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Towards smart sustainable cities vision and challenges

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Abstract

The sustainable smart city is primarily a concept and there is still not a clear and consistent definition among practitioners and academia. In a simplistic explanation, a smart city is a place where traditional networks and services are made more flexible, efficient, and sustainable with the use of information, digital and telecommunication technologies, to improve its operations for the benefit of its inhabitants. Smart cities are greener, safer, faster and friendlier. The different components of a smart city include smart infrastructure, smart transportation, smart energy, smart healthcare, and smart technology. These components are what make cities smart and efficient. Information and communication technology are enabling keys for transforming traditional cities into smart cities. The two closely related emerging technology frameworks Internet of Things and Big Data make smart cities efficient and responsive. The technology has matured reasonably to allow smart cities to emerge. However, there is much need in terms of physical infrastructure, and renewable energy to make the majority of cities worldwide smart. Even today, there are not enough studies on how regulations collaborate to make cities smarter and more sustainable. This paper contributes to filling this gap by investigating the main guidelines of the new City Statute that have the greatest potential to contribute to having smarter and more sustainable smart cities connect people and places using innovative technologies such as Data Mining (DM), Machine Learning (ML), big data, and the Internet of Things (IoT). More recently, the challenges posed by the increasing urbanization experienced by most countries have increased societal demands for more efficient and sustainable urban services, in a digital revolution environment and more sustainability. The study aims to identify the main Data Mining techniques used in the context of smart cities and how the research field of Data Mining for smart cities. To prioritize the guidelines of the contemporary City, the methodology used the strategies of smart city and significant applications of nonlinear analysis to make integration with the main principles of sustainability to enhance the concept of the sustainable smart city so The systems are under increasing environmental, social and economic pressures for sustainable prosperity.

Keywords: Sustainable cities, smart city, smart transportation, physical infrastructure, renewable energy data mining, machine learning, big data and bibliometric
2020 MSC: Primary 90C33; Secondary 26B25

Introduction

Smart city brings enormous opportunities and exciting challenges. In general, a metropolitan area can be considered as smart when city operations and services such as healthcare, education, transport, parking, and electricity grid are

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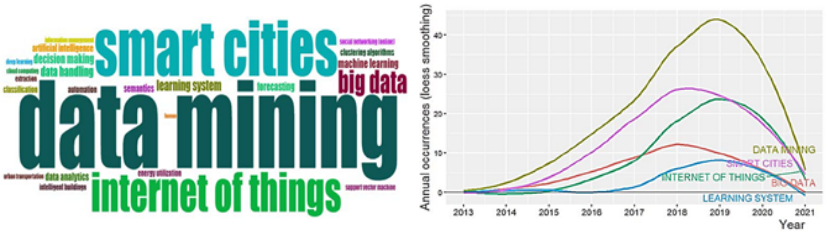
supported through information and communication technology (ICT) infrastructure in order to facilitate efficiency and ease of operation. Some valid examples of such services would be looking for a job, applying for a driver 's license, buying of car and property, change of the address, request for a passport, start of a new business, reporting of a crime, declaration of income taxes, seeking health services, and so on. All such services require execution of several services under an orchestrated coordination. The smart city design must be citizen-centric. Despite the complexity of the city's systems, the architecture must bring benefits to the people regardless of their ICT abilities. The primary goals of the smart city include, offering digital means for supporting social needs in all daily transactions, to adapt the citizens to the notion of the information society and to collect information from the public departments and citizens in order to support sustainable growth of the city. Above all, development of smart city will give way to implementation of a citizen-centered public administration, where corruption phenomena and time-consuming bureaucratic procedures are eliminated. There are many components of a smart sustainable city and different components have been presented in the figure. The components of a smart cities include the following: smart infrastructure, smart buildings, smart transportation, smart energy, smart healthcare, smart technology, smart governance, smart education, and smart citizens. A brief discussion of these components will be presented in the subsequent sections. Different smart cities have different levels of these smart components, depending on their focus.

Problem:

Cities around the world have a tendency to develop smart city policies. An ongoing urge is to integrate the Internet of Things (IoT) in every aspect of urban life. This new paradigm and the rapid advancement in technology have led to the emergence of different types of smart cities with different roadmaps for such development. The newly initiated cities have the advantage of a tabula rasa initiation, but the old cities face difficulties in adapting.

Content:

The frequency of words in a text can be studied by (Zipf's law) , which has been considered as a generalization of both (Lotka's and Bradford's laws). According to Zipf's law, at its simplest, the vast majority of text words appear only a few times, and a limited number are extremely frequent [6]. The most frequent terms that appeared as "keywords plus" in the articles are "data mining", "smart cities", "internet of things", and "big data". Keywords plus are words or phrases that frequently appear in the titles of an article's references but are not included in the title of the article itself (Figure1 (a and b)) [9].



(a) Word cloud

(b) Word dynamic graph.

Figure 1

Definitions:

Smart city: Before (year 2000)

Smart City: A city connecting the physical infrastructure, the information-technology infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city. Smart city is a technologically modern urban area that uses different types of electronic methods and sensors to collect specific data. Information gained from that data is used to manage assets, resources and services efficiently.

Sustainable city: A sustainable city (eco-city, or green city) : is a city designed with consideration for social, economic, environmental impact. **Smart sustainable city:** After (year 2000)

A smart sustainable city is a green city that uses renewable energy, produces zero waste and is healthy & safe to live in by using information and communication (ITC) and internet of thing (IoT). and other means to improve quality of life efficiency of urban operations and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects. This city follows the following

management practices that aid in its objective of sustained green living. [4] The Smart City elements are: (Figure.2)
1-Smart Governance.
2- Smart Environment.
3- Smart Living.
4- Smart People & Education.
5- Smart Mobility.
6- Smart Economy.

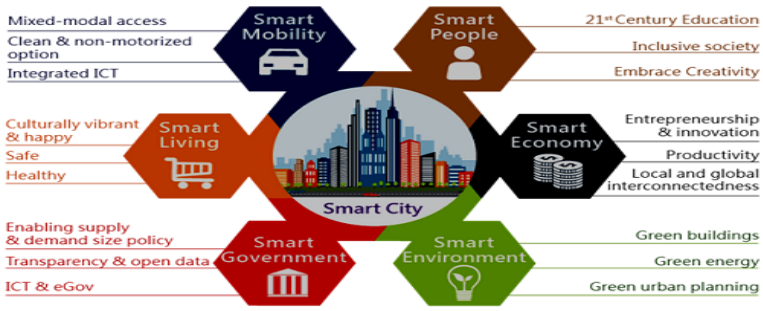


Figure 2: The Smart City elements

1 Smart Government:

The city is a microcosm of the major challenges and opportunities facing the planet today-intensified and accelerated. Here, all man-made systems come together and interact with one another. As crime becomes smarter and high-tech, public safety and security agencies match-up. Law enforcement officers on the ground often use drones, wearable computing, facial-recognition, and predictive video to fight crime and protect public safety. Data plays an increasingly important role in crime prevention as agencies try to preempt crime by tapping into all streams of data including social and crowdsourced data, through the following trends: Enabling Supply & Demand Side Policy, Transparency & Open Data and ICT & E-GOV and all these using: Enabling supply & demand size policy, Transparency & open data and ICT & e Gov. [4]

1.1 City command center:

Integrated Utilities Management and Advanced Traffic Management:
Smart street lighting & traffic light. (Figure.3) also crowdsourcing, emergency apps.
Electronic monitoring and Intelligent Transport Systems (ITS) (Figure.4)

Figure 3: Smart street lighting & traffic light [13]

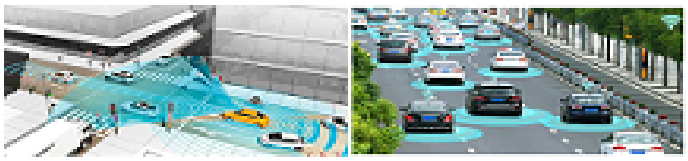


Figure 4: Intelligent Transport Systems (ITS)

1.2 Interactive Community Services and cyber security: (Figure.5)

The smart city contains three phases, During the first phase, real-time data streams are generated by hard and soft sensing. These data should be processed in phase 2 to gain useful information able to support decision making. third phase, knowledge is transformed into actions in the city.
- Drones for risk assessment and Identifying gunshots.
- Augmented security screening.
- Data-based crime prevention and predictive policing.
- Smart cybersecurity and Cctv camera everywhere
- In every gate, specially trained policemen will be present

Figure 5: Smart cybersecurity

1.3 Municipal and Public Amenities:

City administration and System to detect problems of water and electricity. (Figure.6)

Figure 6: City administration & System to detect problems.

2 Smart Environment

For a Smart Sustainable City to live up to its name, using technology to foster sustainable growth is essential. This means leveraging technology to maximize the efficient use of precious resources and encourage sound choices by all players. This includes not only city-owned buildings, but businesses, universities, hospitals and non-profits and individual citizens. This means likely leveraging sensor technology, behavioral economics, and gamification to alter not only physical infrastructure, but to encourage positive resourcing decisions, through the following trends [12]:
- Smart metering.
- Distributed energy resources. (Smart Energy) (Figure.7)
- Responsive devices.

- Lower usage through gamification.
- Self-healing grid.
- Hyper-localized environmental enforcement.
- Embedded environmental sensors.
- Pollution detection.
- Leakage detection.
- Automating water for agriculture and municipal use.
- Just in time waste collection.
- Zero waste.
- Smart Public building. (Figure.8)

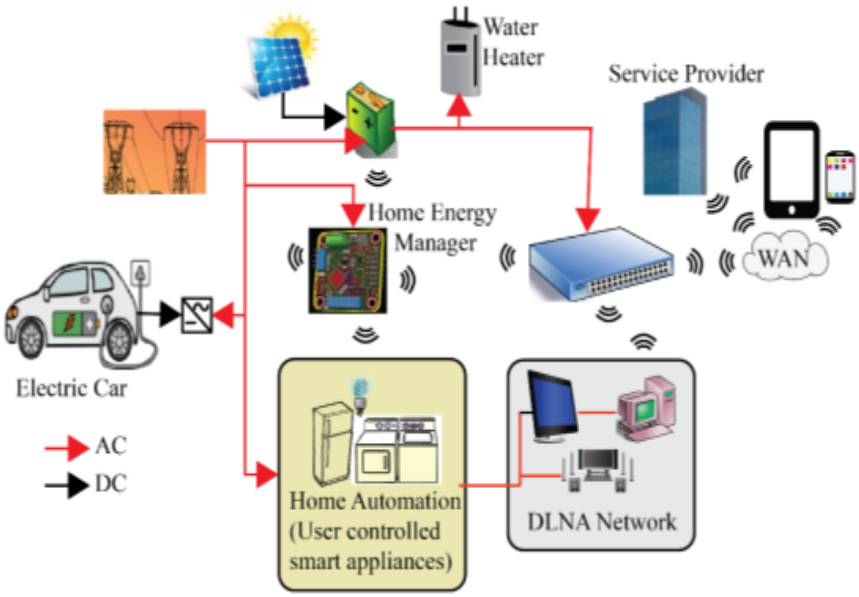


Figure 7: Illustration of a Smart Energy System.

2.1 Data Mining Technologies for Smart Cities

city application, the production of analytics can lead to advanced insights, a better understanding of city phenomena, and supports the design of evidence-based urban strategies and innovation. Searching for interesting patterns and correlations in the public-service facilities of developed cities using a DM approach has gradually become a significant area of research. The extracted patterns can be used to plan layouts or arrange new facilities in cities. Advancements of big DM technologies can support, explore and discover environmental and societal changes, including how people go about their life, behavior, and preferences; social trends, and public opinion. DM and ML are vital technologies for data-centric applications for smart cities. [9]

2.2 Smart Green Public Buildings: (Figure.8)

Smart Technology and the sustainability of all types of buildings.

3 Smart Living:

A Truly Smart City will advance the concept of Smart Living, a variety of approaches that leverage technology to enhance the daily living of residents. Cities can help promote tools and technologies that help citizens monitor their health, wire their homes to improve energy use, or deliver more tailored human services. Coupled with new data approaches such as predictive analytics and insights from the field of behavioral economics, Smart Living encourages citizens to make better choices in their own lives, through the following trends: [8]
- Quantified self for citizens.
- Wearable devices prevent substance abuse.

Figure 8: Illustration of a Smart Energy System.

- Geospatial analytics and hot-spotting.
- Predictive analytics in the community.
- Smart homes for seniors.
- Match energy use to occupancy.
- Homes Operated by Electronic Devices.
- Intelligent feedback.
- Smart Healthcare. [3]

As shown in (Figure.9)

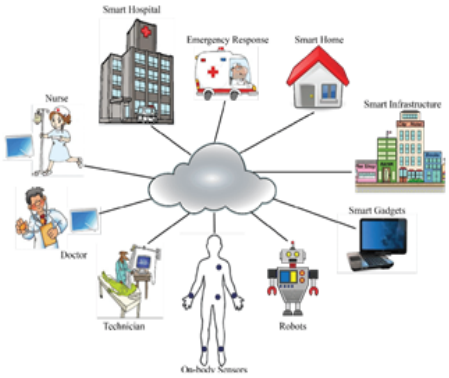


Figure 9: The Idea of Smart Healthcare.

4 Smart People & Education:

(Figure.10) Smart People start through Education enabled by virtual learning, digitization and augmented reality transforms the way we learn. Unbundled, personalized, and blended education is becoming more prevalent. Augmented by rich data and analytics the next-generation teachers can adapt their learning and counselling to maximize student success. The focus shifts from digital content in the classroom (Figure.11) to real-world experiential learning where students, teachers, and real-world experts connect—paving the way for lifelong learning to be Smart People, through the following trends: [4]

- Digitization and unbundling of education.
- Blended learning.
- Personalizing education.
- Lifelong learning. [8]
- Peer-to-peer learning.
- Classroom of the future. - Adaptive learning & counseling.
- Rise of the hybrid teacher.
- Rethinking career pathways.
- School-business collaboration.

Figure 10: smart people using smart facilities

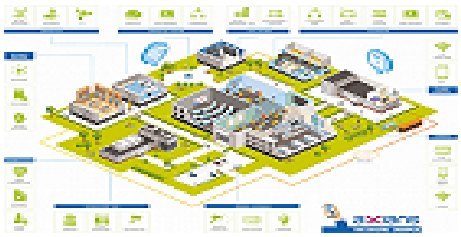


Figure 11: The Idea of Smart People & Education

5 Smart Mobility:

Mobility becomes as much about bits and bytes as it is about the physical infrastructure we walk, bike, drive and ride on in a smart city. Sensor-powered dynamic pricing, mobile-enabled collaborative transport models like ridesharing, and social transport apps help tackle traffic congestion in major urban corridors. Mobility emerges as a service which relies on a digital platform that integrates end-to-end trip planning, booking, electronic ticketing, and payment services across all modes of transportation, public or private, through the following trends:
- On-demand car services and carpooling with GIS controlling. [13]
- Multimodal transportation planning solutions.
- Universal travel accounts.
- Self-driving connected cars.
- Shared self-driving cars.
- Dynamic pricing.
- Usage based car insurance.
- Smart parking.
- Smart traffic control.
- Experience enablers.
- Machine Learning (ML) Algorithms
- Consumption-based dynamic taxes.
- The Internet of Things (IoT) (Figure.12)

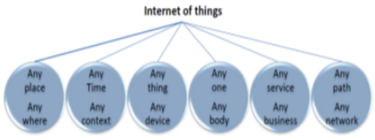


Figure 12: The Internet of Things (IoT)

5.1 The Internet of Things (IoT) [5] (Figure.13)

enhancing the empowerment using internet of Things (IoT) via three main pillars of the society i.e., health, education and wealth embedding with smart devices, sensors, web and mobile applications. This paper has the block diagram, functionality of low cost and effective solutions like "Smart Health Monitoring", "Smart Education", and "Smart Wealth System" to provide equal services, opportunities for everyone on the planet. This is one of the best solutions which shows how to design an efficient system for the society with grouping present technologies, sensors around us like smart wearables, mobile applications, web applications and artificial intelligence. [7] (Figure.14)

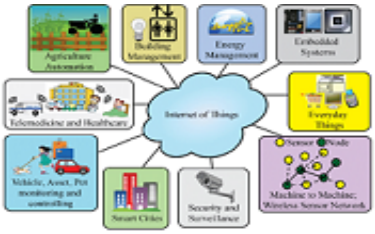


Figure 13: The Internet of Things (IoT)

Figure 14: (IoT) enabled Smart City.

5.2 Machine Learning (ML) Algorithms

Machine learning algorithms are algorithms created using computer programming. These algorithms read input data sets and analyze them. Based on this analysis, these algorithms predict output values. ML algorithms keep these predictions within an acceptable range of values. ML algorithms are capable of handling a large amount of data, as well as providing features such as frequent pattern mining, anomaly detection, predictive modeling, and optimization that can lead to better situational awareness, more efficient, dynamic, and adaptive control. Depending on the characteristics of the specific application and on the requirements of the use case, some algorithms perform better than others. Some ML algorithms have aimed at improving matching time and accuracy, e.g., DL for information retrieval and multimodal interaction. [9]

Top 8 Machine Learning algorithms explained in less than 1 minute each (Figure.15)
In this blog, we will discuss the top 8 Machine Learning algorithms that will help you to receive and analyze input data to predict output values within an acceptable range. [14]

1. Linear Regression
2- Logistic Regression
3- Decision Trees
4- Random Forest
5- K-Nearest Neighbor
6- Support Vector Machine
7- K-Means clustering
8- Naïve Bayes (Figure.16)

Figure 15: Robot humanoid using tablet & computer (Big data analytic and Machine Learning algorithms)

6 Smart Economy:

The smart economy of the future is both seamless and dynamic. The growing ubiquity of digital and exponential growth in other technologies sees government regulatory machinery becoming nimble and responsive. While advances in technology help smart cities can streamline government procedures like permitting and licensing providing a seamless

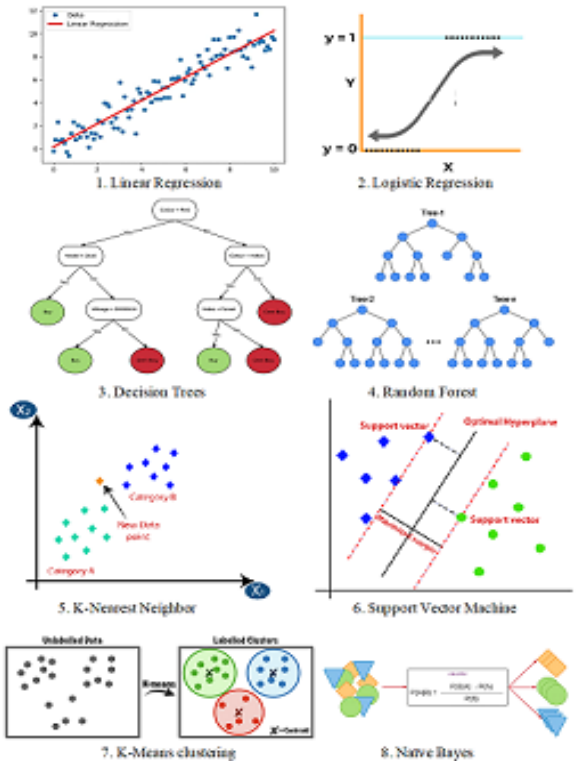


Figure 16: Top 8 machine learning algorithms explained

experience to businesses, through the following trends: (Figure.17)

- Exponential innovation creates regulatory challenges.
- Outcome-based regulation.
- Human-machine combination.
- Treating businesses as customers.
- Open data to facilitate business.
- Matching training to skills required.
- Innovation labs for experimenting new opportunities.
- High landmark buildings for offices of companies.
- Citizen regulators.
- Streamlining licensing.
-The rise of business ecosystems.
- The open talent economy.
- More job opportunities.
- Maker Economy.
- The emergency of the idea of the smart city ought to be seen in the backdrop of the need to contain corruption and meet the requirements of the adequate & efficient service delivery in urban areas using information and digital technologies. The success of the programs will be judged by its power to transform the life of the people, and their ability to reduce growing inequality in our society. So the smart city challenges are :

-Small portion of ICT in new city development.
-Technology changes too fast.
-Too many stakeholders.

Figure 17: The smart economy of the future is both seamless and dynamic

Guide line of successful smart city:

Given the diverse applications of city "smartness", this paper compiles examples of successful smart city solutions in the following key themes: governance and policy, environment, society living, Mobility, infrastructure and services, and business and economy. (Figure.18) & (Table 1)

Table 1: Key themes and issues of successful smart city solutions

Theme	Smart Governance and Policy	Smart Environment	Smart Living & Society	Smart People & Education	Smart Mobility, Infrastructure & Service	Business & Economy
Issues	Enabling supply & demand side policy	Air Pollution Prevention	Public Safety and Security	21st Century Education	Mixed models access	Urban Business Environmental productivity
	Transparency and open data	Land Protection and Re-habitation	Health Provision	Inclusive Society	Mobility in Transport and Geographic Accessibility	Private Sector Investment
	Citizen Engagement	Water Protection and Rehabilitation	Access Usage and Completion of Education	Enhance Creativity	Integrated ICT Connectivity	Development of a Competitive Economy
	City Operations and Finance	Biodiversity Protection and Rehabilitation	Culturally vibrant and happy	Education, Health, Social, Community & Recreation	Energy / Water / Real Estate / Waste	Local and global interconnectedness
	ICT & eGOV.	Green Urban Resilience and Adaptation to Climate Change	Social Inclusion And Demographic Change		Class A cars – motorized option	Entrepreneurship & Innovation

Figure 18: Successful smart city solutions.

Case studies from cities around the world were collated for each theme, including cities that successfully implemented projects and expanded them beyond the pilot stage. These examples include projects that have leveraged leading innovations and technology and show cities that have done more with less by maximizing use of resources to meet the needs of their citizens, the environment and the economy. Each case study was selected based on the following criteria. Namely, the project:
– Can be replicated by other cities, within each city's context.
– Is self-sustaining and has successfully progressed from a pilot to a scaling stage.
– Identifies costs and benefits clearly, and those that can be monetized.
While not all these criteria are measurable, the focus has been on examples that successfully transformed from a pilot project and that present sustainable, scalable and replicable solutions to specific city challenges [11].

The Platform Economy – Amsterdam, the Netherlands (Figure.19)
What : To ensure the public can trust the platform economy in the City of Amsterdam, the city has been leading audits and oversight activities (algorithm audits, privacy audits) to restore trust among users.

Why: The rise of the platform economy has introduced a convenient way to match those in need of services to those who offer them. Public trust in platforms, however, has been damaged and in an effort to restore this trust, the city has been undertaking audits or oversight activities.

How: As a part of its digital agenda, Amsterdam has developed a standard for auditing algorithms together with universities and industry. In the near future, the city will ask companies that operate in Amsterdamto submit algorithms for auditing. Amsterdam is assessing 25 of its own algorithms to ensure the methodology is suitable to apply in permits, concessions or contracts with private-sector parties.Together with the United Nations, the European Union and the national government, the city will put the algorithms auditing standard in a declaration, Cities for Digital Rights, to scale up. Parameters are categorized as honesty, safety, inclusivity and privacy.

Scale: Amsterdam has hundreds of platforms. Under A Digital City for and by everyone agenda, the algorithms used by the city were audited by an independent party in 2019..

Figure 19: The Platform Economy – Amsterdam, the Netherlands

Harnessing City Data – Singapore (Figure.20) The smart city initiative of Singapore originated from Smart Nation Vision established in 2014 which seeks to harness ICT, networks and data as a response to growing urban challenges of the aging population, urban density and energy sustainability. With its legendary infrastructure, technical advancement and the quality of human resources, Singapore's smart services are expected to be highly advanced. So far, the most developed smart services in Singapore is the Intelligent Transportation System (ITS) with history of more than 10 years, as well as e-government which has been incubated since the early 80s. Smart Nation Vision includes a broad spectrum including smart transport, security, energy, building, education, health, and many more, and some services have been launched as trials while others are on their planning stage. Singapore provides an interesting unique case of an entire nation being developed with utilization of highly advanced smart systems and a new form of data sharing platform among various agencies that operate in a discrete manner [10]. What : Singapore has been harnessing data to enhance services and create economic value by leveraging a combination of government and private-sector data in a citywide data platform.

Why: This effort supports better decision-making and planning in six pilots, including health. Singapore's growing elderly population requires services to support independent living and quality care. [10]

How: ConnectedLife's home monitoring solution provides insights to health providers, the insurance industry and government. The solution combines smart technology (IoT, such as motion and sound sensors, data analytics and AI), 24/7 personal assistance and customized insurance coverage from the insurance provider Aviva. It provides caregivers with real-time information and insurance companies with better data, and allows families to protect their elderly members. The solution was developed using DEX

Scale: Harnessing City Data and combining private-sector data sets with government data to enhance services and create economic value. Innovative cities are creating citywide data platforms to provide data sets to develop practical use cases for analytics and AI applications.

Figure 20: Harnessing City Data – Singapore

Dubai Blockchain Strategy – UAE (Figure.21) Dubai is the first city in the world to conduct applicable Government transactions via Blockchain by 2020

What: The Dubai Blockchain Strategy aims to make Dubai the first blockchain city by 2020. It entails more than 20 public- and private-sector use cases from eight sectors.

Why: Multisector, multiparty use cases are specifically selected to benefit most from blockchain technology due to their need for third-party elimination, transaction ledgers and smart controls creating transparency and efficiency.

How: City-level governance is achieved through a joint public- and private-sector council, with blockchain policies developed for compliance and guidance. Use cases are selected through multistakeholder engagement and ideation. An agile process is applied for prototyping and lean design thinking. In addition, a PPP model is leveraged for implementation. Blockchain was identified as a strategic sector for government efficiency, economic sector creation and international leadership. The Global Blockchain Challenge was undertaken, enabling new start-ups in the city to solve real urban challenges in Dubai.

Scale: To scale blockchain, over 20 use cases were identified through multistakeholder engagement and participation. Two pilots were initially identified and delivered as quick wins (digital payments reconciliation and Dubai land title deeds). Scalable and phased technology implementation provided as BaaS (Blockchain as a Service) to city entities created significant operational efficiencies. Implementation of parallel use cases was enabled on the blockchain platform. [2]

Figure 21: Smart Dubai Blockchain Strategy

Table 2: Key themes and issues of smart cities case studies

Conclusions:

Cities are undergoing rapid digital transformation and are experimenting with inclusive and innovative models to integrate Fourth Industrial Revolution technologies into their programs, infrastructure, services and governance. A city becomes smarter with the advance of digital infrastructure that enhances the connectivity between physical space and city management systems, as well as the communication channel between citizen and local government. Through big data analytics and IoT, a new urban social contract is gradually formed between local government, businesses and individual citizens. The actuation feedback system further enables each actor to become part of the solutions to urban challenges, as well as end users themselves. So all cities challenge small portion of ICT in new city development, Technology changes too fast and too many stakeholders, so all results may be changed from year to year. (Figure.23)

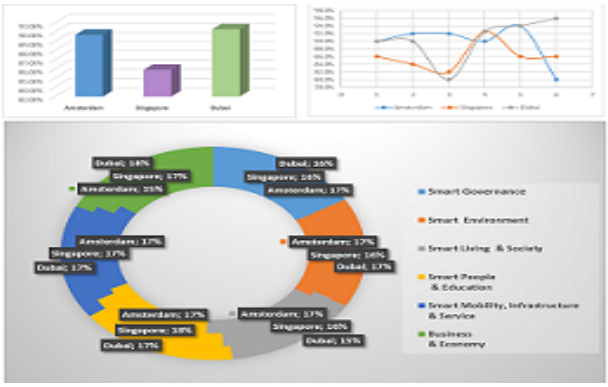


Figure 22: Key themes and issues ratios of the 3 smart cities case studies

Recommendations:

- A Smart City is the integration of technology into a strategic approach to sustainability. 21st Century has brought with it a new global trend of "sustainable urban development" and this concept adds new dimensions to urbanization which require a quick need to upgrade existing cities. The concept of a smart city is a relatively new one. Throughout the years, with the significant contribution from various technologies like computer science, information technology, remote sensing, advance multimedia world etc.

- A smart sustainable city is an environmentally and conscious city that uses information technology (IT) to utilize energy and other resources efficiently.

- The concept of smart sustainable city was born to provide improved quality of life to citizens to live in sustainable city. The key idea is to integrate information system services of each domain, such as health, education, transportation, power grid etc., A city is a system of systems with a unique history and set in a specific social and environmental context. For a city to prosper, all the key city systems need to work together, by utilizing all of their resources to overcome the challenges the city faces. The "smartness" of a city describes its ability to bring together all its resources, to effectively operate with maximum possible efficiency to fulfil the purposes it has set itself. The smart city is a concept and a variety of definitions exist among academia and practitioners. A smart city can have one or more smart components, including smart transportation, smart grid, smart health care, and smart governance. The Internet of Things (IoT), cyber physical systems (CPS), and Big Data are key technologies in the context of information and communication technology (ICT) critical for the implementation of smart cities. Smart cities with minimal implementation and operation cost are the keys for long-term sustainability. There are several smart cities with some form of smart components operating at present at various parts of the globe. The need for smart cities is increasing day by day with the increase of population as earthly resources are limited. [1]

- Uses physical infrastructure more efficiently supporting strong and healthy economic, social, cultural development.

- Reduce usage of environmental capital and support smart growth.

- Promotes the use of information and communication technologies.

- Provides High quality of life [1].

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