Economic potentials of smart cities

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Graduate paper

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Ekonomski potencijali pametnih gradova (smart cities)

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Economic potential of smart cities

ABSTRACT

Rapid urbanisation is a growing challenge worldwide. To offset its detrimental effect, cities across the globe are turning to technology as means for building effective infrastructure under the umbrella term of "smart city". With the latest advancements in technology and changing human behaviour in the context of "smart" mobile devices, this work aims to obtain profound understanding of a "smart city" and its characteristics, explore technologies that can be used for effective city infrastructure development, and what role the "smart" mobile device might have in driving this forward. In the context of this study, extensive literature has been reviewed, and a case study method has been used to examine the topic and provide real-life examples of a "smart city". The subject of this research was the city of Frederiksberg in Denmark, and a wide array of "smart city" solutions they have in place with a specific emphasis on "Smart Mobility". The results gathered point to the positive correlation with the previous studies and literature overview, suggesting that "smart city" could be the key for improving the quality of life and effective infrastructure development. Certain limitations exist to the broad nature of the topic, hence further research with a narrow focus is advised. This work contributes to the field of "smart cities" and has a potential to enrich and inspire cities, and fellow researchers in further exploration of the area.

Keywords: smart city, technology, mobile device, urbanisation, effective infrastructure

Ekonomski potencijali pametnih gradova (smart city)

SAŽETAK

Brza urbanizacija sve je veći izazov u svijetu. Kako bi kompenzirali štetni učinak, gradovi širom svijeta okreću se tehnologiji kao sredstvu za izgradnju učinkovite infrastrukture pod krovnim pojmom "pametni grad". Uz najnovija dostignuća u tehnologiji i promjenama ljudskog ponašanja u kontekstu „pametnih“ mobilnih uređaja, ovim se radom želi steći duboko razumijevanje „pametnog grada“ i njegovih karakteristika, istražiti tehnologije koje se mogu koristiti za učinkovit razvoj gradske infrastrukture i kakvu bi ulogu "pametni" mobilni uređaji mogli imati u vođenju ovog napretka. U kontekstu ove studije, proučena je opsežna literatura te je korištena metoda studije slučaja za razumijevanje teme i pružanje primjera iz stvarnog života “pametnih gradova”. Predmet ovog istraživanja bio je grad Frederiksberg u Danskoj te njihov široki raspon rješenja za "pametni grad" s posebnim naglaskom na "pametnoj mobilnosti". Prikupljeni rezultati ukazuju na pozitivnu korelaciju s prethodnim studijama kao i pregledanom literaturom, sugerirajući da bi „pametni grad“mogao biti ključ za poboljšanje kvalitete života i učinkovit razvoj infrastrukture. Postoje određena ograničenja s obzirom na široku prirodu teme, stoga se savjetuju daljnja istraživanja s užim fokusom. Ovo djelo doprinosi domeni "pametnih gradova" te ima potencijal obogatiti i nadahnuti gradove, te autore u daljnjem istraživanju ovog područja.

Ključne riječi: smart city, tehnologija, mobilni uređaji, urbanizacija, učinkovita infrastruktura

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CONTENT

1. Introduction

In the recent decades, across the globe, nations have experienced turbulent times. The world is moving at an unprecedented pace driven by latest advances in technology across various fields. Humankind is nearly omnipresent in every corner of the planet resulting in a substantial impact on natural resources and increasing urbanisation. Ensuring sustainable urban growth and high quality of life in cities across is high on the priority list of world politics.

To cater to the increasingly urbanised world, the "smart city" concept has emerged in one form or another and has been present in the city development arena since the 1960s. Strong population growth, economic and political migrations together with technological advancement is making the "smart city" topic more relevant than ever. Cities are in dire need to serve their citizens in a sustainable way, driving healthy economic growth and providing high quality of life through leveraging existing "smart" technology and creating "smart" solutions for a better everyday life.

Nearly every single fragment of people's daily life is impacted by the large-scale digital revolution through the strong presence of mobile devices which have become inseparable means of conducting everyday work and a first screen for many citizens. Understanding what the best way would be to utilise this technological revolution and usage of mobile devices like smartphones and tablets to increase quality of life in the cities and fulfill the economic potential of smart cities is an important topic to address. Could the mobile device with internet connection be an instrument of driving economic growth and fulfilling the economic potential of smart cities through its citizens?

This work has a tri-fold focus and is devoted to the following objectives:

- understanding the "smart city" concept and its key characteristics,
- understanding what the latest technologies are and how they could be leveraged in creating "smart" solutions for effective infrastructure development, and
- understanding the role and impact of mobile devices in the context of smart cities.

In this very first chapter, an overview is given of the contemporary context of the work, the importance of the subject and its impact on the society overall. Additionally, focus areas have been provided, as well as the full overview over all the chapters.

In the second chapter, an overview is given over the existing literature in the domain of “smart cities”, its key characteristics and technologies making the most significant impact at the moment. Furthermore, mobile devices are reviewed in the context of smart cities and the effective development of the city infrastructure in general.

In the third chapter, a research methodology overview has been given as well as providing in depth insights on research methodology used in the context of this work.

In the fourth chapter, the conducted research and its results are described in more detail, including a presentation of the case study relevant to the topic.

In the fifth chapter, the discussion will continue looking back at the research and drawing conclusions from the work.

In the final and sixth chapter, the work shall be concluded as well as suggestions given for future research.

2. Theoretical background and previous research

What is a "smart city"? In order to fully understand how to achieve a better life for citizens in urban areas by optimising the infrastructural development and governance, a profound understanding of the "smart city" concept must exist in the first place. In this chapter an in-depth overview of existing literature will be given as well as understanding the historical development of cities and the very beginnings of urbanisation.
Following the historical development, focus will be given to the industrialisation and technological development, usage of mobile devices and implications on effective infrastructural development in the cities.

2.1. Urban development through history

Since the dawn of mankind, human civilization has been ever evolving. From the early cave dwellers to majestic ancient urban civilisations, insatiable human desire for growth, development and expansion has been the driving force in urbanisation and urban migrations.
Mesopotamia has always been considered as a cradle of humankind, however in the recent decades new evidence has emerged of complex urban settlements in Arabian Peninsula as well. As mentioned in the American Association for the Advancement of Science (2007) "Mesopotamia is still the cradle of civilization in the sense that urban evolution began there". They provide further information of archaeologists sharing findings from dozens of urban centers of approximately the same age that existed between Mesopotamia and the Indus River valley in modern day India and Pakistan.

History has been the witness of advanced urban civilisations emerging across the globe to the present day and urbanisation continues to be one of the major trends worldwide. According to Barlow and Levy-Bencheton (2018:2) "the most urbanized regions of the world today are North America (82% of population lives in urban areas), Latin America and Caribbean (81%), Europe (74%), and Oceania (68%) with Africa remaining mostly rural (43%)". As reported by the Department of Economic and Social Affairs, Population Division (2018) "today, more than half of the global population lives in urban areas, while the urban share worldwide is rising from around one third in 1950 to around two thirds in 2050". This amounts to 33 megacities in 2018, as reported by the UN (2018). Due to this, they argue that sustainable development depends

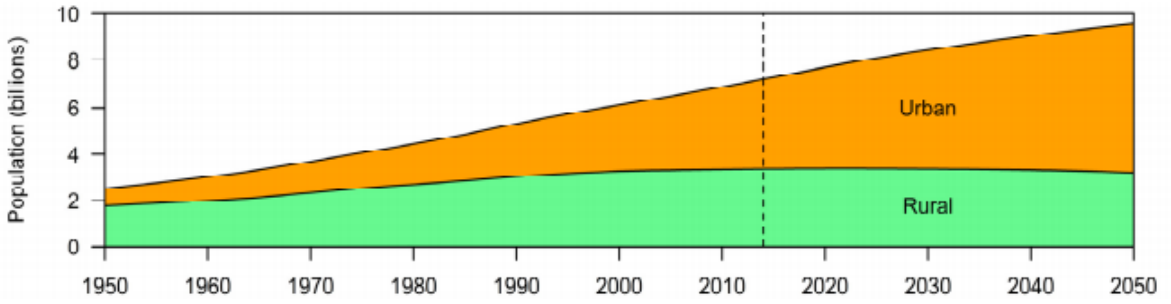
critically on the successful management of urban growth to create sustainable cities in both developed and developing countries. “Urbanisation has damaged the natural processes” Satyam, Calzada (2017:7). Due to this heavy urban expansion in the last century, it is becoming increasingly important to offset negative effects of this development. Understanding key factors driving urbanisation in the past is crucial for future development and focusing on the benevolent ones. There are different factors that have sparked innovation, growth and development in the past ranging from accidental discoveries to devastating global wars. As suggested by Satyam, Calzado (2017:11), the global wars for religious supremacy have been the key drivers for the reorganisation of the world and for the growth of many cities. Many of those events had also been the critical factor in leading the society through several revolutions in industry, science and technology. Today, and in the recent years we are finding ourselves in the fourth industrial revolution - the Information revolution. “The 4IR is the fourth major leap in technological productivity and represents a potent new stage of globalisation” Kirwan and Fu (2020:xxii). Writers also give a broad overview over the first Industrial Revolution of the 18th century that was characterised by machines, iron manufacturing, textiles, rail transport, urbanisation and unprecedented population growth. The second was dominated by steel, oil, electricity, mass production, the telephone and the internal combustion engine. The third is the digital revolution in our recent history: that of the personal computer, basic Internet and ICT. The 4IR is exemplified through cyber-physical systems, breakthroughs in robotics, AI, nanotech, quantum computing, the Internet of Things (IoT), 5G wireless, 3D printing, clear energy, smart cities and autonomous vehicles. Given the limited natural resources the Earth possesses, new smart ways of living need to be found and agreed upon so scarce resources can be efficiently and evenly distributed.

2.1.1. Challenges of growing population

Given the rapid population growth in the last century, as seen in Graph 1, in line with predictions of the growth of urban population in the future, it is crucial to reflect on the detrimental effects it is posing to the natural environment and quality of life on a global scale. Moreover, with the current inequality in the global wealth redistribution, certain parts of the world may be exposed to harsher conditions with less possibilities to offset the negative impact.

The United Nations, as a body overlooking various developments across the world, has been taking an interest in urbanisation aspects and its impact on the global community. As reported

by the United Nations (2021) “The world’s cities occupy just 3 percent of the Earth’s land, but account for 60-80 percent of energy consumption and 75 percent of carbon emissions”. Cities of this scale are additionally accountable for “between 60 and 80 percent of energy consumption and generate as much as 70 percent of human-induced greenhouse gas emissions” (United Nations, 2021).



Graph 1: World Urbanization Prospects: The 2014 Revision (United Nations, 2014)

Closely following the trends and patterns of urbanisation gives detailed understanding of the burden it might bring to less fortunate parts of the world. As specified by the United Nations (2021) “Rapid urbanization is resulting in a growing number of slum dwellers, inadequate and overburdened infrastructure and services (such as waste collection and water and sanitation systems, roads and transport), worsening air pollution and unplanned urban sprawl”. Looking at that, it is also estimated that around “828 million people live in slums today and most of them are found in Eastern and South-Eastern Asia” (United Nations, 2021). The recent global pandemic health crises has emerged as an additional factor contributing to higher infection rates in densely populated urban areas with inadequate infrastructure. It is reported by the United Nations (2021) that the impact “of COVID-19 will be most devastating in poor and densely populated urban areas, especially for the one billion people living in informal settlements and slums worldwide, where overcrowding also makes it difficult to follow recommended measures such as social distancing and self-isolation.” Their food agency, FAO, also warned that hunger and fatalities could rise in substantial numbers in urban areas, without measures in place to ensure that poor and vulnerable residents have access to food.

Addressing the concerns of urban development has been in focus of the United Nations also when agreeing on the Sustainable Development Goals, where goal number 11 focuses on sustainable cities and communities. From the perspective of Yamagata and Yang (2020:23) “International agreements such as Paris Agreement for climate change and Sustainable

Development Goals (SDGs) prompt policy makers to implement these measures at cities where majority populations reside, and economic activities are currently conducted and expected to increase significantly during this century". Considering that the majority of the world governments have pledged to contribute to the fulfillment of the SDGs, it is paramount to adapt the "smart" way of operating on the local city level as well, considering that "cities are now generally considered as frontiers for transformation that will contribute to achieving decarbonisation by 2050 as mandated by the Paris Agreement" Yamagata and Yang (2020:23).

Combating the challenges of a growing population goes in pair with utilising available technology and thinking in innovative ways to solve challenges today's challenges. As phrased by Satyam and Calzada (2017:26) "smart is also about using the capabilities of technologies and resources which are already available, with an objective to improve the quality of life". Authors further suggest that the importance is not necessarily about innovating new technologies but also using the existing ones to improve things in various situations and circumstances. They observe that most of the "smart" solutions are riding on technologies that are already present, because innovations in improving processes and making improvements in policies, procedures and mindsets are "smart".

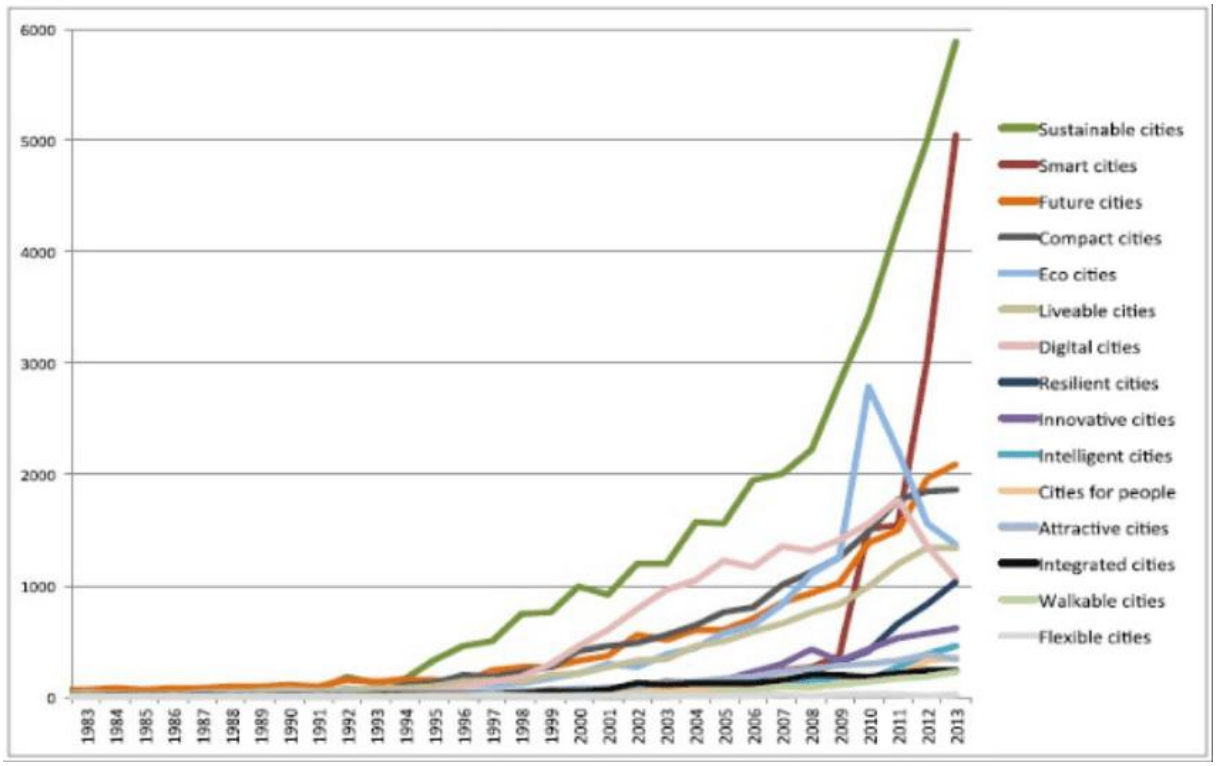
Application of "smart city" technology could alleviate some of the pains of rapid urbanisation by creating "smart", affordable solutions for daily urban challenges across the world. With a wide range of existing technologies, a wide range of solutions could be created such as suggested by The Welding Institute - TWI (2020), an independent research and technology organisation, "to combat climate change and air pollution as well as waste management and sanitation via internet-enabled rubbish collection, bins and fleet management systems".

2.2. The emergence of "smart city" concept

As mentioned previously, "smart city" concept is not a new trend in itself. A notion of combining digital technology and city infrastructure to deliver better services to its citizens has been present from the 60s of the past century. However, a more significant effort has taken place several decades later as reported by Satyam and Calzada (2017:198) by stating that "this mainstream wave or urban standardisation, concerning the Smart city paradigm has so far been domineering policy agendas since the mid-1990s".

Looking at the urban buzzwords Graph 2, “the smart city seems to be the buzzword for the 2010s” (Satyam, Calzada, (2017:196) based on De Jong et al. 2015). Today, “smart cities are becoming a new global movement that uses technology to drive urban development” (Yamagata, Yang, 2020:1).

Despite that, there is no one uniform definition of a “smart city”, rather different authors, cities and representatives create their own idea of what “smart city” means to them. “The smart city concept remains complex and ambiguous in nature; thus, current literature demonstrates a variety of approaches in developing initiatives and actual projects in transforming cities into smart cities” (Grossi, Trunova, 2021).



Graph 2: Urban buzzwords in the last 30 years. (Satyam, Calzada (2017) based on De Jong et al., 2015).

According to authors Kirwan and Fu (2020:2) “smart city” is now the popular concept driving cities around the world to a whole new level of technology innovation and quality of life enhancement while simultaneously a term being co-opted for the purpose of attracting investment and stimulating new economic opportunities. “This latter purpose is a critical part of the establishment of a sustainable business ecosystem that can support the requirements of

the development of a smart city and the next generation of urban growth" (Kirwan, Fu, 2020:2). Another pair of authors, Barlow and Levy-Bencheton (2018:207) suggest that "a smart city relies on innovative ideas and solutions divided by a quadruple helix of stakeholders - government, businesses, members of academic and research institutions, and every one of the city's residents". They believe that a key success factor in this case is teamwork and collaborations amongst all of its stakeholders. In a similar fashion, Kanter and Litow (2009) as stated in Yamagata and Yang (2020:35) agree that smart cities, "depending on their size and purpose, rely on leadership roles from actors of both public and private sectors, such as government officials, private companies, or individuals who facilitate integration of technologies and guide in their use".

It seems that technology is at the heart of the "smart city" concept and its correlating initiatives, but it must be remembered that "technology is an enabler, not a driver" (Barlow, Levy-Bencheton (2018:206). Still, "the underlining backbone of a smart city is the ICT network, which enables the use of data to connect with users" (Yamagata, Yang, 2020:35). As mentioned additionally by Barlow and Levy-Bencheton (2018:10) "the technology must be fully integrated and deeply woven into the fabric of the city" and the city must, as suggested by Satyam and Calzada (2017:55) "constantly evaluate options to utilise all the available solutions, technologies, concepts, and priorities to maximise the quality of life to the citizens and minimise costs".

2.2.1. Key elements of "smart cities"

As seen in the previous chapter, there is no unique definition of the "smart city", as different approaches have emerged depending on individual situations and their characteristics. Despite such diversity of thoughts, a common denominator for all of these is technology.

In a similar fashion, a wide array of key elements of "smart cities" has been presented throughout the literature. In Table 1, several of these key elements have been summarised by the author to provide a short and concise overview and give opportunity for an easier comparison. It is visible that for the majority of different sources there are strong similarities, with only minor differences present when describing what are the key dimensions of a "smart city".

Table 1: Smart City Dimensions Summary, made by the author

Authors	Smart City Dimensions
Kirwan and Fu (2020:17)	Physical, City Infrastructure, Human, Governance, Digital Infrastructure, and Ubiquitous Technology.
Smart City Strategies and Solutions (2017)	Smart Governance; Smart Environment; Smart Living; Smart Mobility; Smart People; and Smart Economy
Satyam, Calzada (2017:70)	Governance, Physical infrastructure, social infrastructure, economics (citizen at the centre)
Barlow and Levy-Bencheton (2018:211)	Smart Mobility, Smart Government, Smart Environment, Smart Living, Smart People, Smart Economy

As these are different depending on context and frameworks, every city is also unique - in its geographical position, natural surroundings, cultural influences, habits and behaviour of its citizens, its political leadership and so much more. Each of these various aspects have a significant influence when defining what should be the key characteristics of a "smart city" applicable to that very city. As explained by Barlow and Levy-Bencheton (2018:142) "there are no standard models or templates for building smart cities, because every city is different". Overall understanding and vision of a "smart city" is more relevant as well as overall layers that could be applied to make a city more "smart" as seen on Image 1 below.

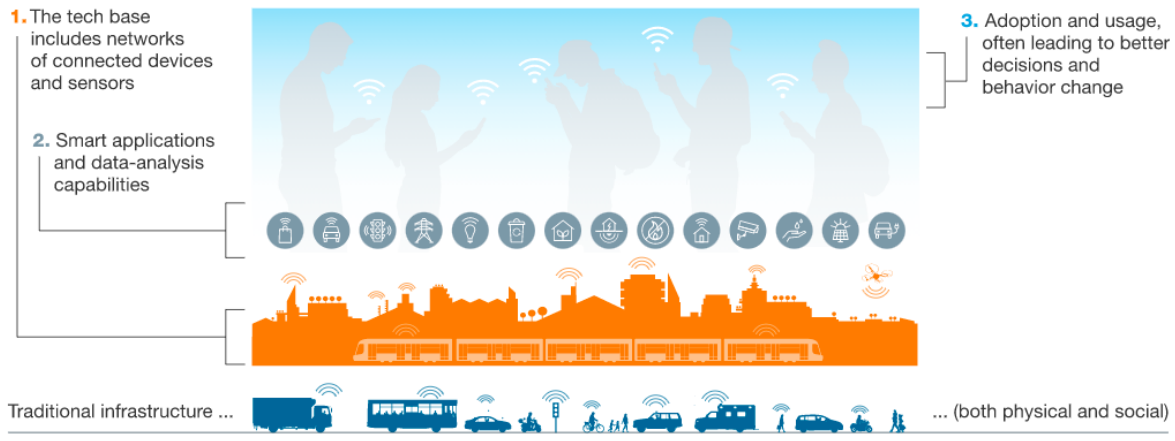


Image 1: Three layers of "smartness" that can ellevate cities in the future (McKinsey Global Institute Analysis, 2018)

However, to make a “smart city” initiative successful, it is of significant importance to have alignment and collaboration from all the stakeholders that are part of a particular initiative or a project. “The most successful smart city projects require participation from a diverse set of stakeholders – a team that is a representative sample of your (future) smart city” (Collier, 2020). As written further by Collier (2020) in the Smart City Journal, stakeholders to keep in mind while conceptualising “smart city” initiatives are “government, industry, entrepreneurs / startups, academia, creatives & artists, advocates & the social sector, residents.”

In the following sections, each key element of “smart city” will be individually reviewed and discussed.

2.2.1.1. Smart Mobility

“Spanning thousands of years, the evolutionary trajectory of mobility has certainly been one of humanity’s major accomplishments and technological advancements” (Kirwan, Fu 2020:146). For many urban areas nowadays, mobility is a crucial concern as it impacts the quality of life on a significant scale. Poor urban mobility contributes to increased air pollution due to carbon dioxide and other harmful substances, increased stress levels due to prolonged and confined daily commute, traffic congestion, ultimately lowering the quality of life. “Fossil fuel-based vehicles, carbon dioxide emissions and burning fuels have contributed to our greatest common disaster on the planet's ecosystem which desperately needs a solution that will manage the impact of patterns of human footprint around the planet, while reducing the resulting negative carbon footprint” (Kirwan, Fu2020:147). They mentioned further that “despite major progress in mobility, humans have not yet solved some of the most basic issues of urban mobility and in most cities around the world; traffic has been one of the most crippling and negative aspects of self-inflicted damage to the natural environment and human quality of life”.

As suggested by Yamagata, Yang (2020:36) “transportation and mobility are key elements of the smart city” and “today, traffic density is the biggest problem of metropolitan cities” (Canli, Toklu (2021). Latter argues that due to the large number of and the lack of sufficient number of car parks in large metropolitan areas, the time, energy and cost of drivers who need a parking lot to search for parking spaces are increasing day by day. Furthermore, Barlow and Levy-Bencheton (2018:70) mention that “transportation is a keystone issue - cities that solve their transportation problems will find it easier to cope with other pressing urban challenges, such as

energy efficiency, public safety, environmental protection, waste management, and economic inequality".

Knowing the importance of mobility, utilising the existing technology to build present and future "smart" solutions is paramount. Starting on the topic of commute, "by 2025, cities that deploy smart-mobility applications have the potential to cut commuting times by 15 to 20 percent on average, with some people enjoying even larger reductions" (Woetzel et al. 2018). Additionally, "smart mobility actions must integrate multiple modes of transport for both people and goods across a city to create a smooth, customer-centric experience" (Barlow, Levy-Bencheton 2018:212). Combining technology and new sources of energy instead of fossil fuels would mean another leap in the protection of the natural environment as envisioned by Kirwan and Fu (2020:149) where they discuss that "smart mobility, especially electric-based transport, also depends on smart grids and clean energy". They consider and provide further details of the possibilities of smart grids to distribute the power more efficiently and sustainably, so there would be a minimal loss and electricity available at more access points. They propose that smart grids could also be able to better respond to peaks and valleys in usage during different periods. From the technological aspect, they see that AI and machine learning will continue to facilitate the efficiency and resilience of these systems, especially as they combine with intermittent sources of energy such as wind and solar.

From the perspective of individual drivers, advances in technology could also bring changes in how motorists drive and park in the form of autonomous vehicles or simply put "driverless cars that use patterns to see what is around and what scenarios in the patterns may emerge" (Satyam, Calzada 2017:104). Barlow and Levy-Bencheton (2018:62) have reviewed the data generation between different variants of cars, concluding that "a typical car generates 25 gigabytes of data per hour and 130 terabytes per year". From their perspective, a fully autonomous car in that case would probably generate 80 terabytes of data in a single day. Those data would be used to feed analytic models that would help software developers and engineers build the next generation of smart city transportation systems. Concluding from above, "smart mobility entails the coordinated use of technology to increase the quality and efficiency of mobility provisions, while minimising or reducing the space consumed and externalities generated by transportation supply" (Yamagata, Yang, (2020:42).

2.2.1.2. Smart Economy

Prosperous economic growth is a strong focus worldwide and there are numerous actors on the sides of supply and demand. The backbone of many economies, the SME sector, has experienced a boom in recent years, only to be stifled by the recent global pandemic. In an environment where the quality of life is at the core of various policies, sustainable economic growth is a key pillar.

In the city arena, various actors interact and are intertwined with each other and in order to foster a healthy economic environment, a city must be able to cater to the various needs of the established corporate sector and raising entrepreneurs. To do so, Collier (2020) suggests that "creating smart city strategies with a cross-section of sectors can help realize the three benefits of becoming a smarter community including: efficiency of delivering city services, a better quality of life for residents, increased economic prosperity". Considering the current turbulent environment "modern cities today have become more calculable than before, as economic actors and multidimensional systems" (Gross, Trunova (2021). Kirwan and Fu (2020:205) offer their view and advise that "smart economy is critical to the successful establishment of sustainable smart cities". "Economies today operate like delicate living systems, but lack self-awareness required to find a healthy equilibrium for its constituents" and "capital flows in and out of economies like blood circulates" (Kirwan, Fu, 2020:157). They suggest that in this flow, the predominant modern global economic system (free market capitalism) produces an abundance of wealth, but the system has not resolved the issue of achieving a more even distribution. "Smart economies must be sustainable, just and inclusive to ensure solid foundations are laid for social development, well-being and prosperity" (Kirwan, Fu, 2020:157).

The Welding Institute (2020) "the main goal of a smart city is to optimise city functions and promote economic growth while also improving the quality of life for citizens by using smart technologies and data analysis." Considering the variety of different subjects operating in a city-level economy " smart cities provide the right conditions for new and established businesses to grow and prosper" (Barlow, Levy-Bencheton 2018:210). Authors continue to add that a "city should strive to create a good climate for start-ups and other entrepreneurial activities, and to be attractive to investors as well as to highly skilled new talent, all of which should lead toward the overall goal of strengthening the city's economy and creation of new jobs". As Collier

(2020) have said “entrepreneurs are experts in transforming frustration into opportunity” and as such “they are masters at rallying scarce resources and prioritizing the activity that creates the greatest results”. Author encourages to create “an effective smart city ecosystem that will integrate startup founders in the strategic decision making so that entrepreneurial thinking can be applied and infused throughout the process”.

2.2.1.3. Smart Governance

Depending where one finds themselves situated in the world, different expectations might be imposed on the government, due to different historical and cultural influences.

The local city government exists to enable its citizens, both private and business residents, to lead a quality life, and provide them services to fulfill those needs. In many cases citizens expect public services to run effortlessly and efficiently, to feel safe and secure, and lead a dignified life. Citizen participation in a democratic society is a cornerstone of public administration and local governments should focus their full efforts to foster a space of innovation driven by technology with active participation. In many instances however, citizens are faced with a slow, inefficient and bureaucratic reality of their local governments. According to Satyam and Calzada (2017:143) “smart ideas and concepts for Smart governance must focus on the following outcomes - citizens empowerment, transparency, fair and equitable, convenient, accessible, effective feedback mechanism, monitoring platform, incident and problem management, access right management”.

Considering that there are multiple stakeholders involved “a smart government forges strong connections between itself and other stakeholders in a municipality” (Barlow, Levy-Bencheton 2018:211). They further suggest that it is building trust through transparency and shared governance, adapting methodologies that allow and encourage citizen participation. “Smart governance implies diverse stakeholders are involved in decision making and public services” (Popescu, 2015). The author further proposes that e-governance is essential in bringing smart city proposals to individuals, and to maintaining the resolution and enforcement process unambiguous, but the style of e-governance should be citizen-centric and citizen-driven.

Applying smart city technology to local governments will directly eliminate some jobs (such as administrative and field jobs in city government) while creating others (such as maintenance,

driving roles, and temporary installation jobs)" (Woetzel et al. 2018). For many, job security and having a job in general, is a basic expectation and a need, thus fear of losing a job due to automation is valid as we have seen it multiple times in human history through three industrial revolutions. Adopting a mindset of long-term education and reskilling would be crucial for success in this field.

There is a great example of a digital government - the first digital European nation of Estonia which had been going digital since the end of the Soviet Union which is based on "blockchain technology is embedded throughout the system, making it impossible to move data in or out without leaving a digital trace" (Barlow and Levy-Bencheton 2018:151). This also includes becoming the first country in the world in 2005 to hold nation-wide elections using Internet Voting (i-voting) as reported by Estonian government (i-estonia, 2021).

City of Tel-Aviv can also show with pride their DigiTel Platform. "DigiTel is Tel Aviv's citizen information platform" (Barlow, Levy-Bencheton 2018:116). This platform was created and designed by the local government to keep citizens engaged and informed. Residents also use DigiTel to apply for permits and licenses, find bargain rates at parking lots, sign up for classes and activities, get discounts on concert tickets, avoid road construction, and remember when it's time to register their children for school.

2.2.1.4. Smart Environment

The physical environment that surrounds us in the context of urban areas is key for wellbeing and high quality of life. Recreational and green resting areas such as parks and playgrounds, transportation infrastructure such as roads, rails, streets and squares, facilities for energy transformation, etc. are interconnected and need to be in balance to offset any negative effects of the industrialised world. While aiming to achieve such harmony "urban planners need to maintain a balance between the built and natural environments in order to maximise the livability of the city for both residents and visitors" (Barlow, Levy-Bencheton 2018:210). In their opinion, certain standards should be established to minimise the environmental impact of new and existing infrastructure.

To be able to have a strong positive impact on the environmental factors in the urban areas, extensive technology application has a pivotal role. "A typical smart city will have millions of

sensors and related electronics deployed throughout the city" (Satyam, Calzada 2017:115). This implies that a sensor network could be rolled out across the city's key areas such as busy streets, public transportation and its stations, airports, malls, playgrounds, pedestrian areas that could collect data and provide signals. "Few of these sensors are 3D face recognition and fingerprint recognition sensors, location sensors, sensing heat, motion sensors, light sensors, voice recognition, chemical sensing, health sensors" (Satyan, Calzada 2017:97). For example, "citizens can also access the system to notify officials of any problems, such as potholes, while sensors can also monitor infrastructure problems such as leaks in water pipes" (TWI, 2020). These could, additionally, warn of pollution in certain locations via different smartphone applications, or traffic congestion. Barlow and Levy-Bencheton (2018:7) also believe that cities could harness the solar energy to power the trash bins and signal when they are full even if "that might not seem like a big deal, but smart trash bins save millions of dollars annually by reducing the cost of collecting garbage". Utilising "smart" technology in the cities to improve the quality of life of its citizens by creating solutions that benefit the environment, would be a significant step forward in preserving the natural environment in its pure form and benefit its fast recovery. For instance, "smart grids have the potential to help distribution systems to better integrate intermittent renewable energies such as wind and solar, and smart city projects are investigating how smart, connected local energy storage systems can support more renewable energy sources on the grid" (Strielkowski et al., 2020). With "smart" technological solutions, urban life could offer a significant positive change to the natural environment.

2.2.1.5. Smart Living

For many decades, humankind has been living out of sync with nature, polluting the air and waters, fishing and hunting more than necessary, producing substantial amounts of food and fabric waste, and due to urbanisation, harming natural habitats of flora and fauna. However, the tide has been changing, and it seems that new generations of consumers are more conscious, have higher ethical expectations from the corporate sector and demand sustainable business practices. This "smart" movement is all about reducing consumption and energy usage, reducing waste and attempting to be in balance with nature. "Optimising the living environment and the methods for its management for all age groups and demographics is the goal of smart-living actions, which will directly impact the quality of life for a city's residents" (Barlow, Levy-Bencheton 2018:211). Here, "electronic services, such as social platforms and solutions

to increase digital inclusion are in focus, as are improved access to health care services and citizen safety" (Barlow, Levy-Bencheton 2018:211).

As it can be seen, technology plays a significant role to enable and make this movement happen across multiple layers of urban life, from the accommodation infrastructure to preservation of energy, as well as water and waste management. "The innovation of public services in smart cities, for example by upgrading buildings to optimize energy consumption or improve the efficiency of public transport, can be combined with the use of technology tailored to the needs of companies to reduce operational costs" (Strielkowski et al., 2020). Additionally, "smart buildings can also offer real-time space management or structural health monitoring and feedback to determine when repairs are necessary" (TWI, 2020). "Leveraging a wirelessly connected IoT and implementing smart buildings can create better housing and working conditions, as well as facilitate aged care or assisted living" (Barlow, Levy-Bencheton 2018:212). These actions that have in focus to enable and encourage civic and social engagement lead to smarter urban living, according to these authors.

There are multiple examples across the world where focus on "smart" solutions has been put in place to contribute to the quality of life of its citizens. For example, "water-consumption tracking, which pairs advanced metering with digital feedback messages, can nudge people toward conservation and reduce consumption by 15 percent in cities where residential water usage is high" (Woetzel et al., 2018). "In Rotterdam, in the Netherlands, an underground car park was combined with a water retention basin" (Admiraal, Cornaro 2020). They mention that in this way, the underground space created was used for both the storage of cars and water, independently of each other. And "street lighting in Barcelona uses LED smart lights, which consume significantly lower energy than sodium vapour or another popular type of lamps" (Satyam, Calzada 2017:65). In order to make this happen, authors inform that several sensors are also mounted on this lightning system to detect motion, gather information on the humidity levels, pollution, noise, temperature and other environmental conditions.

2.2.1.6. Smart People

At the core, the heart and soul of each city are its citizens. "In a democracy, people own the city and its priorities, so the citizens are the primary stakeholders - as the consumers, financiers and final authority" (Satyam, Calzada, 2017:249). Citizens are the center of all initiatives and

services that the city offers, hence the "smart" solutions that are being built need to start from having citizens in mind from the very beginning. "A smart city's job is ultimately to serve its residents" (Collier, 2020). Author believes that people must be placed firmly at the heart of technological innovation. It is the common understanding that "the topic of smart cities is commonly framed by technology but what is often overlooked is the importance of how people work together to implement those digital applications" (Collier, 2020). Author suggested that having the right people in place is one of the most critical factors in creating a smarter community. "The most successful smart city projects require participation from a diverse set of stakeholders – a team that is a representative sample of your (future) smart city" (Collier, 2020). In relation to that, it is crucial to include individual members of the community into smart city planning, and even though it can be challenging from a process perspective, there are different means such as hackathons that can bring added efficiency. "Individuals are the leading characters of a smart city who influence it via ceaseless interplays" (Popescu (2015) hence as such, their active participation is key to adaptation of any new services and "smart" solutions. People are the ones who make decisions, who communicate, interact, socialise with one another and grow as individuals and as a community. So, "as we move more into a digital-everything world, engaging and educating people about what makes a smart city, the ethical considerations that must be put in place and the benefits of infusing connected technology into city operations is a critical one" (Collier, 2020).

Creating services and products with consumers in mind is not a new concept. In the field of Marketing all efforts are focused on discovering and satisfying needs and desires of the consumers in the most efficient and profitable way, therefore, cities would greatly benefit by drawing correlations from the field of Marketing when creating and rolling-out new services to its citizenry. "Smart city initiatives must be explained and justified to citizens by local officials at neighborhood meetings and public events" (Barlow, Levy-Bencheton 2018:139). These must be "marketed to citizens through social media and through traditional media channels, such as print, radio, television, and billboard advertising, using many of the techniques normally used by businesses to market new products and services to potential customers" (Barlow, Levy-Bencheton (2018:139).

It is worthy to remember that "smart cities are more than collections of smart machines, smart data networks, smart power grids, and smart transportation systems - they're magnets for smart people" (Barlow, Levy-Bencheton 2018:77) and cornerstone of active citizen participation is a strong educational background and awareness of technological advancements combined with a

strong vision of a common future. “Smart cities will need smart people to drive their economies” (Barlow, Levy-Bencheton 2018:78). They are needed to launch new businesses and make a positive impact in general. “Smart people are the true capital of smart cities” (Barlow, Levy-Bencheton 2018:78). “As smart cities attempt to encourage "smart citizenship," they frequently concentrate on the enabling of individuals and enhancing civic involvement, interplay and participation” (Popescu, 2015).

As education is key to a brighter future, “implementing smarter education options and forging connections between educational institutions and potential employers can help to develop talent, support innovation, and take advantage of labour market opportunities” (Barlow, Levy-Bencheton 2018:213). As they pointed it out, these actions could generate an inclusive and creative learning climate, and enable the participation of all demographics to improve the prosperity of the city. “The exchange of information among citizens and their life-long education and employment opportunities are the key characteristics of smart people” (Barlow, Levy-Bencheton 2018:212).

When designing the cities of the future, “smart” human experience must be at the core. To purposefully design cities, innovative ways of thinking, such as “design-thinking”, could be utilised to ensure a human-centred approach along the way. “Human centered design begins by looking closely at how people behave in real life and then designing services around their needs” (Barlow, Levy-Bencheton 2018:98). This way, innovation and improvement never really ends - continuous improvement and agile thinking are at service for further development. “Smart cities use human-centered design to flip the traditional model of city government on its head” (Barlow, Levy-Bencheton 2018:98). They propose that this way, instead of catering to bureaucrats, politicians, and special interests, cities focus on serving their citizens.

2.3. Digital revolution on the urban doorstep

It is almost incomprehensible to fathom the advancements in technology that happen on a daily basis across nearly all fields, such as computing, medicine, engineering, etc. This truly is an exciting technological era paving the way for a brighter future where technology is an integral part of high quality of life in urban areas across the world. Nations are witnessing how” digital technologies are reshaping social and economic structures, breaking down communication barriers, and accelerating innovation world-wide” (Bheemaiah, 2017 as written in Yamagata,

Yang 2020:35). It seems that the "emerging technologies are the focus of future-oriented cities as they can foster fast growth and coherence, but it comes with uncertainty and ambiguity" (Kirwan, Fu, 2020:8). These "technologies enable researchers to think of the non-digital aspect of cities digitally, by using computer simulation and modeling, geographic information system (GIS), and building information modeling (BIM) to visualise, model, design, and manage the physical urban environment from large-scale urban to small-scale urban building systems" (Yamagata, Yang, 2020:3).

"Technology has had a clear "automation" function since the industrial revolution and the assembly line was born, and in the 21st century, automation is eliminating the final sectors of physical labour and human work is increasingly abstract" (Kirwan, Fu, 2020:3). Having in mind that a common denominator for previous industrial revolutions was "automation", smart cities must have awareness that it is imperative to serve the people who have created it. Technologies such as "cloud computing, machine learning, big data and technological progress are changing the relationship between the human and the object" (Kirwan, Fu, 2020:112) hence "the relationship between smart cities and data is unavoidable" (Barlow, Levy-Bencheton 2018:187). "With data science, smart cities can determine which intersections are most dangerous and which remedies are most likely to reduce accidents; which homes need smoke alarms; which schools require monitoring for potential violence; which sources of water are most likely to contain contaminants; which parks are most used and need extra maintenance; and which neighborhoods would most likely benefit from additional police patrols at night" (Barlow, Levy-Bencheton 2018:182). This "fourth generation of smart cities is driven by the collective intelligence of all stakeholders, sourcing (best-practice) smart city solutions, ideas and knowledge globally via online platforms to accelerate the development of livable and prosperous cities and communities on the local level" (Barlow, Levy-Bencheton 2018:213).

With a wide array of technologies disposable to cities to create "smart" solutions, in the following two sections the focus will be on AI (Artificial Intelligence) and IoT (Internet of Things) as core pillars of future "smart city" technology integrations.

2.3.1. Artificial Intelligence (AI)

In the recent decades, Artificial Intelligence has become a norm in certain fields, and less of a science-fiction term. Today, “AI is not reserved for robotics or science; it infiltrates everywhere” (Kirwan, Fu, 2020:112). These suggest that services and smart connected objects of everyday life become intelligent. They are able to understand human behaviour and the environment and anticipate needs. Moreover, there are various interpretations and definitions of what Artificial Intelligence is, but in this context Kirwan and Fu (2020:168) assert that it is “what gives machines, computer programs and systems power to learn, adapt to new informational inputs, solve problems and make complex decisions independently of people. “ They also state that AI utilizes techniques and methods developed in several fundamental disciplines, including mathematics, statistics, engineering, natural science, computer science, linguistics and neuroscience. These areas “allow to build machine learning algorithms that underpin a number of key technological capabilities that power the practical applications of AI we all experience daily when we search online, take a photo on our smartphone or shop online” (Kirwan, Fu 2020:168).

From the perspective of urban areas, Kirwan and Fu (2020:147) believe that “cities have been victims of human development and urban mobility is still one of the major problems to solve with the aid of new technologies and AI”. In their opinion, “technology is evolving in teleonomic (undirected) and teleological (directed) ways and converging on AI-driven, autonomous, self-regulating systems” (Kirwan, Fu 2020:3). Ultimately, the goal for Artificial Intelligence (AI) will be to assist in the self-regulation of cities as living systems.

The field of Artificial Intelligence is continuously evolving, achieving progress continuously. This technology serves as a pillar for future technologies and as a foundation for integrations and creation of new solutions. As Kirwan and Fu (2020:110) have stated “ a key advancement in developing a new stage of connectivity is the introduction of 5G harnessing AI technologies to new levels and enabling the vision of intelligent connectivity.”

With the use of Artificial Intelligence, quality of life in urban areas could reach new heights.

2.3.2. Internet of Things (IoT)

In contrast with Artificial Intelligence (AI), the Internet of Things (IoT) is at "the foundation of Smart concepts and Sensors are the Things that create data elements" (Satyam, Calzada 2017:108). As Kirwan and Fu (2020:109) have stated "industry 4.0, combining IoT and cyber physical systems (i.e. virtual networks used to control physical objects), requires continuous and instant communication between various equipment and integrated workstations in production and supply chains".

From the perspective of "smart city" technologies, "it becomes clear that the concepts of the Internet of Things (IoT), in which all devices are interconnected via networks, as well as the Internet of Energy (IoE), in which each subject (consumer) not only selects the information she or he needs, but also making a decision about his or her own or collective energy supply, taking into account the interests of other members of society and the entire socio-natural environment, becomes a key requirement for the smart cities" (Bibri, 2018 as written in Strielkowski et al., 2020). This could bring significant advances to the quality of life as "IoT infrastructure and big data analytics as a new smart city infrastructure provide new approaches to empower cities and communities to track energy, material, water, transportation, and informational flows in the physical environment and turn them into real-time information for better decision-making" (Yamagata, Yang 2020:13). Kirwan and Fu (2020:110) propose that "the ultrafast, low-latency connectivity provided by 5G networks combined with big data collected by billions of devices through the IoT and the contextualisation and decision making capabilities of AI has enabled new processing capabilities in virtually all sectors of smart cities including autonomous transportation, healthcare and enhanced public services". Satyam, Calzada (2017:109) supplied an example of a stolen car or a car moving without authorisation, where "the owner of the car can take out their mobile phone and then click "stop". The mobile phone will send this instruction using the Internet and a cellular network, to the Thing that will instruct the actuator to turn off the petrol supply to the engine." This could also contribute significantly to the safety and road security as well.

Looking at the future developments "combining automation, machine learning and the IoT is allowing for the adoption of smart city technologies for a variety of applications" (TWI, 2020).

To fully harness the power of AI and IoT, it is crucial to have in place “smart” people with a vision who also have a strong belief that the integration with technology could have a positive impact across various city sectors. In addition to that, to increase the data security and scalability, “blockchain technology can be deployed to provide more robust level of encryption that makes it virtually impossible to overwrite existing data records” (Jain, S. 2021).

2.4. Harnessing the power of digital technology

As human civilization has advanced through centuries, technological revolution has followed as well. Each step forward in the field of technology has meant new possibilities and positive changes in the development of effective urban infrastructure, and reaching the economic potential of “smart” cities. Nonetheless, it has also caused detrimental consequences on the nonrenewable natural resources. “About 85% of the energy that we use today comes from the diminishing treasures of fossil fuels” (Satyam, Calzada, 2017:31). Due to humankind’s ambition for higher quality of life, energy consumption is increasing rapidly to provide for those various conveniences. It is obvious that we cannot rely on nature's assets forever. “Renewable energy options are limited, and the current technologies do not make them financially viable especially since fossil fuels are available much cheaper” (Satyam, Calzada, 2017:31). Understanding how to harness the power of digital technology for future urban development is key to a sustainable future.

In the following section, in-depth insights will be provided into the area of economic performance and infrastructural development.

2.4.1. The economic potential of “smart cities” and effective infrastructural development

Positive and sustainable economic performance of local city governments is a key pillar driving decision-makers. “Economics at its core definition is about the distribution of scarce resources” (Kirwan, Fu, 2020:205) and in the context of cities, this notion has a significant meaning, especially knowing the large disparity of funding in cities across the world, usually cities operate with tight budgets and (severely) underfunded, and means for new initiatives, especially in the areas of “smart” technologies do not top the list of priorities. “Technology is able to increase efficiency and reduce scarcity of resources, but the hoarding and price-fixing of resources and products creates artificial scarcities that exploit profit opportunities” (Kirwan,

Fu, 2020:205). Based on Satyam and Calzada (2017:13) “cities are managed by city governments, and funds to run the cities come from tax collections”. They further continue to explain that the amount available to develop the physical infrastructure depends on the tax structure as well as the economic output of the city. Based on the value of tax collections cities prioritise the usage of the funds. However, “smart technology can be used to maximize efficiency and reduce costs in terms of urban security, administrative procedures, municipal maintenance, education and more” (Strielkowski et al., 2020), rendering it important in the context of being an economical decision to invest in such technologies long-term. It is the understanding of Barlow and Levy-Bencheton (2018:78) that “cities of the future will pursue many of the same economic development strategies pursued by cities today” and when it comes to attracting new residents and first-time tourists “they will spend time and money necessary to make certain those first impressions are favourable” (Barlow, Levy-Bencheton 2018:72). “To pull through intense international competition, smart cities should be more linked to the outside world: they are relative capacities of urban systems and should be regulated within the background of network features, should introduce and handle relentless flows of capital, knowledge, and human exchange globally, and should improve their potential to be powerful mediators within the system, optimizing connectivity to a significant variety of diverse cities” (Popescu, 2015). “One possible channel for Smart City policies to exert a positive impact on economic performance and growth is through fostering urban innovation” (Caragliu, Del Bo, 2019). Authors put forward a thought that “smart city” projects are often the result of a strategic interaction between major multinational corporations heavily investing in these technologies, and municipal and regional authorities seeking to enhance local performance by means of adapting such technologies to the local need.

Another challenging aspect from a city management perspective, next to the financial shortages, is usually a larger, ineffective overly bureaucratic governing body. When implementing “smart” technological solutions “city bureaucracies that once required hundreds of workers will require only dozens, and the workers will provide answers and approvals in minutes and hours, not days and weeks” (Barlow, Levy-Bencheton, 2018:83). “Smart cities will save money by scaling back or eliminating jobs involving tedious, repetitive tasks” (Barlow, Levy-Bencheton, 2018:83), In that way, ideally the unspent money will be reallocated to hire people for high-skill jobs that cannot be performed by machines such as teaching, nursing, counselling, policing, and the entirely new job categories that will arise as smart city economies evolve and mature, as mentioned by the authors.

According to the United Nations (2021) “cities and metropolitan areas are powerhouses of economic growth—contributing about 60 percent of global GDP”. However, due to rapid urbanisation and energy consumption in developed urban areas, they also account for about 70 percent of global carbon emissions and over 60 percent of resource use. “In addition to being generators of wealth, cities possess intrinsic value” (Barlow, Levy-Bencheton, 2018:3). These small patches of urban real estate are worth much more than similar patches of land in rural or suburban areas, from the perspective of the authors. “A detailed study by economists at the University of Illinois and the University of Michigan estimated that 76,581 square miles of urban land in the United States is worth roughly 25 trillion dollars” (Barlow, Levy-Bencheton, 2018:3). When calculated, it turns out to be about 511000 dollars per acre, which implies that a typical parking space is worth 2000 dollars, as the authors demonstrate.

Nevertheless, regardless of where they find themselves “today, citizens world over expect a reasonable quality of life” (Satyam, Calzada, 2017:15). They moreover point to the fact that this expectation includes a continuous supply of electricity, water, and cooking gas in addition to telephone and broadband connectivity. “The most affluent cities have these services integrated into the city infrastructure” Satyam and Calzada (2017:15) conclude. These cities also have hospitals, schools, ambulances, police, and fire brigades as their core services. “Most cities have developed a basic infrastructure and logistics for the supply of food - from farms to kitchens” (Satyam, Calzada 2017:30). It is their overall observation that people generally do not want to live more than 10-20 minutes away from a grocery store - driving or walking. “Proximity to a source of food - either a farm or a store - gives us a sense of security, however, citizens of rich countries with decades of confidence in the availability of food and water at all times are probably less insecure” (Satyam, Calzada, 2017:30).

One of the key areas of a city economy, and the economies of its residents, is the accommodation and housing aspect. “Demand for urban space is rising and prices are rising as well” (Barlow, Levy-Bencheton, 2018:3). “Many of the world’s most dynamic and desirable cities have serious housing shortages, driving up rents and home prices” (Woetzel et al., 2018). They believe that expanding the supply of housing can bring down those costs. “In many places, bureaucracy bogs down land acquisition, environmental studies, design approvals, and permitting” (Woetzel et al., 2018). They recommend that digitizing these processes can remove risks and delays, encouraging more construction. In addition, “most cities have a surprising

amount of land sitting idle that could be suitable for infill housing" (Woetzel et al., 2018) concluding that creating open-source cadastral databases can help to identify land parcels for development.

Adapting "smart city" technology in tackling some of these challenges could contribute significantly to the development of effective city infrastructure. "A characteristic feature of "smart" systems is that their degree of intelligence which is ensured by a variety of infrastructure options providing a controlled adaptation of the structure to changing external conditions, the active development of systems based on the information and communication technologies, as well as the presence of man as a subject and object of functioning and development of the "socially oriented meta-system (SoM)" (Strielkowski et al., 2020). Looking at the market, there are multiple potential vendors of "smart" technologies that compete in tenders globally and endure lengthy public procurement processes to provide their services and reach citizens. As put forward by Barlow and Levy-Bencheton (2018:23) "legions of technology providers have already lined up to battle over shares in a market for smart-city solutions and services that's projected to exceed 1 trillion dollars within the next five years". According to Strielkowski et al (2020) "the cost of implementing intelligent networks has reached $20 billion, including the growth in the EU countries estimated to be at a rate of about 27-25%, about 16% in the USA, around 12% in China, and about 30% in other Asia-Pacific countries; it is assumed that the development of smart grid technologies, among other things, will reduce the needs of energy-deficient regions in fuel and energy resources".
There are also interesting examples of combining "smart" technology in order to contribute to effective city infrastructure in The Netherlands. "Amsterdam's Climate Street initiative has the aim to transform a traditional retail street, Utrechtsestraat, into a sustainable shopping area by optimizing the street's stores energy and logistics management, along with the related public services" (Caragliu, Del Bo, 2017). As reported by the authors, smart meters constantly monitor the demand and supply of energy, and grids also constantly measure how full public trash cans are, so that waste collection only takes place when needed. It seems that these combined actions have allowed the city of Amsterdam to reduce annual CO2 emissions from 3,400 tons in 2010 to 1,276 tons in 2012.

2.5. Advanced mobile devices in the context of smart cities

Consumer habits have changed significantly in the past and today, for many people across the world “the first screen” is no longer the television, but rather a variety of advanced mobile devices such as a smartphone or a tablet. Since these devices operate as a portable handheld computer, cities can reach their citizens with ease through a variety of mobile applications designed for specific purposes. “Without the small size of devices that can fit in small places, or be carried around, the “smart” revolution would not be possible” (Satyam, Calzada, 2017:111). This way, citizens can take an active role and drive the effective development of their city’s infrastructure in real-time with their active behaviour, decision-making and their ideas and proposals. “Personal wearable devices, mobile technologies, sensing systems, IoT and pervasive computing are defining new forms of cities” (Yamagata, Yang, 2020:3). “Most mobile devices are currently integrated with mobile cloud, which enables the offloading of mobile services to backend servers” (Balakrishna, 2012). It seems that this offers an unprecedented scalability and availability of a vast computing resource which is useful for collecting large-scale sensor data, as mentioned by the author. “Data analysis may also be conducted in the back-end servers for intelligent usage of the collected data” (Balakrishna, 2012). According to Kirwan and Fu (2020:108) “the ability to develop flexible connectivity is critical as humans move and exchange data on a variety of platforms and in multiple locations and environmental contexts”. It also makes it a rather efficient way of working with its citizens as “the mobile apps are reachable to a vast majority of user-base through established app dissemination channels that exist today such as the app stores/markets” (Balakrishna, 2012). Furthermore, as reported by the author, the majority of smart-phone platforms are open and programmable thereby offering a very low entry barrier for third -party developers”. Lots of research has been done as well to understand how social relations between people influence mobile dynamics networks with the logic that humans carry mobile devices and human mobility is influenced by the social relations mediated by those devices, as explored by Kirwan and Fu (2020:108).

Mobile devices could be used in a multifold way to enable “smart” living. “Smartphones today are embedded with a huge array of sensors and computing and communication resources” (Balakrishna, 2012). Furthermore, as mentioned by the author, they are also diminishing the difference between the virtual world and the real world by capturing the physical world data and making the mobile device more context aware. “The interesting part of mobile sensing is

that these smart sensors are constantly mobile in a given environment and furthermore they are attached to an interesting entity such as the end-user" (Balakrishna, 2012).

"The all-pervasive nature of mobile phones lays out an extensive sensing fabric in the society thereby ticking off the first defining requirement for smart-city application" (Balakrishna, 2012). Looking at the Internet of Things concept, "sensor-enabled smart objects including the smart-mobile devices are proving to be the elements of the future networked -infrastructure" (Balakrishna, 2012) implying that smart mobile devices could lead the way in the wide-scale implementation of "smart city" technologies and improving the quality of life. For instance, to support Smart Living and inform about air pollution, "sharing real-time air-quality information with the public via smartphone apps enables individuals to take protective measures. This can reduce negative health effects by 3 to 15 percent, depending on current pollution levels" (Woetzel et al., 2018). The main enabler for this is "a microphone that senses the variations in air pressure when we talk" (Satyam, Calzada, 2017:97). In addition, most smartphones also have location sensors, popularly known as GPS, that senses the location, using satellites or terrestrial electromagnetic waves, as mentioned by the authors. "The accelerometer senses movements and measures the number of steps walked" (Satyam, Calzada, 2017:97). There are sensors all around and play a key role in Smart Living".

Besides supporting the aspects of Smart Living, usage of mobile devices is also predominant in the context of Smart Mobility, especially in the area of traffic management and parking occupancy. Smart-parking apps can point motorists directly to available spots, eliminating time spent fruitlessly circling city blocks, as stated by Woetzel et al. (2018). As seen in Canli and Toklu (2021), a deep learning and cloud-based new mobile smart parking application was developed to minimize the problem of searching for parking spaces using a subfield of AI - deep learning with Long short-term memory (LSTM) to predict the parking spaces. "Here, dynamic access is provided to the LSTM-based model previously created through the mobile device of the user, and the process of displaying the occupancy rates of the parks at the desired place is accomplished on the mobile device by entering the relevant parameters"(Canli, Toklu, 2021). Barcelona, one of the cities leading the way in the adoption of "smart" technologies, has "installed street sensors that detect any available parking spots or loading areas" (Satyam, Calzad, 2017:64). By using a smartphone, this real-time information is communicated to those looking for parking and it also shows locations of free parking. These sensors not only help people find parking but also provide information on parking patterns over time of the day as

well as the pattern during the year. “Analytics systems use this information to help traffic management authorities in improving the urban mobility system” (Satyam, Calzada, 2017:64). On top of it, it also supports mobility by providing real-time information of available bicycles to its residents and tourists “there is a Bicing App as well that informs users on the real-time availability of bikes; Barcelona has more than 6000 bicycles in circulation and is very popular with students, office-goers and even tourists” (Satyam, Calzada, 2017:64).

Barcelona is also pioneering civic engagement and democratic participation in the context of Smart Governance by deploying mobile apps to communicate and engage its citizens. M - governance is an interactive mobile application and together with cheaper phones empowers citizens to use the government enabled services, as mentioned by Satyam and Calzada (2017:145). “Information is disseminated to citizens, covering a wide range of topics, including healthcare, agriculture, education, power and utilities, and financial services” (Satyam, Calzada, 2017:145). This way, the government also gets easy access to people’s opinions, feedback and complaints in a two-way interaction platform of m-governance. “Subsidies and benefits reach the right people at the right time, penalties and fines are collected easily, and census data is automatically collected through the m-governance initiatives” conclude the authors. Besides this, “the city administrators have developed a centralised complaining filing center to address civic problems” (Satyam, Calzada, 2017:65). These customized apps are helping citizens get residence certificates, locate their towed vehicles and pay for any traffic violations, and much more.

For many cities across the world, mobile devices will be the most efficient, effective and smooth way to reach its citizens, and provide them with real-time information and services on-demand.

3. Research methodology

In order to analyse the subject in full, different methods have been in the context of this research. In this chapter, focus will be on providing further details on the topic of this research as well as methods used.

3.1. Goals and scope of the research project

As previously mentioned, the focus of this work is to understand in-depth the economic potential of smart cities, technologies that enable effective infrastructural development with a particular emphasis on usage of smart mobile devices.

With the above in mind, the research focuses that have been lined out are as follows:

- understanding the "smart city" concept and its key characteristics,
- understanding what the latest technologies are and how they could be leveraged in creating "smart" solutions for effective infrastructure development, and
- understanding the role and impact of mobile devices in the context of "smart cities".

The research has been conducted in the time period between November 2020 and July 2021. In this period, the city Frederiksberg from the greater Copenhagen area has served as a research subject and foundation for observation of the "smart city" initiatives conducted. Considering that one of the research focuses is the impact of mobile devices in the context of "smart cities", Smart Mobility has been given a priority in the research, however examples of other "smart city" projects will be provided as well.

This city has been selected due to their strong initiatives with the area of "smart cities" and more so in the area of Smart Mobility, where 100% of parking operations have been fully digitized according to the city official that took part in the research project.

3.2. Overview of the methods and techniques of the research project

To fully deliver on the topic of this work, several methods have been used to conduct this research assignment.

Collection of secondary data, and extensive literature analysis has been conducted preliminarily to provide context and detailed background information on the topic of "smart city" concept, urbanisation, latest technological advancements and usage of mobile devices in the context of enabling "smart city" initiatives. The principal source of information has been several books from the authors in the field of "smart cities", urban system development, Artificial Intelligence (AI) and Internet of Things (IoT). Furthermore, numerous scientific articles, conference papers and web articles have been reviewed on the same topic. Particular attention has been given to refer and review the most recent literature, not dating further than 2017. There are only a few instances of literature in this work that date further.

Primary source of information and the data collection point have been the interaction with the Parking Manager from the city of Frederiksberg, who has provided first-hand information on the topic of Smart Mobility as well as their main focuses and achievements. In addition to that, EasyPark, a company providing the city with Smart Mobility solutions have provided another set of secondary data, even though those were limited in their nature due to the data confidentiality.

When collecting primary data, semi-structured interviews have been conducted, and participants were informed that the data presented will only be done so in a form of an overview and exploratory description through a case study, and that no personal information will be shared in line with the GDPR requirements. Interviews have been conducted online using Skype for Business and Google Meet platforms in the time period between November 2020 and April 2021. Three interviews have been conducted and the interviewees were selected due to the nature and scope of responsibility of their roles in their respective organisations. One representative of Frederiksberg city, and 2 representatives of EasyPark have taken part. Purpose of the interviews was to obtain a deeper understanding of the Smart Mobility digital solutions offered, and the reality of their implementation in the city of Fredrikseberg, with the final outcome of understanding what role the smart mobile devices could have, and if any economic benefits have been yielded by this digitisation process.

An exploratory case study has also been one of the methods typically used in the reviewed literature where several examples of “smart cities” have been presented, such as Tel Aviv in Israel, and Barcelona in Spain. PressAcademia (2018) gives a concise definition of a case study being that “a case study is a research methodology that has been commonly used in social sciences”. The use of the case study method has been popular for exploration and observation, and a concise presentation of the reviewed subject. The case study approach allows in-depth, multi-faceted explorations of complex issues in their real-life settings and the value of the case study approach is well recognised in various fields as seen in Crowe et al., (2011). “The case study approach is particularly useful to employ when there is a need to obtain an in-depth appreciation of an issue, event or phenomenon of interest, in its natural real-life context” (Crowe et al., 2011). Based on that, the case study method has been selected as the most viable form of presenting the collected data and its analysis.

4. Research description and results

This chapter will focus on providing an overview over the research flow, as well as the results noted from the project. When it comes to the results, a detailed case description of the city of Frederiksberg will be presented.

4.1. Research flow description

As pointed out previously, the research project began in November 2020, and had lasted till July 2021. In this period of 9 months, research projects have gone through several phases:

- The initiation and conceptualisation phase
    - This phase has included preliminary research and understanding the goals and the scope of the research project, availability of primary and secondary data has been taken into the considerations, as well as planning and contacting potential interviewees for the project. Work done in this phase has served as a foundation for the upcoming research.

- The research phase
    - The first interview with the Parking Manager from Frederiksberg city was conducted on 12th of November 2020. During the interview a relevant amount of primary data was collected such as valuable insights into the decision making factors behind the parking digitisation, structure and set-up of the team in charge of the parking, as well as the progress they have made in the last couple of years in this area.
    - Extensive literature has been collected and reviewed, which amounted to 6 books in the field of "smart cities" as well as 30 scientific articles from various journals. Upon reviewing all the literature, only a selection has been included in the actual thesis as references. Moreover, primary data collected from the first interview with Frederiksberg have been complemented with the public data on their website such as their Strategy Development document. Additional interviews have been conducted with two representatives of EasyPark AB, a

company providing Frederiksberg with their Smart Mobility solutions, that led to having 100% of parking operations digitised.

- Additional set of interviews had been done with EasyPark´s Chief Business Development Officer and Marketing Manager for Denmark. Company has also provided further materials on their Smart Mobility solutions, and sales materials used in Denmark.

- The finalisation phase
  - This phase has included repeated literature review, and selection of the most relevant materials for the thesis. Additionally, the preparation of the textual part started in April 2021, which included preparing the initial structure of the thesis and preliminary content.
  - Final completion of the overall thesis work had been done in July 2021, as well as proofreading of the work.

4.2. Describing the research results

In the following section, a case study of Frederiksberg will be presented, as well as the context of high quality of life, which is a symbol of the Scandinavian countries. These countries are well-known for their vast well-fare system, individual freedom and high levels of innovation and technological development. Denmark is no exception.

4.2.1. About Denmark

For a better geographical understanding, “Denmark borders Sweden to the east and Germany to the south” as stated by Kronvall (2020). The Øresund Bridge connects the largest Danish island, Zealand, to Sweden, while the peninsula of Jutland additionally connects it to Germany. The third-largest island, Funen, is connected to Zealand by the Great Belt Bridge and to Jutland by the Little Belt Bridge. Denmark is the most southern of all its Nordic neighbours with a population of around “5.8 million” according to the Statistics Denmark (2021). Country regularly tops world happiness and quality of life rankings, making it one of the most desirable countries to live in. OECD (2016) reported that “Denmark ranks above the average in many dimensions: housing, work-life balance, social connections, environmental quality, civic engagement, education and skills, jobs and earnings, work-life balance, health status, subjective

well-being and personal security". Tremendous quality of life as reported in Denmark is especially visible in its capital city Copenhagen and the Greater Copenhagen area.

The object of the case study, Frederiksberg is an integral part of the Greater Copenhagen area which "aims to be the leading metropolis in Northern Europe in terms of attracting and retaining international investments, companies, tourism and talent" Frederiksberg Kommune (2021).

4.2.2. About Frederiksberg

Frederiksberg is an independent municipality in Greater Copenhagen, situated in eastern Denmark, and dating all the way to 1651 as reported by Brittanica (2010). As indicated on the official website of Frederiksberg city (2021), "in 2016 the population of the municipality was 104,481". Furthermore it reports that the city covers an area of 8.7 square kilometres, making it the most densely populated municipality in Denmark. City offers a variety of different services to its citizens to improve their quality of life. Some of these initiatives are stated under the "smart city" initiatives for the Frederiksberg Kommune which encompass several key areas of "smart cities" especially "Smart Mobility".

4.2.2.1. Frederiksberg - the "smart city" vision, strategy and goals

In their Strategy Document from 2015, Frederiksberg city envisions "smart city as a city of the future where decision makers have the tools and data to make better decisions, anticipate problems to solve them proactively and coordinate resources for the city to function effectively". They also believed that it is about how the users of the city help to shape the city and how these, by actively using data and new innovative technologies, contribute to the development of the city and create the best framework for a safe and sustainable city life.

As mentioned in the literature review, for a "smart city" to operate on a high level an extensive involvement from the community consisting of businesses, academia, and citizen community must be ensured. For Frederiksberg "the "Smart City Frederiksberg" is for everyone who wants to contribute to the city's development, for example the city's business community, educational institutions, citizens, associations, interest groups and the municipality. Frederiksberg Forsyningen, CBS (Copenhagen Business School) and Frederiksberg Centret are examples of companies who want to be involved in the work of developing Smart City Frederiksberg.

To ensure this strategy would come to life and Frederiksberg would have become a “smarter” city it was essential to create concrete projects and initiatives that could have been put into operation in the city. This strategy was also the starting point and an inspiration for further work with “smart city” projects that the city's actors could pursue on their own in the future or in collaboration with Frederiksberg Municipality.

Under the umbrella of the “smart city” strategy, four goals were derived which would guide the upcoming initiatives and projects:

1. Create innovative solutions - in the context of the first goal, it was not just about making “smarter” solutions, but also about using technology in an innovative way. Using the existing technology, data and resources to create innovating solutions for the city challenges was key.
2. Create more business opportunities - with this goal the sole purpose was to ensure that the “smart city” projects must be able to create new business opportunities for city users, businesses, cultural life, etc by using free data, new collaborations opportunities, etc.
3. Develop the city resources - from this perspective, resources should be understood as citizens and businesses, green city spaces, energy, etc. To ensure these resources are used in a “smart” and sustainable way for “greater good” was crucial.
4. Create a basis for better decision making - the usage of data should contribute to making quality decisions in relation to debates and creating solutions. Decision makers should have the necessary tools and data to make better decisions, anticipate problems in order to solve them in a proactive manner and coordinate resources for the city to function effectively.

In addition to these four goals, principles for “smart city” work have also been created:

- Openness - transparency should be broadly interpreted in relation to the approach and the use of data, in collaboration with private individuals and public actors in and outside of Denmark’s borders. Frederiksberg must enter into collaborations and participate in existing networks and platforms.
- Space to experiment - meaning an adaptation of an agile approach: testing on a small scale before rolling projects on a large scale. In this way, no permanent solutions should

be created to temporary problems. Space to make mistakes and close projects should be ensured.

- Smooth process, fast results - business cases that provide fast results should be prioritised. The bureaucracy must be challenged, and risk taking must be demonstrated within the framework of the law.
- Winnings for everyone - creating business opportunities that benefit the entire city and the citizens. Create growth in Frederiksberg. These winnings do not need to be only financial, but can also be a quality boost to the city life and infrastructure.

After putting in place all of these key pillars of "smart city" strategy development, in the upcoming years various projects have been aligned to fit into this strategic framework.

4.2.2.2. Frederiksberg - a city pioneer in digital network coverage

Following their strategic set-up in 2015, the city has been making great advancements in the following years. In 2018, it became the first city in Denmark to introduce a comprehensive "smart city" network to cover the entire city after it had been set-up in 2017. This gave the possibility to companies, educational institutions and everyone else to connect to the network and try out "smart city" technologies with first "smart city" solutions being connected to the network. The network was a prerequisite for Frederiksberg to be able to offer smart solutions for the benefit of those who live and work in the city. It also made the city stand out from other cities by being the first municipality with a network that covers so massively, and which was designed in a manner that it was easy to update when new technologies appear in the future. On top of that, it gives so many other possibilities as well such as collecting the consumption data, monitoring the wiring networks and informing about available parking spaces.

4.2.2.3. Frederiksberg - active community engagement in driving "smart city" solutions

As discussed at the beginning of this work, an integral part of "smart cities" are its people. Citizens and all other city users must be at the core when thinking about creating and providing "smart city" solutions. "Smart People" are key in adaptation of newest technologies and are main consumers of the innovative city services, and as such should be active participants in creation of "smart city" initiatives.

As reported by WIRE (2019), in February 2019, students, researchers, businesses and citizens of Frederiksberg Municipality had the chance to flex their innovative muscles and come up with solutions to some of the city's challenges in a "Smart City Challenge" hosted by CSB (Copenhagen Business School) in collaboration with Frederiksberg Municipality. This Smart City Challenge has four main collaborators: Frederiksberg Municipality, the University of Copenhagen, CBS; and the Royal Danish Academy of Music – all of which have some of their campuses in Frederiksberg, and citizens themselves. Here participants are given 48 hours to transform an idea into a realistic concept and present the concept to a panel and receive feedback at the end of the challenge.

Questions such as "how can Frederiksberg Municipality make the city more resilient to climate change" or "how can the city encourage people to be more physically active and increase their overall well-being and health" were just some challenges that were presented to the participants of the "Smart City Challenge".

Engagement of the student population through receiving their inputs is believed to be a key to providing different ways of thinking and new perspectives according to Hasse Hauch, Head of Geographical Information Systems (GIS) and Digitalization at Frederiksberg Municipality, as reported in WIRE (2019).

4.2.2.4. Frederiksberg - efficient energy consumption through implementation of a wireless meter grid

As listed out in their Strategy Document and reported by the Nordic IoT (Internet of Things) Centre (2020), Frederiksberg Municipality has wanted to become a "smart city" and has implemented a digital solution for registering households' energy consumption with the implementation of a Cloud solution for analysis of big data and optimization of energy consumption. Frederiksberg Forsyning, which supplies water, heat and electricity to Frederiksberg Municipality, has collaborated with Develco to develop a "smart city" solution. The project includes more than 1,000 gateways that are hung up in the street lighting with wireless connection to heat and water meters in the individual households. All gateways are PoE (Power over Ethernet) connected to a network connected to collection points with consumption data. Frederiksberg Forsyning has gained access to real-time data that provides better and more precise regulation of district heating and water supply and thereby savings in

operating costs. The “smart city” solution in Frederiksberg Municipality has a positive effect on the environment and contributes to sustainability.

4.2.2.5. Frederiksberg - optimising urban life through “smart mobility” solutions

As indicated throughout this work, due to the rise of urban population, traffic congestion has become one of the biggest challenges cities must solve in order to increase the quality of life for its citizens. A range of problems arise in densely populated areas, such as traffic congestion, carbon dioxide emissions and resulting air pollution, and limited parking availability all which have detrimental effects on urban well-being.

“In recent years, Frederiksberg has suffered from traffic congestion” EasyPark (2017). One of the key drivers of this is a densely populated urban area of 100 000 inhabitants, but also traffic which comes from those who work in central Copenhagen and park in this area of green spaces and residential roads as further reported. To successfully combat this, previously a city administration would need to increase the number of permits handed to residents and install large amounts of expensive Pay & Display machines throughout the area. However,” due to their strong vision and strategic orientation to the “smart city” solutions, the city of Frederiksberg has decided to go with a different solution”, according to EasyPark (2017).

As reported by EasyPark (2017) “a collaboration has been initiated with EasyPark to implement a smart parking infrastructure, also known as HUB”. “This is a common database, and combines all aspects of parking in one place which gives Frederiksberg more control over traffic flows and parking, and gives the drivers more choice on how to pay, and more clarity on where to park” as stated by the company. “The HUB combines multiple parts and there is mobile paid parking, digital permits for current residents, cashless payment on Pay & Display machines, in-car park and pay, and even sensors in the ground which allow drivers to get real time information on where they can park their cars” as presented. Initially, the implementation seemed to be a challenge, firstly for the team in Frederiksberg to combine so many different components, and also for the drivers to get used to a whole new way of parking. Even though it took some time to embrace new habits, it wasn’t long before everyone adapted to the new system. According to Poul Eldrup, as reported by EasyPark (2017), “94% of all parking tickets are paid for by phone” making the mobile device the key element in driving new user behaviour.

The HUB has been a great success story for everyone including the team in Frederiksberg, the residents and commuters. Now, only 18 new Pay & Display machines had to be installed in the area instead of a previous projection of 900 to ensure those still looking to use traditional parking payment methods were still provided for, which meant a significant financial saving. Furthermore, “the total number of transactions related to parking saw a substantial increase of around 50% in just three months and it showed that it’s more convenient for the users, and more financially viable for Frederiksberg itself” (EasyPark, 2017). “Administration and control have become much easier” Paul has reported according to EasyPark (2017).

This approach has had multifold benefits because “the less time drivers are searching for a parking space, the less time their engines are running” (EasyPark, 2017). It also meant less fuel was burnt, and less harm was done to the environment. “It also means there should be less traffic, as cars will be parked more quickly, so taking up less space on the roads” (EasyPark, 2017).

As reported during the research and the interview with the Parking Manager of Frederiksberg, a decision to continue with the digital solutions in the area of mobility are “purely economic” by taking into consideration the price of “Pay and Display” machines, and their maintenance in relation with the city budget. Additionally, the team working with parking reinforcement, dedicate their time to other projects in the city as well, as new technology enables them to be more efficient and save more time.

When referring back to the Strategy Document, “smart mobility” solution is an integral part of goal number four - creating a basis for better decision making. With the HUB service, the city has the digital infrastructure to collect data and analyse traffic and parking patterns in the city, which in turn gives them valuable data to make sound economic decisions. Additionally, real-time monitoring of the city's parking spaces provides an overview of available spaces, minimum CO_2 emissions that occur and contributes to an increasingly green and sustainable city.

5. Discussion

In this chapter, focus will be on reflecting upon and understanding the meaning and implications of the results and key findings that have emerged throughout this research. As it was mentioned in the "Introduction" piece of this work, the research has had 3 focuses:

- understanding the "smart city" concept and its key characteristics,
- understanding what the latest technologies are and how they could be leveraged in creating "smart" solutions for effective infrastructure development, and
- understanding the role and impact of mobile devices in the context of "smart cities".

In the following sections a critical review will be provided in relation to these objectives, overview over the research limitations as well as summary of the findings and contributions made.

5.1. Interpretation and implication of key findings

This study has proven valuable in terms of providing another layer of insight into how advanced technology, in particular driven by "smart" mobile devices could create a positive impact in a city, and reflect in a beneficial way on the quality of life in general.

Looking at the case study of Frederiksberg presented in chapter four, and data that have materialised from it, an indication of alignment with previous studies have emerged, with additional real-life examples to confirm those. As seen in chapter two, "Theoretical background and previous research", many authors suggest and give ideas how advanced technology could be utilised to create "smart city" solutions to not only benefit the city life but also the bottom line.

The results showcase multiple examples of "smart city" technology that can be leveraged in an effort to create "smart" solutions to improve the quality of life in the cities and create an effective city infrastructure, and offset negative effects of rapid urbanisation. As presented in the case study, a significant impact and importance of data in making decisions on a city level by leveraging on IoT (Internet of Things) could lead to higher energy preservation and more

efficient waste management. Implementation of a wireless network grid in the city of Frederiksberg is only one example of those, as well as the digital parking HUB that enables city officials to monitor and collect data in real-time for better urban planning in the future and understanding behavioural patterns of motorists throughout the city. This suggests that cities across the world would benefit from orienting themselves towards adapting technological advancement when thinking about bettering services to their citizens. Since Denmark, and Copenhagen often rank at the top of world Happiness and Well-being rankings, it could be implied that technology plays a key role in delivering on these objectives.

The study has also looked into the usage of mobile of devices in the context of driving "smart city" solutions, and while a more comprehensive study should be done, on the example of Frederiksberg, results suggest that a mobile device such as smartphone is a preferred tool for many drivers to pay for their parking, amounting to 94% of all parking tickets being paid by phone. This being also the most obvious finding to emerge from this study, also has financial implications as less "Pay and Display" machines need to be installed, there is less need for paper receipts and parking reinforcement can be done in a more efficient way. Looking at this, "smart" mobile devices seem to be a great tool for interaction, engagement and implementation of "smart city" solutions in a city.

As seen in Frederiksberg, work with "smart city" initiatives and projects must be an active decision, as well as include those who are the main consumers of the city services - the citizens. As it was suggested in the literature review, "Smart People" segment of the "smart city" framework is a key pillar and cornerstone of positive change. With its inclusive "Smart City Challenge" the city of Frederiksberg aims to bring together businesses, academia and citizens to work together on challenges that are present in the city today and in the future. All the "smart city" solutions are created to enable a better life and better preservation of natural resources. It is also interesting to note that in order for "smart city" solutions to be created and adopted in a city, city leaders must possess vision and profound understanding of technology in the context of urban life, as well as knowing their citizens on a deeper emotional level, including what drives them and what is important to them. Only then a valuable "smart city" solution will be created.

An interesting and unexpected finding was the notion of how fast the city of Frederiksberg has evolved in only six years after setting in motion their "smart city" strategy in 2015. From rolling

out a comprehensive “smart city” wireless grid, monitoring parking in real-time to working actively with ensuring to leverage “big data” to make better decisions in the city. This finding suggests that, once set, the technology could develop rapidly, if the original system put in place can be built upon. Hence, creating initial solutions in the right way, is key for the upcoming technological upgrades and ensuring longevity of “smart city” initiatives and projects and long term positive effects.

The findings above are helpful to understand how “smart city” solutions come to existence in reality, and what it takes from a city standpoint to put them in motion and drive their implementation together with their citizens.

5.2. Limitations of the research project

As the field of “smart cities” and technology used is rather broad, several limitations in carrying out this research have appeared.

Firstly, the case study has been conducted based on the Frederiksberg city in Denmark, where the most available public literature published by the city administration is in Danish language. Given that the author is not a native Danish speaker, several translation methods have been used, primarily Google Translate, which could have slightly altered the original and intended meaning.

Secondly, due to its broad theme, only one aspect of “smart cities” has been reviewed in depth through the case study, which is the Smart Mobility. For a more holistic overview of the entirety of “smart city” initiatives, the proposal is to conduct a more extensive and longer study that could encompass all other elements of “smart cities” such as Smart People, Smart Governance, Smart Economy, Smart Environment, and Smart Living.

Thirdly, the size of the focus group, being three people that had taken part in interviews gives a limited understanding of the entire topic. For a proper understanding of “smart city” initiatives from various perspectives and its true implementation in a given city, a recommendation is to conduct a study with a participation of a variety of different representatives of the city organism, which includes government, citizens, academia and business.

5.3. Recommendation for further research

Key to solving challenges of rapid urbanisation across the world is to leverage on existing technology to create “smart” solutions, hence the “smart city” field of research is an important issue for future studies and research. As stated in the literature review, not all parts of the world are developing at equal pace, so that disparity should also be taken into consideration in any upcoming examinations.

When comparing the results with previous studies, as mentioned above, an indication of alignment exists, however, a detailed study is suggested if more profound data are to be collected, especially in the area of “smart” mobile devices being at forefront of driving the adaptation of “smart city” solutions. Very little was found in the literature of actual examples where cities use and focus extensively on leveraging the “smart” mobile devices in driving “smart city” solutions and engaging their citizens, however great examples do exist such as those in Frederiksberg, Barcelona and Tel Aviv. This implies that, from the overall perspective of this research, it is not completely clear how big of an effect “smart” mobile devices have in driving “smart city” initiatives, however, from what it is gathered in this study, it certainly has a high potential looking at the current trends of owning “smart” mobile devices, and patterns of their usage. There is abundant room for further progress and deeper understanding in this area and the impact of “smart” mobile devices for future research.

In future studies, it might be valuable to solely focus on the “smart” mobile devices in the context of a “smart city” and potentially conduct experimental work on a real “smart city” challenge in collaboration with a specific city. A suggestion to include citizens in such a study in a large-scale research project could prove itself more beneficial to understand what role the “smart” mobile device might have in this context.

Furthermore, a separate study could be carried out dedicated to measuring the financial impact of implemented “smart city” solutions and the economic benefits they would generate.

6. Conclusion

The rise of urban population is a trend witnessed through centuries, however the contemporary challenges of it are having a detrimental effect on the quality of life across the world more significantly than before. Latest advancements in technology are proving to be a key solution to offsetting the negative effects of urbanisation on natural resources and the world as a whole. The "smart city" topic has been discussed since the 60s of the last century, and there are multiple ideas and concepts on how technology can be used to improve the quality of life and build effective city infrastructure. In line with that, the aim of this paper was to obtain a profound understanding of "smart city" concept and its key characteristics, latest technologies that could be used for effective city infrastructure development, with a focus on "smart" mobile devices that could be used as an indispensable tool of driving implementation of "smart city" solutions on a citizen level.

The study has identified and showcased real-life examples in the city of Frederiksberg in Denmark, which is a city pioneer when it comes to implementing "smart city" technology to drive effective infrastructure development, while keeping the bottom line in mind. The key pillar of their "Smart Mobility" solution is the usage of "smart" mobile devices when it comes to paying and administering parking by the motorists, which in turn provides valuable real-time data to city officials for better decision making and continues urban development when it comes to traffic infrastructure.

The overall conclusion from this research is in line with previous studies which confirm the positive impact of utilising "smart city" technology for effective infrastructure development, and having citizens at heart when it comes to creating solutions that they will be consumers of. From this perspective, citizens are pivotal in adapting "smart" solutions, especially those based on "smart" mobile devices and related mobile applications, as it requires their active participation. We could conclude that, for the time being, mobile devices seem to be rather underutilised when it comes to driving "smart city" solutions, however the study suggests they seem to have a rather high potential in contributing towards the efficient development of effective infrastructure.

The study has raised important questions of the role of citizens in terms of being key actors of "smart city" initiatives, and indicates that the active participation of community is crucial to fully harness the technological and economic potential of "smart cities" and produce positive effects that reflect on the city as a whole.

The findings of this study might be of interest and serve as an inspiration to cities worldwide on their journey of adapting a "smart" approach in tackling their infrastructural challenges, and those who hold a personal interest in the topic of "smart cities" and the economic potential they might generate.

While the study has its own limitations, nevertheless it offers interesting insights in the world of technology and its benefits for the cities and the lives of urban populations across the world. Further research might explore in depth the role of "smart" mobile devices in the context of "smart cities", and in that way enrich our understanding of how to further engage citizens as "smart" people.

"Smart city" technology indeed could lead us into a better, more sustainable and green future, backed by the collaboration of all of the actors of the urban city ecosystem - business, academia, citizens and city administration.

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