Smart City: Adding to the Complexity of Cities

A Critical Reflection

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This paper seeks to further the state-of-the-art knowledge on what a smart city is; by analysing the smart cities across the world. It also seeks to find out how different approaches to the smart city creation influence the city. This worked based on the ongoing review on Smart Cities that was started in 2014. In particular, it is structured as follows. First, definition of "smart city" are reviewed, next typologies of smart cities were generated by analysing the different types of smart cities across the world. Following this, case studies are reported. Case studies are followed by a reflection. Paper drawn to conclusion following this section by giving research directions to take this research further.

Keywords: *smart cities, future cities, urban planning, city transformations, number of smart cities*

INTRODUCTION

In this critical reflection we are looking to understand whether the smart city solutions are considered as technology projects or part of a holistic planning solution which would lead to smart urbanism. The key question we want to answer is to whether we are adding another layer of complexity to the aging siloed structure of the city systems or whether the utilization of data and technology will prevail a more successful urbanism for the future cities.

Cities

Cities are complex, organic, self-organizing and non-linear systems and they evolve and change constantly. Contemporary cities can be considered as immense numbers of interconnected citizens, businesses, transport and communication networks, services and utilities.

From the beginning of the city life in Jericho (8500-6000 BC) and Catalhoyuk (7000-5500 BC), as Smith (2012, 33) explains, *the fundamentals of human life in the first cities did not differ greatly from ours today. From the love of good food expertly cooked and enjoyed with friends and family, to the need to work and the pleasure of shopping, their daily life mirror ours*. Furthermore, *cities have always been places where innovations in transport, communications media, printing, publishing, the processing information and the creation of knowledge have been concentrated* (Graham 2004). These qualities and the possibilities that city life offers are some of the reasons for the growing population in cities since the beginning. On the other

hand, as Albino, Berardi, and Dangelico, (2015) explains *the metabolism of cities generally consists of the input of goods and the output of waste with consistent negative externalities, which amplify social and economic problems. Cities rely on too many external resources and, as a matter of fact, they are (and probably will always be) consumers of resources*. It can be speculated here that the joys and opportunities of cities also lead to wicked problems such as poverty, pollution, depletion of resources, traffic, congestion, waste, and social exclusion.

Growing populations in cities and their unequal consumption of the world resources have become one of the greatest challenges for cities for some time now. The United Nations predicts, *by 2050 70% of the nine billion world population will be living in cities* [1].

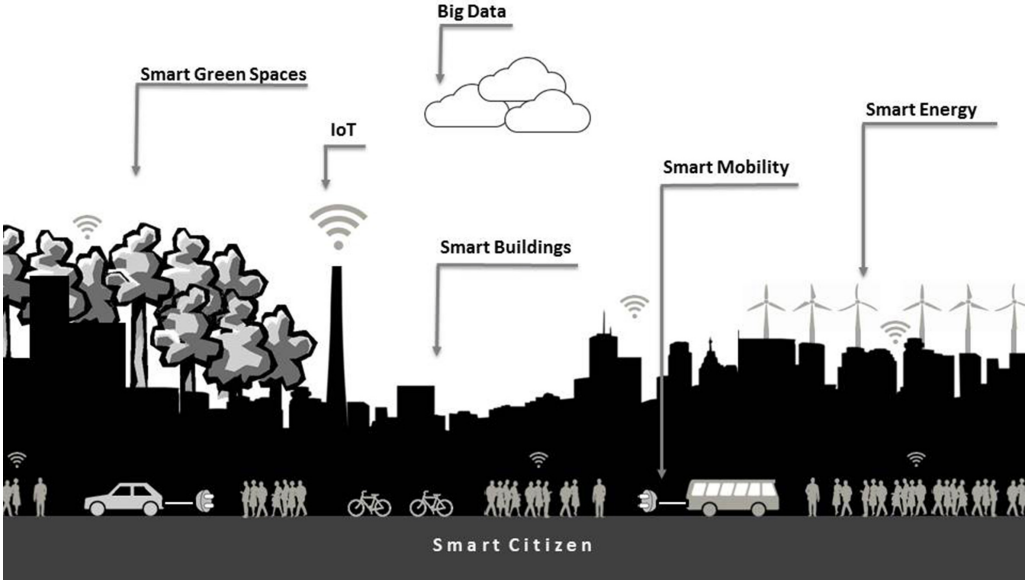
Urban challenges such as planning, economic development, resilient water supply, integrated data and security systems, responsive transport networks, environment protection, sustainable resource management, risk management, sustainable waste management, energy management, education, social care and support, providing local services and facilities are putting immense pressure on the city resources and city governance. Over the several decades, the complexity and the speed of change in cities, amalgamated with the need for integrated solutions, have been presenting major challenges upon local authorities, who traditionally have tackled issues in silos. Like many of the previous urban visions, Smart City concept also tires to tackle the city challenges. This holistic approach is there to enable creation of liveable, just, and sustainable and economically stable places.

Smart Cities

The question of "What is a smart city?" is not an easy one to answer. The answer depends on the where the focus is and who is giving the answer. Although still a definitive definition is lacking, in many aspects this is by no means a terrible void. Smart City concept is wide and many players and notions are involved and therefore capturing all these elements in one definition might not be possible. However, there are numerous definitions in the scientific literature and in governmental reports. For a thorough appraisal of varied definitions Albino, Berardi, and Dangelico's (2015) paper is a great resource. They *analysed several different definitions and clarified that previously technology focused understanding of smart city is changing and the smart city concept is no longer limited to the diffusion of ICT, but it looks at people and community needs*. With this in mind the definition generated by the British Standards Institution (BSI 2014) which focuses on integrating diverse systems namely, physical, digital and human systems is our preferred definition: *Smart city is an effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens*. It is good to point out at this stage that as Gil-Garcia, Pardo, and Nam (2016) explain *being smart is not an end state, but rather can be an enabling condition that my lead to other desirable social, economic, or environmental outcomes*.

It is clear that, data and ICT a big plays part in the smart future urbanism. But equally there are other major concepts contribute towards creation of smart cities. As Neirottio et al. (2014) highlights, *ICT is unable to transform cities without the human capital which brings the liveability of a city to attention*. Angelidou (2014) explains that, *smart cities represent a conceptual urban development model based on the utilization of human, collective and technological capital for the enhancement of development and prosperity in urban agglomerations*. Angelidou (2015) continues to point that *there are two shaping forces of the "smart city" conception: Urban Futures (the past 100 years of visions about the city of the future under the influence of state-of-the-art technology) and the knowledge and innovation economy*. Apart from these shaping forces it is also important to look into the key players in the smart city arena. There are three key players towards the smart city concept: universities, industries, and local government. *The scientific papers and practitioner reports reveal the presence of a triple helix concept of knowledge-society even if each key player has*

Figure 1
What makes a Smart City?



different aims: research and knowledge spreading for universities, business and profit for private companies, local well-being and political consensus for public bodies (Dameri et al. 2016).

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Smart City and Urban Planning

In first account, it is obvious that smart cities, although specifically developed as an idea during the past 20 years, have a long history dating back to previous century's visions about urban futures. Although elusive, the visions were and continue to be an essential part of urban planning and development discipline and they have always been urging to move forward (Angelidou 2015). Urban planning as discipline is changing with the technology driven concepts and tools such as Open Data, Big Data, IoT, urban sensing, volunteered geographic information, and electronic democracy. And these concepts and tools are redefining the city and how to manage and govern the city. These recent explosions of ICT technologies within every aspects of city life also altering the urban planner's job description to where a planner needs to practice smart urbanism with more awareness of the data-rich city governance. *Traditionally, the challenge for urban planners was the generation of meaningful and timely information. Today, the urban planners' challenge is no longer the timely generation of urban data, rather, it is in relation to how much information can be exploited and integrated successfully into the contemporary spatial planning and governance* (Thompson et al. 2106). Luque-Ayala et al. (2016) points out *smart urbanism is the consolidation and expansion of relatively novel ways of knowing and thinking the city*. They continue to tell us that *in the interface between digital technologies and urbanism, the city comes to known through*

data, algorithm, modelling and a combination of visual and media channels. We think there is no doubt that technology plays a fundamental role in making cities smarter however how cities utilizing the technology and the data for the specific needs and requirements for the citizens, is as important as the technology implementation the smart city process.

METHODOLOGY

Since September 2014, data on smart cities, definitions, applications and locations have been collected for this ongoing project. This desktop survey included:

- City resources- city websites, articles with regards to strategies, visions, plans, projects, etc.
- General sources including websites
- Smart City project websites
- Academic books and journals
- Reports from government and non-governmental organization
- Seminar and conference notes, presentations

After gathering data from these resources, sorting and analyses this raw data took place. Initially the total number of smart cities was found out. In this paper, we classed cities as "Smart" even though they might have one smart city project or an initiative and not a "smart city" per se with a view that the smart city is a process rather than an end product. One of the main reason behind this, that smart city term encompasses 3 layers according to Manville (2014) and these layers are *Smart City projects, Smart City Initiatives and Smart Cities (Smart City projects are a sub-category of Smart City Initiatives which in turn are a sub-category of Smart Cities)*.

In order to find out the typologies of smart cities, similar work from previous research were identified in the literature and *six application areas defined by the Centre of Regional Science at the Vienna University of Technology (smart economy, smart mobility, smart environment, smart people, smart living, and smart governance)* (Giffinger et al. 2007) set the foundation for our study (Table 1). Another classification also influenced our work comes from Neirottio et al. (2014) where they classify Smart Cities based on domains and sub-domains (Table 2). Although these various classifications differ slightly from research to research (more at, Lee J-H 2012; Manville 2014; Thompson 2015), the typologies in general cover similar areas.

Smart Economy Competitiveness	**Smart People** Social and Human Capital
Smart Governance Participation	**Smart Mobility** Transport and ICT
Smart Environment Natural Resources	**Smart Living** Quality of Life

Table 1
Six application areas of Smart Cities.

After this initial analysis, compression between the identified typologies from literature and from our survey is completed. Any differences from these guides were noted to report back.

Focus then given to the smart cities itself and more in depth information on some of the countries and the EU were in order to understand the smart city process in these geographic locations since have top most smart city applications and initiatives in the world. Following this section a reflection given followed by the concluding remarks and future research directions.

Limitations

The results of this conference paper have to be interpreted within the limitations of the research methodology and choices that were made by the researcher. Limited number of case studies has several implications. Initially, it is almost impossible to generalize from this sample size. Following this, it should be pointed here that this quantitative research is the initial stages of this ongoing research and consulting all the actors in Smart City developments will make the basis for the qualitative research which will make the second stage of this study. Within the time-frame and scope of the research qualitative research was not possible.

Table 2
Classification of Smart City domains and sub-domains, (adapted from Neirottio et al. 2014).

Domain	Sub-domain
Natural Resources and Energy	Smart Grids Public Lighting Green / renewable energies Waste management Water management Food and agriculture
Transport and Mobility	City logistics Info-mobility People mobility
Built Environment	Facility Management Building Services Housing quality Construction Urban Planning Urban Design
Living	Entertainment Hospitality Pollution control Public Safety Healthcare Welfare and social inclusion Culture Public spaces
Government	e-government e-democracy Procurement Transparency
Economy and People	Innovation and entrepreneurship Cultural Heritage management Digital education Human capital management

RESULTS AND DISCUSSION

As explained previously, by surveying the smart cities across the world we aimed the find out what smart city applications or domains are popular choices to implement. applications

In our survey of smart cities, we have observed 1101 smart cities (proposed, just embarking on the project or classed as smart city already) and examined the available data from these initiatives. This process indicates that apart from the six application areas mentioned above, there are different smart city application types also in operation, for example; Living Labs (Figure 2). It should be pointed here that many cities analysed have more than one smart city application. Also it is important to note that some of cities although they are classed as "smart" in the literature we could not access the types of applications that is in operation for those cities yet. However, overall 1707 smart city applications from 1101 smart cities were available to analyse. Out of these applications 31% based on Living Labs, 22% on Smart Government, 16% on Smart Environment, 13% Open Data, 11% on Smart Mobility, 7% Smart Economy, 5% Smart Living, 4% Smart People, 1% on Digital Initiatives, and rest of the 2% of the applications were a combination of Smart City from scratch, education, health, innovation, planning, public safety, smart infrastructure (Figure 2).

It can be said that the "smart city solutions" mainly brought by big IT companies initially and in general they are created for a specific city or a community. However as Chourabi et al. (2012) explain, it is also clear that the smart city projects *have an impact on the quality of life of citizens and aim to foster more informed, educated and participatory citizens and smart city initiatives allow members of city to participate on the governance and management of the city and become active users*.

80% of all smart city applications in our survey came from Chinese (20%), European (54%) and Indian (6%) cities. For this reason examples from some of these locations are further examined.

Approaches to Smart City Developments

Our Smart City survey indicates that there are two different approaches to develop a smart city. A typical top-down approach can be observed in the India's Smart Cities Mission prepared by the Government of India, Ministry of Urban Development in June 2015 [2] and the Chinese Government's latest China's Five-Year Plan (13th Five year plan: 2016-2020) encompasses the National New-type Urbanisation plan for the same period. The previous Five Year plan had also planned investment in Chinese Smart Cities agenda. However in Europe although there are some top-down approaches, in city level Europe has more of a bottom-up approach for development of smart cities.

China. China is one of the countries that adopted top-down approach. *In January 2013, the Ministry of Housing and Urban-Rural Development (MOHURD) formally announced the first list of national pilot Smart Cities* (Yang et al. 2016) and *as September 2013 total*

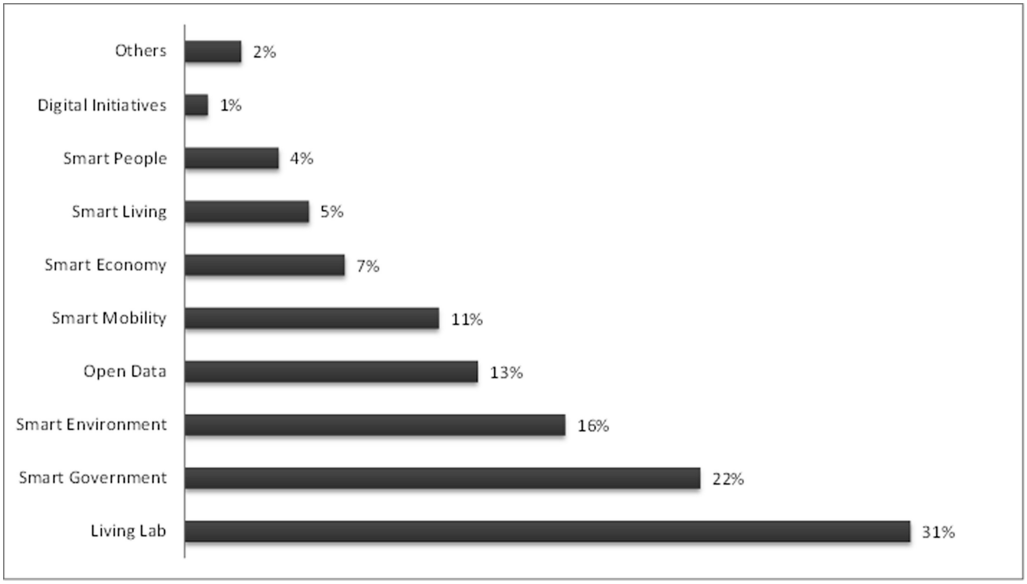

Figure 2
Smart City
Application types.

of 311 cities in China have proposed or are embarking on smart city developments, including all cities above the sub-provincial level, 89% cities at the prefectural level and above, and 47% cities at the country level and above. The 12th Fiver plan budgeted to spend approximately 220 million Euros on its Smart Cities project (Yanrong and Whyte 2014). It is speculated that the Chinese government is more focused on the technological issues in developing Smart Cities. With this understanding in mind, as Li, Lin and Geertman (2015) explains *the technology is seen as the central importance, and 'smart city' can be divided into four layers, that is, sensor layer, network layer, platform layer and application layer*. Two types of funding approaches are set for Chinese Smart Cities: Fully supported by government or PPPs (More information can be found at Li et al. 2015). *There are currently no laws and regulations directly governing Smart Cities in China. The Chinese government has, however, introduced a number of guidance notices: Notice to Speed up the Project Implementation of Smart Cities, National New Urbanisation Plan (2014-2020), and Guidance on Promoting the Sustainable Development of Smart Cities* (Yang et al. 2016).

India. Smart City Mission is the one of the most comprehensive selection process of developing Smart Cities. *The Mission's objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model which will act like a light house to other aspiring cities* (MoUD, 2015). Each aspiring city needed to compete in two stages of the selection process. These are: Stage 1 of the competition: Shortlisting of cities by States and Stage 2 of the competition: The City Challenge round for selection. The proposals needed to be modelled on one of the strategic components, namely: city improvements (retrofitting), city renewal (redevelopment), and city extension (greenfield development) and a Pan-City initiative in which Smart Solutions are

applied covering larger part of the city. The implementation of selected smart city projects will run by body (Special Purpose Vehicle - SPV, a limited company in which State ad Urban Local Bodies 50:50 equity shareholding). This organisation will plan, appraise, release funds, implement, manage, operate and evaluate Smart City development projects [2].

Europe. Our survey showed that more than 78% of the smart cities in Europe came from 8 countries (Germany 16.46%, UK 13.01%, Spain 12.80%, Italy 9.96%, France 8.33%, Poland 8.13%, Romania 5.08%, Netherlands 4.67%). Rest of the %21.5 comes from 21 different countries in Europe (It should be pointed here that percentages comes from the amount of Smart City applications in that specific country and does not take into account the size and population of the country in this initial analysis).

The European Innovation Partnership for Smart Cities and Communities was launched in 2013, and it seeks to establish strategic partnership within the Smart City arena and aims to boost the development of smart technologies. EU Policy Framework for Smart City Developments based on the EU 2020 goals (20% reduction of greenhouse gas emissions from 1990 levels, 3% EU's GDP to be invested in R&D and innovation, 75% of 20-64 year olds in work, and 20 million fewer people in or at risk of poverty and social exclusion). When looking at the member state level and at the level of individual cities and regions, it is not surprising to find out an abundance of approaches to development and operation of smart cities. This strong degree of independence of EU Communities results in very different solutions being implemented with respect to any aspect city modernisation. It is also makes it somewhat difficult to create national or EU level approaches to a common and coherent smart city development. However this lack of top-down decision making authority is offset by the possibility to incentivise and encourage the cities follow targets developed on EU or national level by way of providing additional support (Yang et al. 2016).

There are many city level documentations such as VIENNA 2050: Ensuring Quality of Life Through Innovation - Adopting the Smart City Wien Framework, and under the UK Goverment's Future of Cities Foresight project; City visions: Newcastle 2065, City visions: Birmingham and West Midlands 2060 are some examples from UK.

City Level Cases

Although many to chose from, for this paper two cities selected from China and Europe since these locations where the main contributors towards the total number of smart cities we have surveyed originally.

Bristol, UK.

- UK's eight largest populous city.
- Bristol, in May 2016 were selected as the UK's leading smart city, sharing this spot with London.
- Smart City Bristol is a collaborative programme between the public sector, business and community and led by the City Council.
- Aim: Use smart technologies to meet City's targets to reduce CO_2 emissions by 40% by 2020 from a 2005 baseline, as well as the city's wider social and economic objectives
- Drivers are based on economic, environmental, efficiency and transparency.
- Funded through sources such as the City Council budget and funding from the European Commission, UK Government, Technology Strategy Board, UK Research Councils and private company funding.
- Investments: Metro bus, cycle city, enterprise zone, smart parking, broadband connections solutions, smart energy, smart data, open data, city data platform, Apps, smart mobility.

Beijing, Haidian District, China.

- Northwest of Beijing, the Haidian District is an important area and it is famous for its science and technology, culture, education and tourism.
- Smart Haidian Top-level Design, Smart Haidian Development Program, and Smart Haid-

ian Construction Program brings together the overall programme for smart city.

- Aim: establish smart administration, smart parks, smart urban areas, smart homes and IT industry HUB
- Smart Haidian is built under the full responsibility of Haidian District Government, with Haidian's smart city industry alliance, project management units, consulting and design units.
- Haidian invested about 300 million Yuan annually in 2011 and 2012 and 500 million Yuan in 2013, which mainly comes from district government financial allocation.
- Wireless and fiber optic and other basic networks and data centers in Smart Haidian are shared by different projects. ICT infrastructure is shared via a cloud platform. Haidian spatial data sharing platform is built for the Haidian GIS technology and other business applications.

Information on the sample cities are gathered from, Yang et al. (2016), [3], [4], [5].

REFLECTIONS

Increasingly, neither state intervention, nor neoliberal market solutions are seen as satisfactory approaches to urban planning challenges. The former is criticised for its managerial inefficiency while the latter is criticised for its neglect of external and community interests (Thompson et al. 2016). We believe that smart urbanism shapes and manages complex and multidimensional places by engaging multiple stakeholders. This integration enables better design, delivery, governance and maintenance of cities.

- As (Albino et al. 2015) points out *the concept of the smart city is far from being limited to the application of technologies to cities*. Cities and "smart" cities for that matter, is for citizens and therefore their involvement is a top priority.
- Cities consist of many systems that interact with each other continuously. Without a strategic vision, infusion of intelligence to these various systems in soiled fashion is not the correct approach. However these one system solutions if they are applicable can act as demonstrators and should be utilized as part of the whole smart city / future city vision.
- Biggest numbers of smart cities comes from locations that have either a direct top-down approach (China and India) or an in-direct top-down approach (Europe).
- Achieving the first implementation stage is only the part of the problem. Barriers such as moving beyond pilots, securing further finance, digital infrastructure, human capital (education and establishing understanding) and most importantly an overall vision to take these projects further needs to be considered.
- Cities also need to consider the vulnerability of complex technological processes to the many unintentional and / or malicious interventions.

Whether we are adding another layer of complexity to the aging siloed structure of the city systems or whether the utilization of data and technology will prevail a more successful urbanism for the future cities is still remain to be seen since many of smart city initiatives are new and therefore it is hard to assess the outcomes yet. However, it should be pointed here that smart city concept is not only for creating new holistic systems but also it is about improving current systems as well.

The majority of strategies for becoming "smart" are not something that can be achieved here and now but they imply a strategic approach to fulfilling a long-term aspiration The vision about the city of the future is an essential driver of the smart city discourse, be it within, or out of immediate grasp (Angelidou 2015). Recent literature that explains *the pillars of the smart city consist of connections (as networks and technological infrastructures), Open data and Sensors (including citizens able to actively participate in a bottom-up way in city activities)*. However we believe citizens will needs to be considered as one of the fundamental support

mechanism for a successful smart city development (Figure 3).

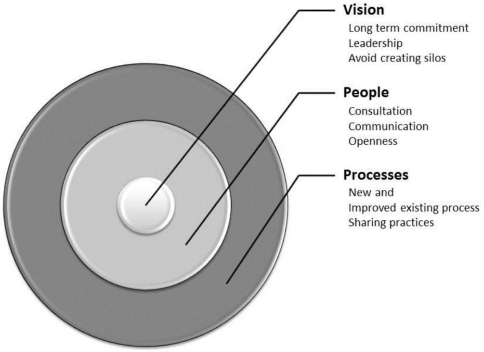

Figure 3
Smart City Framework.

CONCLUSION

Points to consider

Smart city framework should have vision, people and processes as the main drivers.

Political willingness and long-term commitment is one of the key factors needs to be taken into account. Strategic vision is profoundly related to the long-term commitment and will provide continuity beyond routine election related changes in cities.

Tackling common and local challenges should be the priority and these challenges needs to have a direct relation to the demands from citizens, cities, regions and the country. Local strengths should also influence the project selection process.

Leadership with professional mechanisms to coordinate and consolidate needs to be in place and this needs to be backed up with concrete strategic objectives for the city.

The impact of the smart city work on the city should not be underestimated. Necessary precautions in the form of public consultations, openness and processes etc. need to be in place. And financial and managerial challenges need to be considered at all stages.

Instead of creating another new silo for the city processes, the understanding of that the smart city is not a standalone platform needs to be one of the first things to be established.

Smart City should not be only considered as creating new solutions/systems but also improving the existing processes with the knowledge and understanding established from these new process, applications etc.

Balance between the data requirements and data privacy needs to be well-adjusted and considerations needs to be taken on a case by case basses until standards established.

Solutions, although cities are different and can have varied problems, should be replaceable.

Further Research

Future research will focus on maintaining the collecting of data on smart cities across the world however apart from the quantitative analysis more in depth qualitative analysis will be conducted to further this research.

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