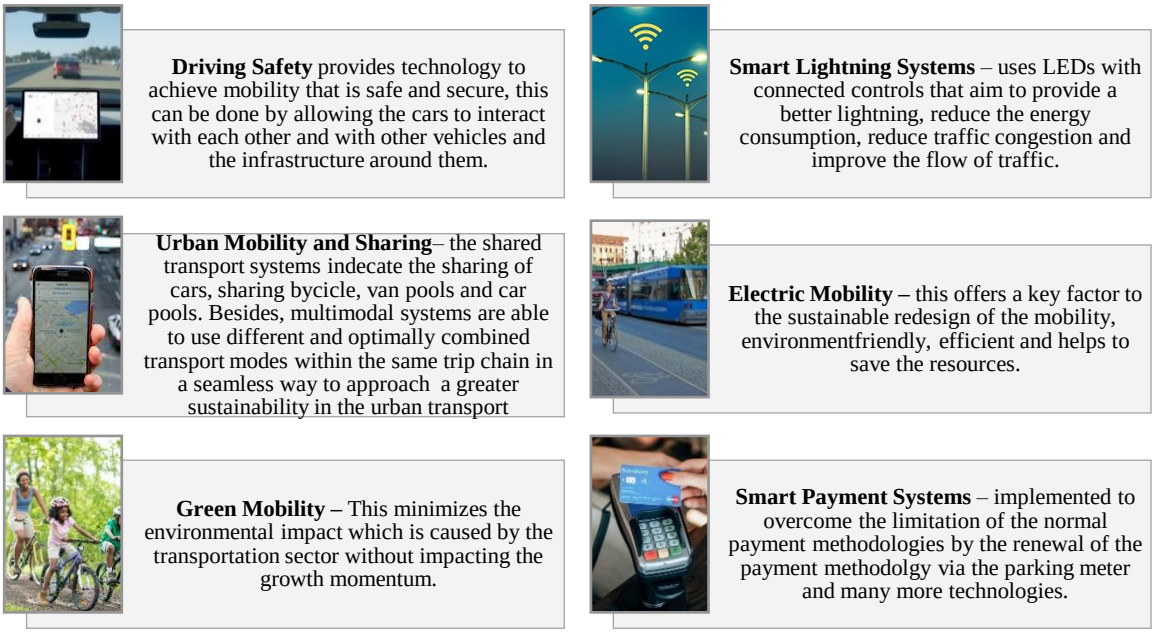


Diagram (2): Smart Mobility main Areas, source: (Faria, R., Brito, L., Baras, K., & Silva, J. 2017, adopted by Author)

Smart mobility technologies and services work in many extensive domains – they might assist or replace driving the (automated cars), they might also enable better en-route navigation for travelers (congestion-aware navigation apps), or facilitate making a better management of traffic system (traffic control centers), they the use of better means of transport (shared micro mobility and ride-hailing), theyenhance the use of uncommon public space (dynamic parking control and curb access management), they facilitate the energy management (smart charging infrastructure) through the use of multiple transport services (Mobility as a service, smart ticketing technologies) **(**Orlowski, A.,

&Romanowska, P. 2019). **Across all of these domains,Smart mobility solutions have the potential indelivering benefits, as illustrated in the following**:

- **Transport efficiency,** is the majorpillar of transport that supports the Sustainable Mobility and the Smart Connectivity to make sure that commuters and goods are able to move to the required destinations in the most effective way with the cheapest coast, less time and less use of resources whether they were human, natural or man-made. Providing the right infrastructure, capacity and services, supported by new technologies help in improving the performance. These are vital to link economic centers, and to ensure efficiencies in the transport networks that are sustainable **(**Porru, S., Misso, F. E., Pani, F. E., & others.2020).
- **Transport affordability and accessibility for people and society**in order for the mobility to be sustainable, it needs to be affordable and accessible, such affordability (both for the private individual and for the public sector financing it) must be seen from the society's point of view as a whole and this should be considered for the public as well as for the private transport **(**Lyons, G. 2018).
- **Transport safety Sustainable mobility and smart connectivity** must be safe and they are seen to be safe by safer roads and less traffic, too many accidents, and related fatalities and injuries continue to affect mobility. As an effect of the COVID-19 pandemic and during the most restrictive periods, the use of public transport has been in some areas at a virtual standstill. Even when travel and work restrictions were eased, people's worriesregarding safety in the public or the "shared" transport systems has meant it has been the least utilized mean for travel **(**Orlowski, A., &Romanowska, P. 2019).
- **Transport security**focuses on recognizing threats, justifying risks and controlling the incidents when they happen. It looks fordealing with the threats of transport and the supply chain in which they arenot controlledat all sincethe ones who commit them find more and morecreative ways to damage, disrupt or destroy the natural and legal flow of goods and thecommute of people **(**Colldahl, C., Frey, S., &Kelemen, J. E. 2013).
- **Transport and environment,** are very significant issues regarding the sustainability, the effect of transport on the environment that is directly related to mobility. Regarding the environment, sustainable transport involves guaranteeing the mobility while certifying an efficient use of energy that decreases all types of emissions and land use.**(**Mozos-Blanco, M. Á., Pozo-Menéndez, E., Arce-Ruiz, R., &others. 2018).

1.2.4. Smart mobility services

Smart-mobility services still remain capable of collecting various types of data, as shown in "Diagram.3"

Diagram (3): Smart mobility services, source: (Aoun, C. 2014, adopted by Author)

1.2.5. Smart mobility ecosystem

Rather than just investing in roads and public transit systems, governments need to consider all aspects of smart mobility, including the user experience: Governments can priories the user experience as a means of generating early momentum because it is the people-facing aspect transportation system, **Existing smart mobility modes**:urban residents have more efficient transportation options than the last few years.Technology and digitalization are increasingly allowing cities to integrate such stylesby a single border (Karim, D. M.2017). **Emerging technology:** As technologies develop new solutions of mobility are developing. For example, the automated vehicles that are able tolessenthe driver's errors and accidents will be ready very soon (Ibid). **Data and analytics**: The smart mobility eco system produces an enormous quantity data through theconnected vehicles that are increasing, traffic management center, transit fleets, users, agencies,mobile devices and smart infrastructure (Flügge, B. 2017). **Infrastructure:** the mostsignificant element of the value chain for smart mobility is the city's investment in intelligent infrastructure. This shouldincludesidewalks parking's, signals, signage, and many morefeatures that are able to gather information and communicate both with centralized management hubs and with vehicles (Marcocchia, G., &Maniak, R. 2018). **Governance and regulation:** smart mobility entailsasuitableframework of governance and suitable regulations, both of which request legislative action and participation from manyauthorities. Transportation modes are currently in use, more advanced solutions are still related to the development of data and technology, infrastructure, governance and regulation (Flügge, B. 2017).

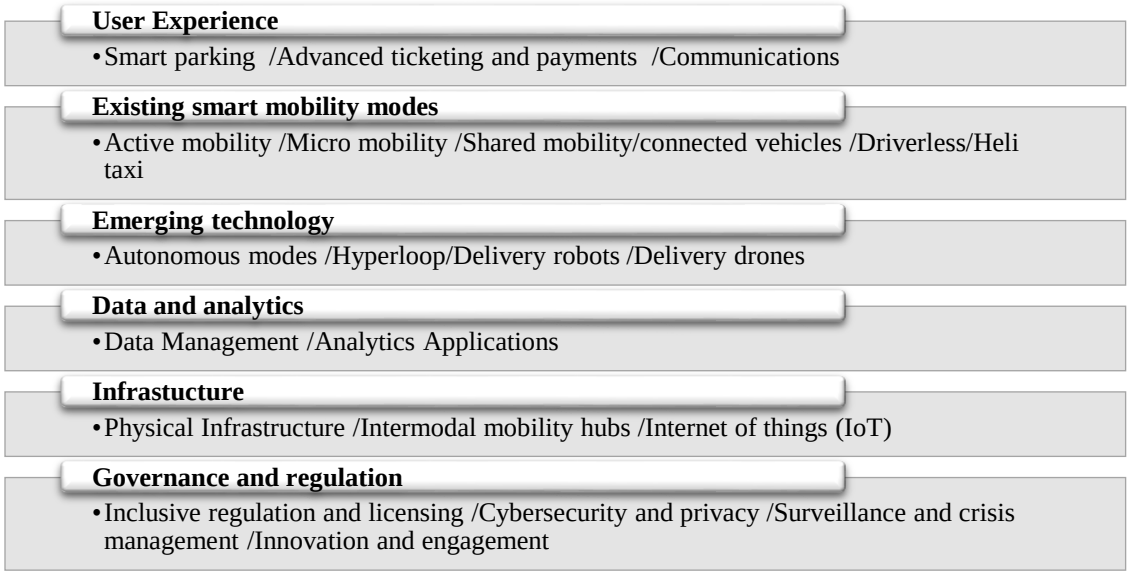


Diagram (4): Smart mobility ecosystem elements, source: (Author,2021)

1.3. Saudi Arabia

Saudi Arabia is known for being an Islamic country with 33.5 people. It is governed and ruled by the descendants of the Ibn Saud (Alkhedheiri, A.A., 1998). Saudi population is aging at a fast rate, its median age will be nine years higher by 2030 (Doheim, R. M., Farag, A. A., &Badawi, S. 2019). Saudi Arabia has proved a very strong performance in the field of economics. This has enabled a continued growth that

can be described as huge support in the recent decade (Ibid). The growth has been hardened by the economic disaster or economic challenges that has hit Saudi Arabia beforemany years because the change of the prices of oil. In other words, the oil was very cheap and its prices are no longer cheap as before (Ibid). However, living in the city has many difficulties that haveurged theauthorities in Saudi Arabia to offer new suggestions, recommendations and solutions regarding thesemodernchallenges. Accordingly, Saudi Arabialooks to overcome the economic crisis and to be an international role model or leaderthroughencouraging the scientific and technological investments in order to be able to prove its presence in this field. Saudi also looks to make a huge transformation and to stop frombeing a country that depends oil into to a smart country that adopts smart approaches in all of the development sectors (Khorsheed,M.S. 2015).

Figure (1): Saudi Arabia, source:(https://www.arabnews.com/node/1938601/business-economy)

The future vision of Saudi Arabia is the smart city initiative that looks to target five Saudi cities by 2020 in sequenced stages. Makkah and Riyadh, were expected to be transformedbefore the ending of 2018, (Doheim, R. M., Farag, A. A., &Badawi, S. 2019). In reality, Saudi Arabia has gathered over $500 billions to make investments across 285 municipalities for the employment of smart cities that are able to afford a better quality of life for theinhabitants through engaging them in the development ofthe future cities in Saudi Arabia (Ibid).

1.3.1. Overview of Riyadh urban development

In 1902 Riyadh city was a traditional small Arab town with a population less than 19,000 who live in an area of 1 km2 (Middleton, D. A. 2009). In the era of the King Abdul-Aziz Al-Saud, the first stage of the radical change of the city has happened in 1931 when the king announced Riyadh will be the capital of the modern Saudi Arabia. During the first phase of transformation, the city started to grow and it reached an area of 13 km2 with a population of nearly 83000 people. In 1950, the second phase of transformation happenedwith the growth of the oil sector, the city became an extrovert (Ibid).

Since the urbanization of the city was amorphous and not well striped, authorities acknowledged that there is a need of city code that manages and controls the urban development of the city. The first and major plan was performed in 1960 by Doxiad is Associates, a Greek architect consultation organization.

However, the first plan failed because of the unexpected growth that exceeded the urban planned borders. Hence, a second master plan was made and it wasalsoflopped. (Al Zohbi, G. 2021). During the growth of the oil in the early 1970's, Riyadwent through radical changes in its population and in its urban development. This exceeds the city guidelines that determined by Doxiad(a plan that is caused by the deliberately increase of the government's expenditure). HenceDoxiad is a plan that is required to deal with the city's huge expansion (Ibid). In 1976, the SCET International/SEDES of Paris was requested to accomplish the revision of Doxiadwhich is a plan that focuses to develop and adjust the expansion and the phasing plan (Ibid). In 2003 a Comprehensive Riyad Strategic Plan (CRSP) was established by the Authority of Riyadh Development (ADA) and it comprised the motif of thegrowth of a city like the urban transportation and economy. The CRSP highlighted the urban growth to the specified areasthroughdetermining the urban growth boundaries (UGBs) (Alkhayyal, Z. 2017). UGBs aim to lead and restrict the urban growth in order to determine the geographicalzone over a definite period of time. The increase of oil prices in 2015lead toa quick growth rate in Riyadh.

Figure (2): Riyadh City, source: (https, https://www.google.com/search?)

The rate of urban growth causedenvironmental, socialand economic issues. Actually, the urban growth in Riyadh city is increasingrapidly. Thisrapid urban expansion contributes in creating an unmaintainable environment through increasing the length of the roads, the distance of driving,the numbers of vehicle, the consumption of fuel, the pollution of greenhouse gases emission, and ecological modification. (Al Zohbi, G. 2021).

1.3.2. Future vision of Smart mobility prototypes in Riyadh City:

In the following figure, shows the Future visionof Smart mobility prototypes in Riyadh City to improve the situation of mobility sector in Riyad city,

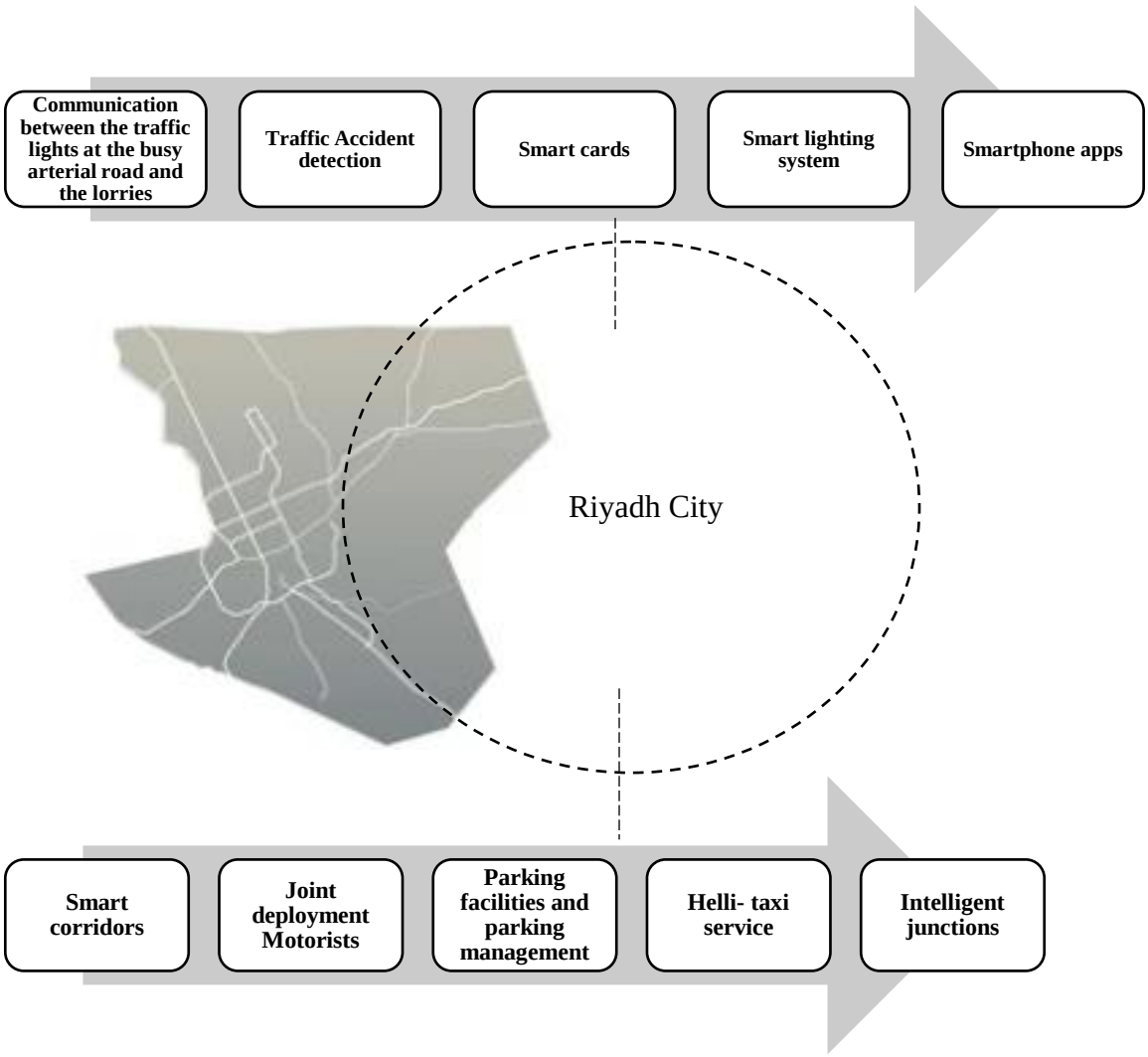
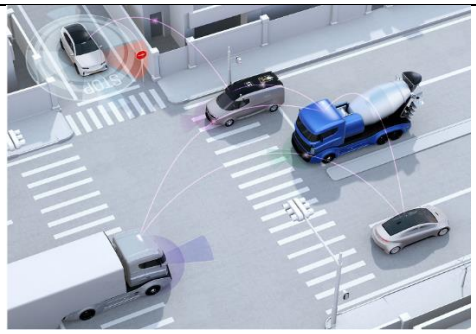
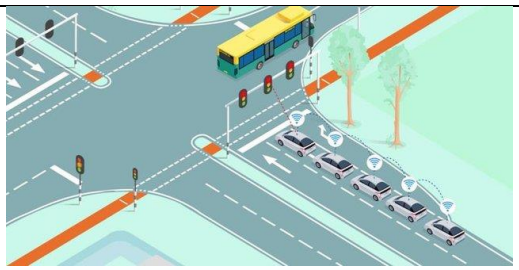


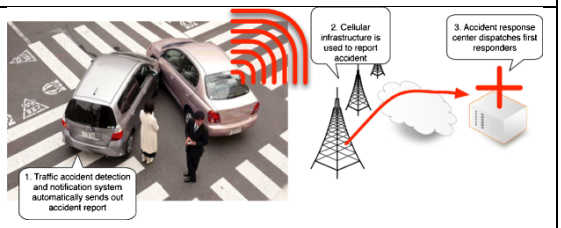
Figure (3): Future vision of Smart Mobility prototypes in Riyadh City, source: (Author,2021)

Table (1): Future vision of Smart mobility prototypes in Riyadh City

Smart mobility prototype	The Method	The Example

Smart corridors	**Smart corridors** Creating smart motorways by theusethe latest ITS solutions in cooperative and transport systems.	 Figure (4): Smart corridor, source:(https://www.nhwnc.net/nhwnc-considers-speed-enforcement-ticketing-cameras/)
Intelligent junctions	**Intelligent junctions** Smoothing the traffic flows and reducing the door-to door travel times by a cooperative communication between the cars, , public transport vehicles, lorries bicycles and emergency services with one another as well as with traffic lights and other beacons and sensors.	 Figure (5): Intelligent junctions, source:(https://www.digi.com/blog/post/introduction-to-smart-transportation-benefits)
Joint deployment Motorists	**Joint deployment Motorists**they receivea detailed information on theroad works over a secure Wi-Fi connection, throughcars thatserve as a mobile sources for traffic information to send data to traffic control centers	 Figure (6): Joint deployment Motorists ,source:(https://www.polisnetwork.eu/topic/intelligent-connected-and-cooperative-transport-systems-3/)

Communication between the traffic lights at the busy arterial road and the lorries	**Communication between the traffic lights at the busy arterial road and the lorries**enable the system to afford the drivers with speed advice through displaying the remaining time to green.	 Figure (7): Communication between the traffic lights at the busy arterial road and the lorries, source: (https://www.researchgate.net/publication/341602742_The_impact_and_potential_of_cooperative_and_automated_driving_for_intelligent_traffic_signal_corridors_A_field-operational-test_and_simulation_experiment/figures)
Smart cards	**Smart cards** have a simplified and an accelerate fare charging process and expand the possibilities for its users (more ways of charging, one card for multiple services, etc.).	 Figure (8): Smart cards, source:(https://www.metrotransit.org/go-to-card-users-guide)
Smartphone apps	**Smartphone apps** can be for payments, and they can serve asa source of information regarding the real time of traffic, public transport, or the status of parking facility.	 Figure (9): Smartphone apps, source: (https://en.wikipedia.org/wiki/Mobile_phone_tracking)
Parking facilities and parking management	**Parking facilities and parking management** are apps that are used for enhancing theaffordable car parks, devices such as sensors to count the available on-road parking spaces, smart cards for charging parking fees, software for parking management, etc.	 Figure (10): Parking facilities and parking management, source: (https://www.fiware.org/2019/01/14/fiware-and-save-a-space-position-parking-at-the-

		centre-of-intelligent-mobility/)
Traffic accident detection	**Traffic accident detection and support systems integrate hardware, software, procedures, and facilities** for real-time detection of traffic accidents and rapid assistance to the injured.	 Figure (11):Traffic accident detection, source: (https://www.google.com/search?)
Heli taxi service	**Heli taxi service** will reduce the travel time to around 15 minutes, a journey that takes a few hours by road otherwise.	 Figure (12):Heli-taxi, source: (https://www.itln.in/bengaluru-to-introduce-heli-taxi-service-aviation)
Smart lighting system	**Smart streetlight** is known as being a public lighting fixture that includes the use of technology, including cameras, light-sensing photocells and other sensors. It helps in optimizing theuse electricity and simplifies the control, such as dimming.	 Figure (12):Smart street lighting, source: (https://www.manufacturer.lighting/info/210/)

Source: (Author, 2021)

Conclusion:

This paper has presented many solutions that deal with many concepts such as services, approaches, and models proposed by researchers to apply Smart Mobility. The proposed solutions illustrate clearly the importance of Smart Mobility in the cities in addition to the researchers' efforts to find solutions to make our cities more sustainable, livable and comfortable.

There is a need for smart mobility, to enhance:

- **Connectivity** in which it helps in ensuring that the commute of people and the move goods from their origins to destinations is accomplished in the most effective way and with the least possible time and cost.
- **Security** looks for detecting threats, justifying risks and manages any issue or situation that might happen.
- **Safety Sustainable mobility** must be safe and can be safer through building safer roads that has a lesser traffic and lesser accidents too.
- **Sustainability,** Smart mobility can lead to a decrease in the negative environmental effects of the sector of transportation, this can be achieved through providing travelers and the system of transportation operators with an environmental and friendly options.
- **Energy management,** smart mobility improves the smart charging infrastructure through the use of various transportation services such as mobility services and technologies of smart tickets.

It is obvious that there is a need for consistent databases for smart mobility, which leads for an aid in developing a concept or illustration for the concept Smart City. Further steps in researching for smart mobility should be taken into account; adjusting the databases of indicators with modern methodologies, evolving sustainable smart mobility plans for each city especially in Riyadh and ensuring the availability of financial resources for smart city and smart mobility solutions.

References:

- Al Zohbi, G. (2021). Sustainable Transport Strategies: A Case Study of Riyad, Saudi Arabia. In E3S Web of Conferences (Vol. 259). EDP Sciences.
- Albino, V., Berardi, U., &Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. Journal of urban technology, 22(1), 3-21.
- Aldusari, A. N. (2015). Smart city as urban innovation: a case of Riyadh north-west district. Journal of Sustainable Development, 8(8), 270.
- Aljoufie, M., &Tiwari, A. (2021). Citizen sensors for smart city planning and traffic management: crowdsourcing geospatial data through smartphones in Jeddah, Saudi Arabia. GeoJournal, 1-20.
- Alkhayyal, Z. (2017). Urban Growth Change Analysis of Riyadh, Saudi Arabia: 2005–2015. Saint Mary's University of Minnesota University Central Services Press, 20, 10.
- Alkhedheiri, A.A., 1998. The Role of Secondary Cities in the National Development Process of Saudi Arabia (Doctoral dissertation). University College London (University of London).
- AlSelami, F. A. (2021). On the Implementation and Development of Smart Cities based on IoT Technology.
- Aoun, C. (2014). Smart cities Cornerstone series: Urban Mobility in the smart city age. Council Advisor the Climate Group and ARUP.
- Aoun, C. (2014). Smart cities Cornerstone series: Urban Mobility in the smart city age. Council Advisor the Climate Group and ARUP.
- Bazzan, A. L., &Klügl, F. (2013). Introduction to intelligent systems in traffic and transportation. Synthesis Lectures on Artificial Intelligence and Machine Learning, 7(3), 1-137.
- Benevolo, C., Dameri, R. P., &D'auria, B. (2016). Smart mobility in smart city. In Empowering organizations (pp. 13-28). Springer, Cham.

- Bıyık, C., Abareshi, A., Paz, A., Ruiz, R. A., Battarra, R., Rogers, C. D., &Lizarraga, C. (2021). Smart Mobility Adoption: A Review of the Literature. Journal of Open Innovation: Technology, Market, and Complexity, 7(2), 146.
- Brčić, D., Slavulj, M., Šojat, D., &Jurak, J. (2018). The role of smart mobility in smart cities. In Fifth International Conference on Road and Rail Infrastructure (CETRA 2018).
- Campolo, C., Iera, A., Molinaro, A., Paratore, S. Y., & Ruggeri, G. (2012, November). SMaRTCaR: An integrated smartphone-based platform to support traffic management applications. .In 2012 first international workshop on vehicular traffic management for smart cities (VTM) (pp. 1-6). IEEE.
- Colldahl, C., Frey, S., &Kelemen, J. E. (2013). Smart cities: Strategic sustainable development for an urban world
- Correia, L. M., &Wünstel, K. (2011). Smart cities applications and requirements. White Paper. Net, 9.
- Correia, L.M., Wu¨nstel, K., 2011. Smart Cities Applications and Requirements. Net! Works European Technology Platform, White Paper.
- Doheim, R. M., Farag, A. A., &Badawi, S. (2019). Smart city vision and practices across the Kingdom of Saudi Arabia—a review. Smart cities: Issues and challenges, 309-332.
- Dudzevičiūtė, G., Šimelytė, A., &Liučvaitienė, A. (2017). The application of smart cities concept for citizens of Lithuania and Sweden: comparative analysis. Independent journal of management & production, 8(4), 1433-1450.
- Faria, R., Brito, L., Baras, K., & Silva, J. (2017). Smart mobility: A survey. In 2017 International Conference on Internet of Things for the Global Community (IoTGC) (pp. 1-8). IEEE.
- Flügge, B. (2017). The Smart Mobility Ecosystem. In Smart Mobility–Connecting Everyone (pp. 75-95). Springer Vieweg, Wiesbaden..
- Giffinger, R., &Pichler-Milanović, N. (2007). Smart cities: Ranking of European medium-sized cities. Centre of Regional Science, Vienna University of Technology.
- Irvin, R. A., &Stansbury, J. (2004). Citizen participation in decision making: is it worth the effort?. Public administration review, 64(1), 55-65.
- Karim, D. M. (2017). Creating an innovative mobility ecosystem for urban planning areas. In Disrupting Mobility (pp. 21-47). Springer, Cham
- Khisty, C. J. (2000). Citizen involvement in the transportation planning process: What is and what ought to be. Journal of Advanced Transportation, 34(1), 125-142.
- Khorsheed, M.S., 2015. Saudi Arabia: from oil kingdom to knowledge-based economy. Middle East Policy 22 (3), 147e157.
- Lyons, A. C., &Kass-Hanna, J. (2020). T20 SAUDI ARABIA 2020.
- Lyons, G. (2018). Getting smart about urban mobility–aligning the paradigms of smart and sustainable. Transportation Research Part A: Policy and Practice, 115, 4-14.
- Maldonado Silveira Alonso Munhoz, P. A., da Costa Dias, F., KowalChinelli, C., AzevedoGuedes, A. L., Neves dos Santos, J. A., da Silveira e Silva, W., & Pereira Soares, C. A. (2020). Smart Mobility: The Main Drivers for Increasing the Intelligence of Urban Mobility. Sustainability, 12(24), 10675.

- Mangiaracina, R., Perego, A., Salvadori, G., &Tumino, A. (2017). A comprehensive view of intelligent transport systems for urban smart mobility. International Journal of Logistics Research and Applications, 20(1), 39-52.
- Marcocchia, G., &Maniak, R. (2018). Managing'proto-ecosystems'-two smart mobility case studies. International Journal of Automotive Technology and Management, 18(3), 209-228.
- Middleton, D. A. (2009). Growth and expansion in post-war urban design strategies: CA Doxiad is and the first strategic plan for Riyadh Saudi Arabia (1968–1972). Georgia Institute of Technology.
- Mozos-Blanco, M. Á., Pozo-Menéndez, E., Arce-Ruiz, R., &Baucells-Aletà, N. (2018). The way to sustainable mobility. A comparative analysis of sustainable mobility plans in Spain. Transport policy, 72, 45-54.
- Nallur, V., Elgammal, A., & Clarke, S. (2015, May). Smart route planning using open data and participatory sensing. In IFIP International Conference on Open Source Systems (pp. 91-100). Springer, Cham.
- NEIROTTI, P. (2012) Current trends in Smart City initiatives: Some stylised facts. Cities 38 (2014) 25–36
- Neirotti, P., De Marco, A., Cagliano, A.C., Mangano, G., Scorrano, F., 2014. Current trends in Smart City initiatives: some stylised facts. Cities 38, 25e36.
- Orlowski, A., &Romanowska, P. (2019). Smart Cities Concept: Smart Mobility Indicator. Cybernetics and Systems, 50(2), 118-131
- Porru, S., Misso, F. E., Pani, F. E., &Repetto, C. (2020). Smart mobility and public transport: Opportunities and challenges in rural and urban areas. Journal of traffic and transportation engineering (English edition), 7(1), 88-97.
- Sanchez-Iborra, R., Bernal-Escobedo, L., & Santa, J. (2020). Eco-efficient mobility in smart city scenarios. Sustainability, 12(20), 8443.
- Silva, C. M., Aquino, A. L., &Meira, W. (2015). Smart traffic light for low traffic conditions. Mobile networks and applications, 20(2), 285-293.
- Sunardi, H. I., Sulistyo, S., &Mustika, I. W. (2020). Analysis of Smart Mobility Readiness in Banjarmasin City.
- The Ministry of Interior, Report 2021,KSA,Traffic Accidents**,** Available at:https://www.moi.gov.sa/wps/portal/Home/sectors/publicsecurity/traffic/trafficriyadh/contents/!ut/p/z0/fYwxDoJAEAC_QnP1ruRCbAkFIg1EEnEbszlAVnGR82L091JY280kkwGCFkj5JRcOMitPq58oOWNh7W5j4zJvMotpnVV1WTQxbhM4sIc90P9ovch1WSgFcrOG_h2gDZ6HQZzBH0RePtyNEXuDdxY1yM5J12t4wuOWH7_odmO_/ (Accessed in 11-12-2021)
- Tomanek, R. (2017). Sustainable mobility in smart metropolis. In Happy City-How to Plan and Create the Best Livable Area for the People (pp. 3-17). Springer, Cham.
- Tomaszewska, E. J., &Florea, A. (2018). Urban smart mobility in the scientific literature—bibliometric analysis. Engineering Management in Production and Services, 10(2).
- Toppeta, D. (2010). The smart city vision: how innovation and ICT can build smart, “livable”, sustainable cities. The innovation knowledge foundation, 5, 1-9.
- Ujwary-Gil, A., &Gancarczyk, M. (2020). New challenges in economic policy, business, and management. Institute of Economics, Polish Academy of Sciences.

- VAN AUDENHOVE F.; DAUBY L.; KORNIICHUK O.; POUBAIX J. (2014) Future of Urban Mobility 2.0.Arthur D. Little Future Lab. International Association for Public Transport (UITP)
- WALRAVENS, N. (2015) Mobile city applications for Brussels citizens: smart city trends, challenges and a reality check. Telematics and Informatics, v. 32, p. 282- 299.