Future Cities and Environment

Smart Dimension of Sustainable Urban Form

TECHNICAL ARTICLE

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ABSTRACT

The rise of Information and Communication Technology, the spread of sustainability and urbanisation are among the three most unprecedented global trends in their size, impact and evolution, and will likely radically change our world. The world is expected to become largely urban and computerised in just a few decades.

The global drive to integrate technology with the city to improve the functioning of the city's various systems and urban areas is confirmed by numerous studies and research on the topic of information technology and urban communication ICT. Still, mostly in the context of smart cities (SC), as for SCC sustainable smart cities, there needs to be more research on this topic because these cities are emerging cities and pave the way for a new urban age. This paper will be one of the research on smart sustainable cities SSC explains the researcher's motivations for the need to produce smart, sustainable urban forms that achieve greater sustainability by using more innovative and powerful engineering solutions that support models of such forms using the advanced ICT key of Context-Aware computing applications (CAA) and Big Data Analytics (BDA). The study concluded that it is necessary to take advantage of the innovative engineering solutions provided by CAA and BDA and integrate them with sustainable urban forms to achieve greater sustainability while demonstrating how these forms are produced and The importance of joint and close collaboration between researchers, architects, urban planners and urban ICT companies in the context of smart sustainable cities.

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1. INTRODUCTION

Accelerated technological developments and global openness have led to the production of huge amounts of data sourced by context- Aware computing applications and huge data that become for any society if managed correctly – will be the main driver of society's strength.

Arab societies in general and Iraq in particular, despite their efforts to use and exploit technological means, still lack adequate investment in processing and analysing data to benefit from them for sustainable development.

The research paper aims to "Explore and employ the knowledge of engineering solutions produced by CAA&BDA (software, applications, sensors, etc.) and combine them with sustainable urban forms (to achieve greater sustainability in the context of smart sustainable cities and to achieve the goal (11) of achieving sustainable communities by 2030". Because of recent developments in Internet Things (IoT), artificial intelligence (AI), Context-Aware computing applications (CAA), and Big Data Analytics (BDA), with 5G contributing to data transmission more quickly and processing vast amounts of data in less time, all indicators confirm and support the implementation and development of smart sustainable cities and make them a reality.

2. THEORETICAL BACKGROUND

To recognise the motivations of the researcher's need to produce smart sustainable urban forms and the way these forms are produced in the context of smart sustainable cities, it is necessary to know in advance about sustainable cities and smart cities to access smart sustainable cities while highlighting the cycle of Context-Aware computing applications and big data and their importance on knowledge-based decision-making.

2.1 CITIES (SUSTAINABLE CITY, SMART CITY, SMART SUSTAINABLE CITY)

2.1.1 Sustainable City

Sustainability grew from the immediate necessity for real transformation because of serious concerns that the social development model had become poorly functioning in preserving the environment and Increasing citizens' living level. The sustainable development idea emerged with its three dimensions (environmental., economic., and social.) in the late 1980s. The cultural dimension was added by (HABITAT III., 2016-1) '(HABITAT III., 2016-2) 2016. Since the early 1990s, urban sustainability and the principles of sustainable urban development have been integrated into urban planning and design (Wheeler, S. M., & Beatley, T., 2010).

Sustainable cities tend to focus primarily on the following:

A. A natural environment encompasses all organisms and non-living elements found on Earth naturally without human intervention, such as soils, rocks, water, climate, and air.

B. Infrastructure consists of the physical components of interconnected systems that provide the necessary services and goods to enable or improve citizens' living conditions. These include the road, bridge, network, resources, water, sanitation, electrical networks, energy telecommunications, etc. (Höjer, M., & Wangel, J., 2015: 3)

C. Metabolism (food production and consumption within the city›s administrative boundaries). (Williams, K. et al., 2000: 12).

In addition, there are some factors affecting sustainability:

A. the built environment includes the use of land, urban design, transport systems, mobility within the physical environment, and human activity. It is expected to worsen as the world's urbanisation increases. (Handy, S., 1996)

B. Sustainable urban development, which takes into account the Environmental., Economic., Social. and cultural dimensions of exploiting available resources to meet the needs of individuals while retaining the rights of future generations. (Salim, H. & Basee, D., 2023)

C. Sustainable Urban Form: (Lynch, K., 1981; Handy, S., 1996) describes it as Patterns of spatial regulation for land use, transportation systems, and urban design elements that include building, street format, as well as the inner composition of the city. According to (Williams, Kati., et al., 2000), the sustainable urban form. Refers to "urban and space formations that affect urban development and meet changing needs". (Figure 1).

(Williams, Kati., et al., 2000) Put the basic principle of sustainable urban formation: Accessibility., convergence., and integration of jobs. (Jabareen, YR., 2006) Add energy reduction, Pollution, waste reduction, car use reduction., maintaining the Open Space System., and Urban formation is livable and safe. There is consensus by (Williams, K., 2000; Jenks, M., 2005; Jabareen, YR., 2006) that sustainable urban form is produced: 1. Mixed land use 2. density 3. Compactness. 4. Diversity. 5. sustainable transport 6. Passive solar design 7. Greening.

The researcher named these effects "generators of sustainable urban form". The research explains the relationship of each generator to the following main indicators:

(1) urban form characteristics (urban fabric, pattern, urban space). (2) The possibility of preserving historical and cultural heritage. (3) Access to services

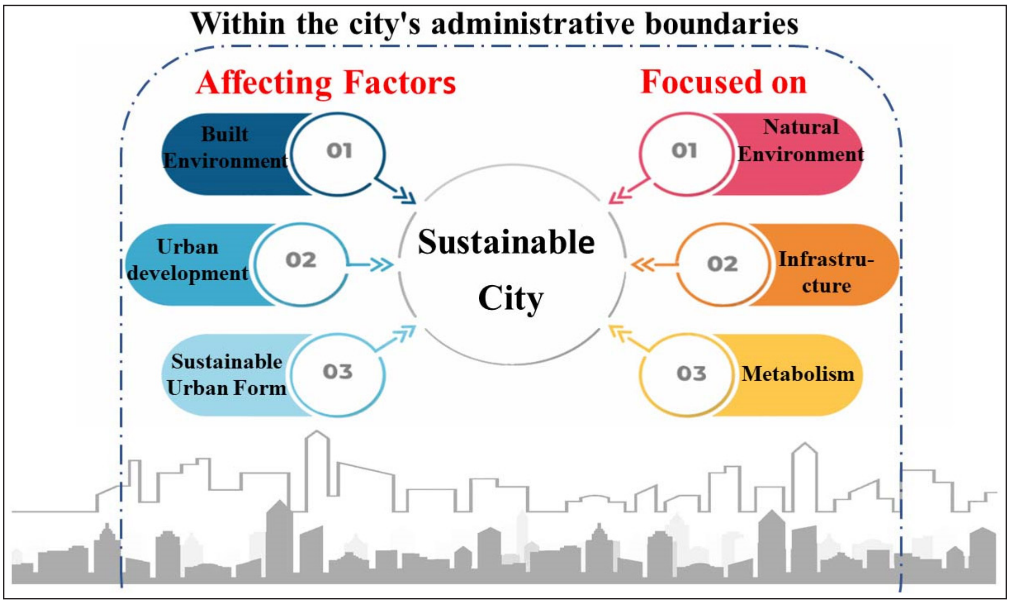

Figure 1 Sustainable Cities.
Source: The researcher.

and benefits.(4) urban competence. (5) Addressing human needs. (6) Climate quality. (7) Supporting the economy. (8) Citizens' Public Participation.

These indicators reflect the image of the city with environmental, economic, social and cultural dimensions while addressing human needs.

2.1.1.1 The generators of sustainable urban form are:

1. Mix-Land use: It refers to the concept of Diversity in land use, such as the presence of Institutions of educational, health, and service between commercial, residential, and industrial buildings. The strategy of mix-land use achieves Sustainable urban forms through its contribution to the impact on urban fabric vocabulary (fabric vitality, place identity, spatial convergence, purpose correlation, morphological transformations) on the compact urban-pattern and urban space vocabulary (social space, convenience, space vitality, uniqueness, attractivity), It has the potential to maintain historic places and Culture and through activating events and encouraging tourism in. It also promotes access to services and facilities. It encourages walking, cycling and reduces transport distances between activities and their duration, thereby reducing traffic congestion and pollution. Furthermore, it limits the land use for certain purposes. (Jabareen, YR., 2006; Bibri, S.E., 2018: 58). It supports the sense of safety, peace, and pleasure in public places. Add to the ability to support a vibrant economy and encourage citizen participation.

2. Density: Indicates the proportion of people, residential units, or buildings in the land area. It is preferable to intensify in abandoned or undesirable lands. Density is a strategy for achieving sustainable urban forms through its impact on the urban fabric. (urban fabric, human scale, clarity, degree of complexity, permeability, urban fabric vitality, place identity, morphological transformations), the urban pattern (interconnected, coherent), and the urban space vocabulary (space flexibility, social space, openness, uniqueness). Access to services and facilities. Encourages walking and cycling, thereby reducing the emission of CO2, contributing to improved air quality, and also works to achieve urban efficiency by providing energy and managing water and waste as well as preserving rural land while reducing crime and feeling safe (Williams, Kati., et al., 2000; Jabareen, YR., 2006; Bibri, S.E., 2018: 57) preserving rural land with the possibility of contributing to the promotion of e-commerce and citizen participation.

3. Compactness: refers to the interdependence and coherence of the urban space and built environment or (compression) as a strategic issue to achieve sustainable urban forms. Through its similar Effect of (Density) on the vocabulary of urban form characteristics (urban fabric, urban pattern, and urban space), With the contribution of hoarding to Achieving social justice (Williams, Kati., et al., 2000: 28) and sense of place and access to services and benefits Compactness encourages walking and riding bicycles. It reduces the number and duration of Auto-mobility, thereby contributing to improved air quality while preserving energy, resources, water, and rural land protection (Jabareen, YR., 2006; Bibri, S.E., 2018: 57) in addition to its contribution to the promotion of citizens participation.

4. Diversity: Through Diversity (housing types, family size, age, income, jobs, and cultures) and as a strategic issue to achieve sustainable urban forms through the similar effect of density and Compactness on the vocabulary (urban fabric, urban pattern, and urban space). Diversity encourages walking and riding bicycles. It thus contributes to reducing traffic congestion and air pollution. (Jabareen, YR., 2006). (Bibri, S.E., 2018: 58–59). It gives a sense of pleasure and a sense of place; It contributes to supporting the economy and encouraging citizens' participation due to job diversity and age.

5. Sustainable transportation: This is the main issue in environmental discussions on urban form. As a strategic issue for achieving sustainable urban forms through its impact on urban fabric (Illustration, degree of complexity, spatial convergence, fabric vitality, permeability, place identity, purpose correlation, Morphology transformations) and in the urban pattern (compact, loose) and it has the same effect (density, Compactness, Diversity) on the vocabulary of urban space. Sustainable transport can preserve cultural heritage and history by encouraging walking and cycling, particularly in the country's heritage areas. (Abbas, S. S., & Imran, Y. T., 2016). With the potential to achieve access to services and benefits by reducing reliance on cars for personal Auto-mobility, using public transport, and providing energy-efficient modes of transport, thereby reducing CO2 emissions and reducing pollution (Jabareen, YR., 2006; Bibri, S.E., 2018: 59). Sustainable transport contributes to human needs feeling safe, comfort with health benefits, pleasure, and a sense of place. It also contributes to supporting a vibrant economy.

Sustainable transport is an urban system that meets the needs of sustainable development without affecting the quality of life of future generations and access to destinations safely, healthily, and inexpensively while promoting the use of renewable energy sources.

6. Passive solar design: This is achieved by reducing energy demand using specific measures of (positioning, orientation, building density, street canyon, openness ratio to sky vision, colour, and texture of exterior finishing materials of buildings and outdoor spaces). Passive solar design is a strategic issue to achieve sustainable urban forms through its impact on urban fabric (fabric vitality, clarity, human scale, degree of complexity, permeability), Urban pattern (Central, linear, etc., coherent and compressed), and urban space (space flexibility, openness, uniqueness). It Effect airflow, the view of the sun and sky, the impact of heat absorption and reflection on buildings and exposed surfaces and outdoor spaces, Thus achieving urban efficiency quality (Jabareen, YR., 2006; Bibri, S.E., 2018: 60). With the possibility of using it as a strategy to preserve the cultural and historical heritage. Moreover, it gives a sense of psychological comfort and protection from external conditions.

7. Greening: Green infrastructure is important in sustainable urban planning. Green space is a strategy for achieving sustainable urban forms through its impact on urban fabric (Permeability, place identity, urban fabric vitality) and its impact on urban space (space flexibility, social space, openness, convenience, uniqueness, space vitality, attractivity) it could be used as a strategy to preserve cultural and historical heritage. And it is achieving access to services and benefits in addition to contributing to modifying urban weather events, conserving urban biodiversity and reducing pollution. (Jabareen, YR., 2006). According to the results of his study (Irvine, K. et al., 2010; Bibri, S.E., 2018: 59–60), the green urban landscape encourages children to play and meets human needs by giving comfort, safety, and a sense of place, pleasure, and urban happiness. It also increases economic attractiveness and encourages citizen participation (Figure 2).

Integrating urban-form generators into specific patterns (linear, networked, central, etc.) leads to sustainable cities such as Compact cities, Environmental City-Green Cities, and new urbanisation cities. The compact city emphasises Mix-Land use, density, and Compactness. The Environmental City – Green City focuses on urban greening, negative solar design, and diversity. The new urbanisation of the city emphasises sustainable transport, greening, Mix-land use, and Diversity. (Jabareen, YR., 2006). (Figure 3).

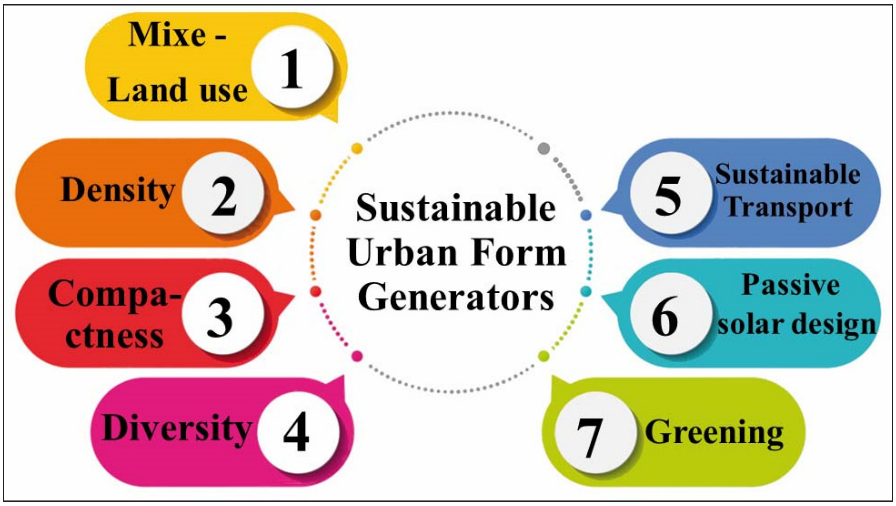

Figure 2 Sustainable urban form generators.
Source: The researcher.

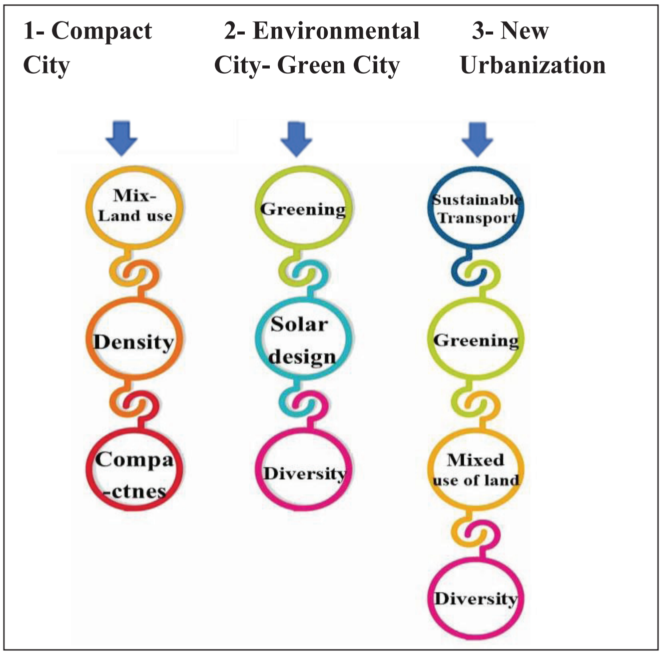

Figure 3 Sustainable City Models Most Prevalent.
Source: The researcher.

2.1.2 Smart City (SC)

Views differ on the concept of a Smart City (SC) in the previous studies. According to (Gabrys, J., 2014), the concept is rooted in the 1960s under so-called "electronically planned cities. (Neirotti, P., et al., 2014). The smart city relies on the smart management of urban systems using information technology and communications. Despite the wide use of the (smart city) concept, there is no legal definition of an SC or even universally agreed that it is difficult to define accurately and identify typical orientation at the global scale. Moreover, interpret the concept of SC (Neirotti, P., et al., 2014: 35) "as a common concept that leads cities around the world to a new level of technological innovation and quality of life improvement". At the same time, this term is chosen to attract investment and stimulate new economic opportunities; the existence of investment is a necessary but insufficient condition for creating Smart City.

(Giffinger, R. et al., 2007: 12) Defines "a smart city that performs its functions proactively in the economy, governance, people, transportation, living, and the environment."

The smart city relies on two main approaches: 1. The ICT-oriented approach (Kitchin, R., 2014) 2. The people-oriented approach, stakeholders, and knowledge (Galán-García, J. L., 2014). Other perspectives also focus on services (Belanche, D., et al, 2016).

Determining what is needed to make the city smart comes from each city's unique geographical location, physical composition, population, labour force, government structure, and policy. The term "The urban code of the city" reflects each city's complex composition. (Kirwan, C. G., & Zhiyong, F., 2020). SC has been criticised for its lack of environmental sustainability (Bibri, S. E., & Krogstie, J., 2017a; Höjer, M., & Wangel, J., 2015). According to the researcher, this was one of the reasons why researchers needed to think of smart sustainable cities.

2.1.3 Smart Sustainable City (SSC)

The concept of SSC has more great attention all over the world (universities·research institutes· governments, ·policymakers, and ICT companies) as a response to sustainability and urbanisation challenges. However, this concept became widespread only in mid-2010 (Bibri, S. E., & Krogstie, J. 2017a) as a result of many global interconnected developments and transformations (Höjer, M., & Wangel, J., 2015: 334–337), most notably the emergence of sustainable cities And smart city SC, Urban computing, Information and Communication Technology ICT., sustainable development., Sustainability and Urbanization Sciences. The main idea of Smart Sustainable City (SSC) is to take advantage of the benefits of advanced ICT deployment everywhere and harness it in the transition to the desired sustainable development. smart sustainable cities are a complex concept of smart cities and sustainable cities.

The signs of this city emerged from scientific studies presented by both (Höjer, M., & Wangel, J., 2015). Where you can make cities sustainable without using information technology, smart communication and smart technologies can be used in cities without contributing to sustainable development. Only when smart technologies are used with sustainable cities then (SSC) will be creating.

The first attempts to define SSC were by the International Telecommunication Union (ITU) In 2014 "A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, the efficiency of urban operation and services, and competitiveness while ensuring that it meets the needs of present and future generations concerning economic, social, environmental as well as cultural aspects".

(Höjer, M., & Wangel, J., 2015: 347) Defines "Smart Sustainable City it meets the needs of its current population without compromising other people's or future generations' ability to meet their needs. Therefore, it does not override local or global environmental constraints and is supported by ICT".

(Bibri, S.E., 2018: 53) Defines it as "a city supported by the widespread and large presence of advanced ICTs and related to different urban systems and areas in a complex and coordinated manner, respectively, to enable Controlling resources securely, sustainably, and effectively allows the city to improve social and economic results, the SSC is multidisciplinary and enables the community to live in healthy environments with minimal environmental impact and resource demand".

The researcher came up with the procedural definition of an SSC as a future city that integrates and harnesses the strengths of both SC and sustainable cities by developing a common framework to impart human and technological intelligence to overcome or address the main disadvantage of both categories of cities by their contribution to sustainable development goals.

2.2 INFORMATION TECHNOLOGY AND URBAN COMMUNICATION

2.2.1 Urban ICT

ICT in development and urban planning refers to devices and software connected through wireless communications and mobile networks that continuously deliver information on physical forms and city infrastructure (operational, functional, environmental, economic, social, and cultural). These technological components are used to record, collect, store, coordinate, integrate, analyse, process, simulate, manage, and share urban data to observe, understand, explore, plan, evaluate, and decision making in SSC to achieve certain goals (Bibri, S. E., 2015a). Urban ICT extends to many systems, urban areas, and subdisciplines, which can be compact with (buildings, Infrastructure, educational facilities or services, etc.) It is also linked to citizens and their movements during their daily activities. For example, it is linked to smart transport., and smart traffic., smart energy., smart governance., smart planning., smart environment., smart education., smart healthcare., smart safety.

2.2.2 Data Mining Science

Due to the Effect of ICT, every aspect of Science is changing, leading to the scientific discovery of data science, the fourth model of scientific evolution (Bell G., et al., 2009). Data science is gaining momentum in many areas of scientific and academic research because it is a science with a thriving field whose unique issues are only recently raised and whose general principles are fulfilled by achieving the result of enhancing decision-making for a large number of systems and urban areas based on data analysis. Data science in the context of SSC includes integrated and sophisticated principles, processes, and techniques spread across diverse urban entities wanting to understand and analyse automatically of urban data along with the expert knowledge used to analyse urban problems and phenomena, expertise, and creativity of planners, architects, engineers, professionals, researchers, and urban analysts (Provost, F., & Fawcett, T., 2013). Data in the context of SSC are sourced from either the (CAA). (Figures 4, 5, 6).

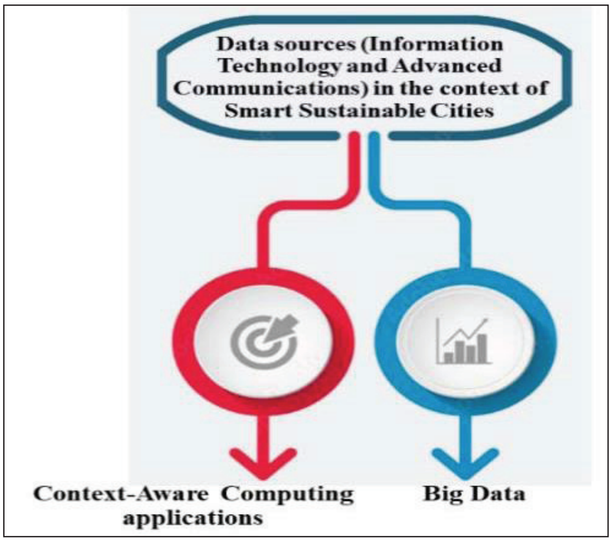

Figure 4 Data Sources.
Source: The researcher.

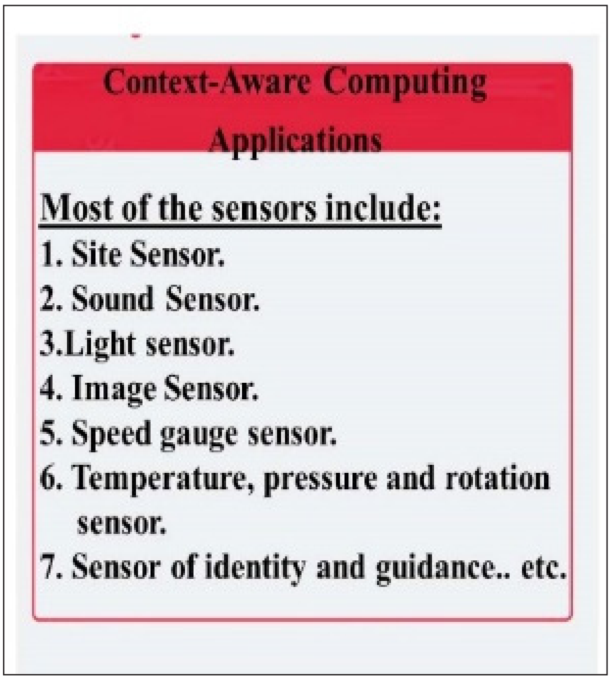

Figure 5 Context-Aware computing applications (CAA).
Source: The researcher.

Figure 6 Big Data (BDA).
Source: The researcher.

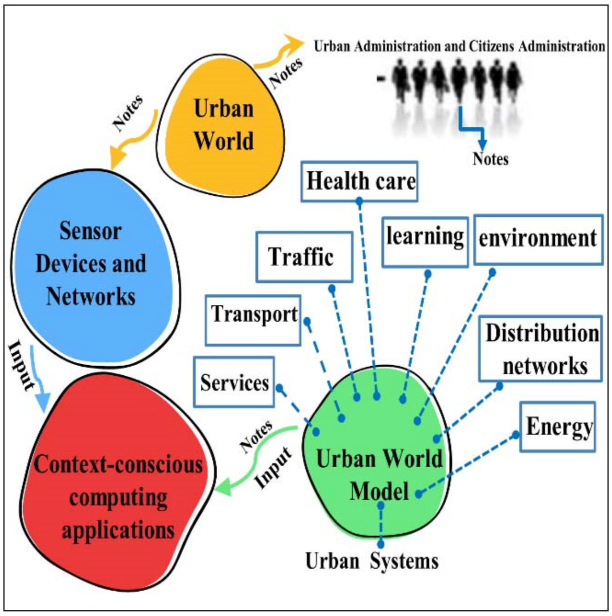

Figure 7 Context-Awareness Applications (CAA).
Source: The researcher.

2.2.3 AI, urban intelligence and Context-Aware computing applications

Artificial intelligence (AI) is interested in human intelligence and developing computing systems capable of imitating intelligent human behaviour. (McCarthy J), who invented the term in 1956, defines it as "the science and engineering of the smart machinery industry" (McCarthy J, 2007).

(Kaplan, A., & Haenlein, M., 2019) Defines AI as "the system's ability to correctly interpret external data, learn from this data, and use that knowledge to achieve specific goals and tasks through flexible adaptation". The researcher found that it is the simulation of human intelligence through machines.

The foundation of urban intelligence is the premise that (AI) technologies can identify, understand, infer, and model urban life situations in a way that adapts or take more relevant actions proactively on the systems and Urban areas. (Bibri, S. E., & Krogstie, J., 2017a; Batty, M., et al., 2012). Urban intelligence contributes to Improving the performance of systems like traffic systems, transportation systems, power systems, telecommunications systems, etc., as well as providing the city's best services, including health care., education., safety., service facilities, etc., Context-aware is defined as a description of technology capable of appropriately feeling and responding to contextual variables or adapting through real-time thinking capabilities or pre-programmed thinking. (Bibri, S. E., 2015a).

The dissemination of context-conscious computing applications within smart and smart sustainable cities depends on cities' financial capabilities and technological advancement. (Figure 7).

2.2.4 Big Data

Big data are characteristics or information, mostly numerical, collected through observation. Cities, in all their complexities, have the potential to generate huge amounts of data. The term big urban data does not have a legal or definitive definition in the context of smart and smart sustainable cities, but it can be used to describe a huge amount of urban data (Khan, M., et al., 2012). It is important to note that these data are characterised by spatial and temporal markers (Khan M, 2014). The main features of the large data are:

The huge amount of data, The speed with which data can be analysed, and the great variety of data types.

2.2.5 Big Data Analytics (BDA)

It refers to various sophisticated and specialised software programs and database systems driven by computers with a very high processing capacity that can translate a significant quantity of urban data into valuable information to facilitate informed decision-making. (Bibri, S. E., & Krogstie, J., 2017b; Bibri, SE. and Krogstie, J., 2017a). The data analytics aim to support intelligent decisions to control., improve., Automation., management., planning of urban systems operations., the organisation of urban life., services related to facilities., health care., education., transportation., safety and strengthening of the ecosystem. In other words, data analyses change the scientific evolution model and move from drafting, testing, or manually collecting, studying, and contemplating hypotheses to increasingly relying on data processing, analysis, modelling, simulation, prediction, and verification. This development extends to many academic and scientific research areas and will help make decisions faster, easier, and more knowledge-based.

2.2.6 Data Mining

Data mining is known as (knowledge discovery). Any analysis of large amounts of data to detect correct and new data patterns is called a (model). Mining is a computational process to examine data sets and Check data sets to find repetitive, hidden, previously unknown accurate patterns and relationships to make useful, meaningful and correct associations and summarise the results in new ways (Provost, F., & Fawcett, T., 2013) knowledge Discovery process in databases (includes sequenced and accurate methodological steps:

1. Processing the Data by collecting and screening them from several databases to ensure that they are free from errors, shortcomings, reprocessed, encrypted, and aggregated
2. Data storage in a data repository
3. Taking a sample of data.
4. Choosing the Mining type and the appropriate algorithm.
5. Modeling and simulation to extract knowledge and patterns.
   Modelling means creating a (model) representing an object that may be the same or almost identical to the original system. Simulation is a technique for studying and analysing real-world behaviour through a placebo system and using a computer. (Batty, M., 2012)
   Modelling and simulation help to reduce costs., save resources., increase the quality and performance of systems., document and archive lessons learned. Simulation is safer, cheaper, and faster than experiments in the real world or actual events.
6. Evaluating the knowledge.
   Evaluating the extracted knowledge and determining which of them is useful and thus making use of this knowledge.

Data mining is the automated extraction of useful knowledge from large datasets in the context of smart sustainable cities that contribute to decisions by analysing data for different systems.

3. MOTIVATIONS FOR THE PRODUCTION OF SUSTAINABLE SMART URBAN FORMS

The researcher found it necessary to produce smart sustainable urban forms for the following reasons

The theme of sustainable urban form and the problem of addressing it have led to limited and differentiated outcomes (Jabareen, YR., 2006; Neuman, M., 2005), especially for the beneficial effects of sustainability. (Neuman, 2005) emphasises this: “The perception of cities in terms of forms is still insufficient to achieve the sustainable development goals”.

A traditional urban planning approach or sustainable urban planning approach alone is no longer relevant to ensuring the effective design, management, operation and evaluation of urban systems in addressing or continuously improving the sustainability challenges due to issues generated by rapid urbanisation and technological development.

The fact is that today’s cities are constantly evolving and changing the knowledge behind their planning and design. The design and performance of cities must consequently be scalable and adaptable to population expansion, environmental change, Social, cultural and economic.

In most cases, a city’s Infrastructure is prioritised when discussing the notion of a sustainable city. This includes waste treatment, water supply, and power generation (Höjer, M., & Wangel, J., 2015: p.3). Thus, there are deficiencies in smart solutions in various urban areas.

Today’s cities are increasingly perceived as data-centric adaptive systems characterised by dynamic changes. Hence, they need innovative engineering solutions that keep pace with dynamic city changes caused by urbanisation and technological evolution.

There is a need for more creative approaches to address the intractable issues related to sustainable urban forms by monitoring, understanding., analysing., and evaluating these forms.

All the reasons above required the researcher to demonstrate that we can benefit from advanced ICT (CAA & BDA) in promoting greater sustainability in the context of SSC.

4. CONCEPTUAL FRAMEWORK

Create a table-shaped conceptual framework that includes generators of sustainable urban form with advanced information and communication technology (CAA) & (BDA) in the context of smart sustainable cities. See Table 1.

4.1 MAIN INDICATORS OF URBAN FORM RELIED ON

Utilisation of three kinds of sustainable urban forms to contribute to sustainability, as the integrated city emphasises Mix-land use, density, and Compactness. The ecological city and green urbanisation focus on greening, passive solar design, and Diversity. The new urbanisation confirms sustainable transport, greening, Mix-land use, and Diversity.

The use of urban forms generator vocabulary (1. Mixed Land use 2. Density 3. Compactness 4. Diversity 5. Sustainable Transport 6. Passive Solar Design 7. Greening) and its relationship with.

MAIN INDIVIDUAL	SECONDARY VOCABULARY	INDICATORS		(CAA)	(BDA)
Characteristics of urban form	**properties of the urban fabric**	• Urban fabric (granulation)	• Humanitarian Scale	✓	✓
		• Clarity	• The vitality of the urban fabric		
		• complexity	• place Identity		
		• Spatial convergence	• Purpose correlation		
		• permeability	• Urban Fabric Flexibility		
	Urban pattern	• central	• Compact	✓	✓
		• linear	• loose		
		• network	• scattered		
	Urban Space Characteristics	• Space flexibility	• Space vitality	✓	✓
		• social space	• Surface finishing (walks…)		
		• openness	• Singularity/exclusivity		
		• Appropriate	• attraction		
The possibility of preserving historical and cultural heritage		Preservation of the traditional fabric of the city		✓	✓
		Activating events in historical and cultural places			
		Encourage tourism to historical places			
Achieving access to services and benefits		Encourage public transport		✓	✓
		Encourage walking and cycling			
		Provision of energy-saving modes of transport			
		Reduce the number and duration of transport			
Urban competence		(Resources/Energy/water/waste) management		✓	✓
		Promoting renewable energy sources			
		Rural Land Protection			
Addressing human needs		• safety • social justice	Pleasure and Urban Happiness	✓	✓
		freedom of movement	sense of place		
		For psychological comfort and benefits for his health	Protection from external circumstances		
Climate quality		Effect on airflow, view of the sky, and exposed surface area		✓	✓
		Impact of heat absorption and Reflection on Buildings			
		Impact on absorption and thermal reflection processes on the building's exterior surfaces and exterior spaces			
		Reduce the emission of contaminated gases and reduce pollution			
		Modification of extreme urban climatic phenomena			
		Preservation of urban biodiversity			
Supporting a vibrant economy		Increased economic attractiveness		✓	✓
		Promoting e- commerce			
Citizens' Public Participation		Traditional Participation – Digital Participation		✓	✓

Table 1 Shows the availability of (CAA & BDA) data for sustainable urban form generator indicators in the smart sustainable city context

Source: The Researcher.

Note: This is a general Table: Its main and secondary vocabulary and indicators are reflected on each generator of urban forms (Mixed Land use, Density, Compactness, Diversity, Sustainable Transport, Passive Solar Design, and Greening).

✓ Availability (CAA) for this indicator. ✓ Availability (BDA) for this indicator.

1. **Characteristics of the urban form, which include:**

    - Indicators of urban fabric characteristics (clarity, degree of complexity, permeable spatial convergence, human scale, urban fabric vitality, place identity, purpose correlation, morphological transformations).
    - urban pattern indicators (central, linear, networked, compact, loose, scattered).
    - urban space indicators (space flexibility, social space, openness, convenience, urban space vitality, finishing pavements, Singularity, and attraction).

2. **Indicators of preserving civilisation heritage and culture** (preservation of the traditional fabric of the city, Activating Events In cultural and historical places, and Encouraging tourists in historic places.
3. **Indicators of access to services and benefits** (promotion of public transport, walking and riding bicycles, energy-saving modes of transport, reducing the number and duration of transport trips).
4. **Indicators of urban quality** (resources, energy, water, and waste) management, renewable energy sources promotion, and rural land protection.
5. **Addressing human needs** (safety, freedom of movement, psychological comfort and health benefits, pleasure, urban happiness, sense of place, and protection from external conditions).
6. **Climate quality indicators** affect airflow, exposed surface area, and sky view, effects on absorption processes and thermal reflection on the building's exterior surfaces and spaces, reduce the emission of polluting gases and reduce pollution, modifying extreme urban climatic phenomena, preserves the biodiversity of urban areas.
7. **Supporting a vibrant economy** (increasing economic attractiveness, encouraging electronic commerce).
8 **Encourage citizens**' participation in Public through traditional participation and digital participation.

Create a conceptual relationship in the possibility or readiness of integrating sustainable urban form generator indicators with advanced ICT technologies (context- Aware computing applications and extensive data analyses), especially since these technologies will become a more technologically developed and financially affordable future. Harnessing (CAA & BDA) capabilities to monitor, monitor, record data and make predictions or guesses based on real-time thinking or inference capabilities from its modelling and simulation. In a way that facilitates proper decision-making, improves planning, operation and performance of these generators and achieves the quality of life for citizens.

The outcomes of this will be reflected in the promotion of greater urban sustainability (environmental, economic, social and cultural) in the context of smart sustainable cities.

THE RESULT

MAIN INDIVIDUAL	SECONDARY VOCABULARY	(CAA)	(BDA)
1- Characteristics of urban form	**properties of the urban fabric**	1- Programme DGPS and GIS. 2- Whitebox Geospatial Analysis. 3- ILWIS. 4- Land cover mapping. 5- Remote sensing. 6- Geo-technologies. 7- Programme Google Earth.	1- Programme anaysis using depth map. 2- Programme Arc GIS. 3- SAGA GIS. 4- Global Mapper. 5- Maptitude. 6- gVSIG. 7- GeoDa. 8- GRASS GIS. 9- Map Window GIS. 10- open Jump. 11- Falcon View. 12- AutoCAD Map 3D. 13- QGIS. 14- Diva-GIS 15- Orbis GIS. 16- MapInfo Professional. 17- MapServer. 18- uDig. 19- Programme Surfer. 20- Digital Surface Model. 21- rfMaps, from Lepton software. 22- I GIS Desktop. 23- Geo site. 24- MapInfo pro. 25- Geosite. Trimble TerraSync. 26- DTNMarine&Offshore Weather Intelligence.

(Contd.)

MAIN INDIVI-DUAL	SECONDARY VOCABULARY	(CAA)	(BDA)
	Urban pattern	1- Programme DGPS and GIS. 2- Whitebox Geospatial Analysis. 3- ILWIS. 4- Land cover mapping. 5- Remote sensing. 6- Geo-technologies. 7- Programme Google Earth.	1- Programme anaysis using depth map. 2- Programme Arc GIS. 3- SAGA GIS. 4- Global Mapper. 5- Maptitude. 6- gVSIG. 7- GeoDa. 8- GRASS GIS. 9- Map Window GIS. 10- open Jump. 11- Falcon View. 12- AutoCAD Map 3D. 13- QGIS. 14- Diva-GIS 15- Orbis GIS. 16- Maplnfo Professional. 17- MapServer. 18- uDig. 19- Programme Surfer. 20- Digital Surface Model. 21- rfMaps, from Lepton software. 22- I GIS Desktop. 23- Geo site. 24- Maplnfo pro. 25- Geosite. Trimble TerraSync. 26- DTNMarine&Offshore Weather Intelligence.
	Urban Space Characteristics	1- Programme DGPS and GIS. 2- Whitebox Geospatial Analysis. 3- ILWIS. 4- Land cover mapping. 5- Remote sensing. 6- Geo-technologies. 7- Programme Google Earth.	1- Programme anaysis using depth map. 2- Programme Arc GIS. 3- SAGA GIS. 4- Global Mapper. 5- Maptitude. 6- gVSIG. 7- GeoDa. 8- GRASS GIS. 9- Map Window GIS. 10- open Jump. 11- Falcon View. 12- AutoCAD Map 3D. 13- QGIS. 14- Diva-GIS 15- Orbis GIS. 16- Maplnfo Professional. 17- MapServer. 18- uDig. 19- Programme Surfer. 20- Digital Surface Model. 21- rfMaps, from Lepton software. 22- I GIS Desktop. 23- Geo site. 24- Maplnfo pro. 25- Geosite. Trimble TerraSync. 26- DTNMarine&Offshore Weather Intelligence.
2- The possibility of preserving historical and cultural heritage		1- Programme DGPS and GIS. 2- Whitebox Geospatial Analysis. 3- ILWIS. 4- Land cover mapping. 5- Remote sensing. 6- Geo-technologies. 7- Programme Google Earth.	1- Programme analysis using the depth map. 2- Programme Arc GIS. 3- SAGA GIS. 4- Global Mapper. 5- Maptitude. 6- gVSIG. 7- GeoDa. 8- GRASS GIS. 9- Map Window GIS. 10- open Jump. 11- Falcon View. 12- AutoCAD Map 3D. 13- QGIS. 14- Diva-GIS 15- Orbis GIS. 16- Maplnfo Professional 17- MapServer. 18- uDig. 19- Programme Surfer. 20- Digital Surface Mod.

(Contd.)

MAIN INDIVIDUAL	SECONDARY VOCABULARY	(CAA)	(BDA)
3- Achieving access to services and benefits		1- Cameras. 2- Radar sensor. 3- Laser beam. 4- traffic control 5- Automotive radar. 6- lidar. 7- traffic sensors. 8- autonomous driving. 9- intelligent transportation systtems. PortoLivingLab sensor	1- road construction. 2- traffic updates. 3- management system. 4- live traffic. 5- smart car. 6- case study. 7- road safety. 8- Waze. 9- Think Soft Apps. 10- CoPilot GPS 11- HERE, WeGO. 12- Sygic. 13- Osm And 14- Petal Maps. 15- 2GIS. 16- GPS Navigation. 17- Mobile Crowdsensing (MCS). 18- Moovit. 19- UbiGo. 20- SkedGo. 21- Beep, Inc. 22- Umo Mobility Platform. 23- Trafi MaaS Suite. 24- BRIDJ. 25- Mobilleo. 26- TeleDriver. 27- Trapeze View. 28- HASTUS Software, fromGIRO. 29- GoalDriver. 30- Routefinder pro. 31- Justeide. 32- Trip Fixed Route Software. 33- GoalBus. 34- EZTransport. 35- Trapez Travel Information(TI). 36- SmartBus. 37- Drivewyze Infrastructure Services. 38- Spare. 39- Routematch, from Uber. 40- EZTransit. 41- Remix, fromVia. 42- Liftango. 43- Trapeze Intelligent Transportation System(ITS). 44- Routematch. 45- Cityfinder. 46- Bestmile. 47- AddTransit. 48- Datamatics Trufare. 49- Conduent Seamless Transportation System. 50- TripMaster. 51- AT&T Smart Cities.
4- urban competence		Sensors: 1- Programme ENVI-MET 2- smart energy. 3- water monitoring. 4- smart farming. 5- smart water supply. 6- quality monitoring. 7- desalination plant. 8- smart irrigation system 9- bin. 10- waste classification 11- waste reduction. 12- Light Sensor. 13- Different types of sensors used in agriculture. 14- PortoLivingLab sensor	1- Programme (Energy Plus., Autodesk Ecotect), Bentley Tas Simulator eQuest, DesignBuilder (Autodesk Green Building Studio, Graphisoft EcoDesigner). 2- Contributing to the mapping of pollution (air, water, soil) 3- applications for food manufacturing, smart waste, renewable energy, electricity, solid waste. 4- The Smartainability approach. 5- Cloudpermit. 6- CityView Suite.

(Contd.)

MAIN INDIVIDUAL	SECONDARY VOCABULARY	(CAA)	(BDA)
5- Addressing human needs		1- Lidar camera. 2- Android Wear. 3- HAR technology to strengthen the security sensor-based HAR. 4- MEMS IMUs (Micro Elector-Mechanical Systems) (Technology Watch) 5- Sensor of identity FRID. 6- Image Sensor. 7- Explosives detection devices, drugs and gunshots. 8- Raven by Flock Safety	1- Sentiment Analysis: An ERNIE-BiLSTM Approach to Bullet 2- A Novel Front Door Security (FDS) Algorithm Using GoogleNet-BiLSTM Hybridization. 3- Programme : Programme ArcMap-ArcGIS. 4- The Smartainability approach. 5- LexisNexis Accurint. 6- Metropolis Technolgies. 7- SAP Future Cities. 8- Fusus.
6- Climate quality		1- CEM DT-8820 Sensor. 2- Kestrel 4500 Sensor. 3- Based on a Three-Dimensional Sampling Algorithm and UAV-Based Radiometric Measurements. 4-3D Thermal Technology for Heritage Building Energy 3D-TCV. 5- automatic meter reading (AMR). 6- Light Sensor. 7- Site Sensor. 8- Temperature, Pressure Sensor. 9- Sensor Network (WSN) 10- PortoLivingLab sensor.	Programme: 1- Airvisual App (IQAir) 2- CAIT Climate Data Explorer-WRI. 3- Climate time machine-NASA. 4- Global calculator – government. 5- Climate Change Calculator-Financial Times, 6- Energy Innovation. 7- Fossil Fuel ticker-The Guardian. 8- US opinion map-Yale. 9- eoTracer application. 10- The Smartainability approach. 11- Weather Defender. 12- Bird. 13- AT&T Smart Cities. 14-IESve
7- Supporting a vibrant economy		The use of many sensors contributing to the improvement of the economy, such as 1- Agricultural applications 2- Exploration for underground water, oil and gas. 3- Search for sources of wealth on the seabed and oceans. 4- Bank Sensors Market. 5- NotaMaster and NotaScan sensors in banks 6- Using daily satellite sensor 7- Satellite Data in Economics. 8- Different types of sensors used in agriculture. 9- Various sensors in many industries (automotive industry, chemical industry, etc.) Add the contribution of sensors to monitoring and monitoring the quality of factories.	1- Data by the public sector (Governments, authorities, organisations). 2- vMAP Portal. 3- Data from commercial entities and banks. The best e-commerce 4- Shopify. 5- Wix. 6- BigCommerce 7- Adobe Commerce. 8- eCommerce 9- PrestaShop. 10- Squarespace 11- GoDaddy. 12- Volusion. 13- amazon. 14- Shift 4shop. 15- The Smartainability approach. 16- cyberSWIFT Land Acquisition and management system. 17- Neighborly software. 18- Verizon Smart Cities. 19- Oracle Smart Cities. 20- AT&T Smart Cities.
8- Citizens' Public Participation		1- Lidar camera. 2- Android Wear. 3- HAR technology to strengthen the security sensor-based HAR. 4- MEMS IMUs (Micro Elector-Mechanical Systems) (Technology Watch) 5- Sensor of identity FRID. 6- Image Sensor. 7- Explosives detection devices. 8- drugs and gunshots. 9- PortoLivingLab sensor	Applications: 1- Zoom. 2- Google Hangouts. 3- google DUO. 4- Free Conference Call. 5- Uber Conference. 6- Webex 7- Go to Meeting. Best social media apps: 1. Facebook. 2. Instagram. 3. Snapchat. 4. LinkedIn. 5. Twitter. 6. WhatsApp. 7. Telegram. 8. hareChat. 9- The Smartainability approach. 10- LexisNexis Accurint. 11- Granicus govMeetings. 12- Maptionnaire. 13- CitizenLab. 14- Social Pinpoint. 15- Paylt. 16- CivicClerk. 17- Verizon Smart Cities. 18- IBI Group Smart Cities.

Table 2 The type of data available from (CAA & BDA) for each sustainable urban form generator indicator in the context of smart sustainable cities. Source: Researchers scan many websites, collect: software, applications and sensors, and their inclusion under the main vocabulary.

FINDINGS INFORMATION

The charts appeared in (Figure 8) by analysing the results of Table 2 with the achievement of the following objectives.

1. The researcher explored engineering solutions produced by (CAA & BDA) (software, applications, sensors, etc.) from websites and collected and sorted them according to their use on sustainable urban form generator indicators (Table 2).
2. Using knowledge of engineering solutions and combining them with generators of urban forms in the context of smart sustainable cities is a form Figure 8 achieves greater sustainability under the characteristics and advantages of these solutions. Thus, reaching the (11) target of achieving sustainable communities by 2030.
3. Many data (CAA) & (BDA) for indicators of the following sustainable urban forms are available in the context of the smart sustainable city.

Indicators of characteristics of sustainable urban form, which include:

3.1. Indicators of urban fabric characteristics
3.2. Indicators of preserving civilisation heritage and Culture
3.3. Indicators of access to services and benefits.
3.4. Indicators of urban quality.
3.5. Indicators of climate Quality.
3.6. Indicators of supporting a vibrant economy.
3.7. Indicators of encouraging citizens' participation in public.

4. Need many data CAA & (BDA) for Addressing human needs indicators because the researcher found it more limited than others, mostly with the safety indicator.
5. Figure 8 gives a perception of the researchers, architects, urban planners and information and communications technology companies about the amount of data available from (CAA & BDA) to monitor and measure the city. And The importance of joint and close collaboration between researchers, architects, urban planners and urban ICT companies in the context of smart sustainable cities.
6. The researcher finds that cities and especially developing countries need to recognize the importance of taking advantage of the growing market for low-cost technologies to be used to promote sustainability, taking into account the potential negative effects of these technologies.
7. The researcher considers it necessary to move towards a knowledge-based economy driven by information technology and urban communication to reach a smart, sustainable economy.

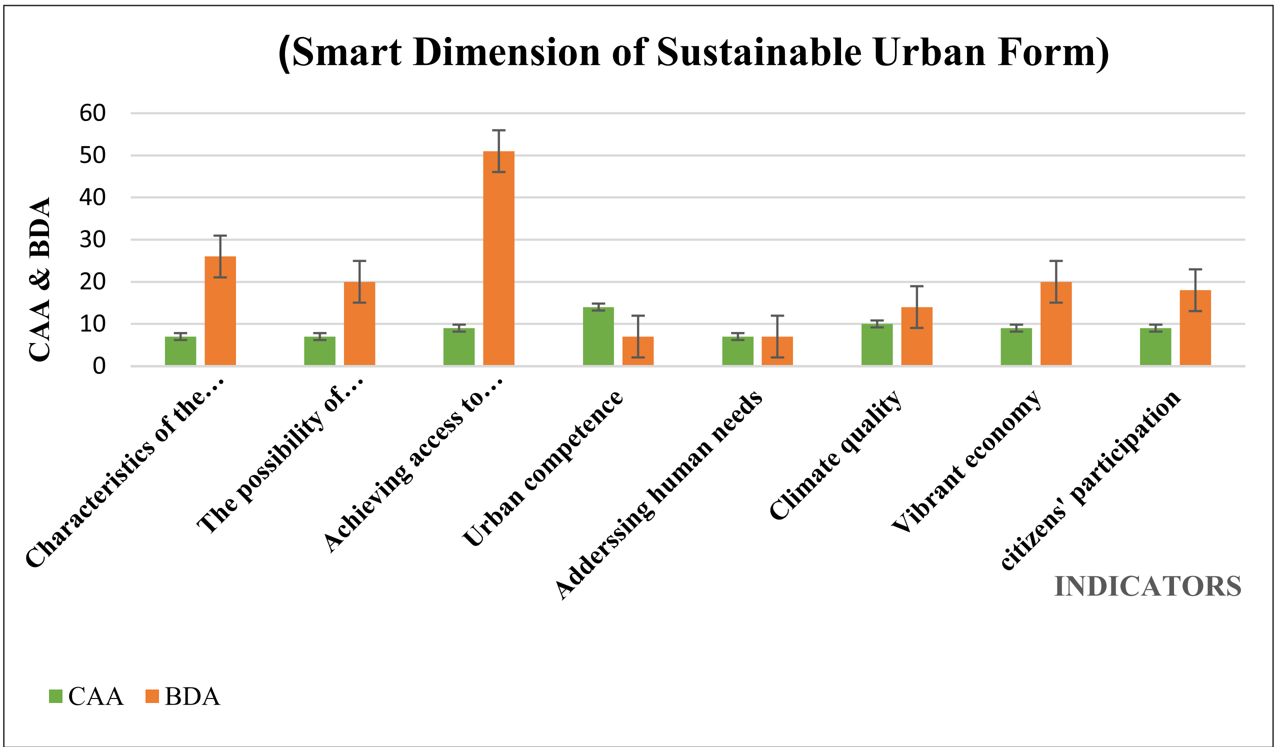

Figure 8 Amount of data available from Context-Aware computing applications (CAA) and Big Data Analytics (BDA) for indicators of sustainable urban form in the context of smart sustainable city.

Source: The Researcher.

5. CONCLUSIONS

Smart Sustainable urban form in the context of smart sustainable cities is achieved by integrating many sustainable urban form generators with information technology and advanced communication (Context-Aware computing applications with big data). See Table 2. Through innovative and sophisticated engineering solutions in monitoring, understanding, analysis and evaluation, knowledge-based decision-making is made, and greater urban sustainability is achieved urban sustainability. (Environmental, economic, social and cultural) as a result of improvement in 1. Characteristics of urban form. 2. Preservation of cultural and historical heritage. 3. Access to services and benefits. 4. Urban competence. 5. Meeting human needs. 6. Climate quality. 7. Vibrant economy. 8. Citizens' participation.

According to the results of Figure 8, the researcher considers it necessary to produce more Context-Aware computing applications and big data by information technology and urban communications companies for the subject of meeting human needs because the researcher found them to be more limited than others in the context of smart sustainable cities.

COMPETING INTERESTS

The authors have no competing interests to declare.

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REFERENCES

Abbas, SS and **Imran, YT.** 2016. Sustainable transportation and urban form. *The Iraqi Journal of Architecture and Planning*, 15(1): 187–206. DOI: https://doi.org/10.36041/iqjap.v15i1.383

Batty, M, Axhausen, KW, Giannotti, F, Pozdnoukhov, A, Bazzani, A, Wachowicz, M, … & **Portugali, Y.** 2012. Smart cities of the future. *The European Physical Journal Special Topics*, 214: 481–518: Springer. DOI: https://doi.org/10.1140/epjst/e2012-01703-3

Belanche, D, Casaló, LV and **Orús, C.** 2016. City attachment and use of urban services: Benefits for smart cities. *Cities*, 50: 75–81. United Kingdom: Elsevier. DOI: https://doi.org/10.1016/j.cities.2015.08.016

Bell, G, Hey, T and **Szalay, A.** 2009. Beyond the data deluge. *Science*, 323(5919): 1297–1298, United States: A American Association for the Advancement of Science. DOI: https://doi.org/10.1126/science.1170411

Bibri, SE. 2015a. The humanface of ambient intelligence. *Atlantis Ambient and Pervasive Intelligence*. Atlantis Press: Springer. DOI: https://doi.org/10.2991/978-94-6239-130-7

Bibri, SE. 2018. Smart sustainable cities of the future. Springer Berlin Heidelberg.

Bibri, SE and **Krogstie, J.** 2017a. Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable cities and society*, 31: 183–212. Netherlands: Elsevier. DOI: https://doi.org/10.1016/j.scs.2017.02.016

Bibri, SE and **Krogstie, J.** 2017b. ICT of the new wave of computing for sustainable urban forms: Their big data and context-aware augmented typologies and design concepts. *Sustainable cities and society*, 32: 449–474. Netherlands: Elsevier. DOI: https://doi.org/10.1016/j.scs.2017.04.012

Gabrys, J. 2014. Programming environments: Environmentality and citizen sensing in the smart city. *Environment and planning D: Society and space*, 32(1): 30–48. DOI: https://doi.org/10.1068/d16812

Galán-García, JL, Aguilera-Venegas, G and **Rodríguez-Cielos, P.** 2014. An accelerated-time simulation for traffic flow in a smart city. *Journal of Computational and Applied Mathematics*, 270: 557–563. Netherlands: Elsevier. DOI: https://doi.org/10.1016/j.cam.2013.11.020

Giffinger, R, Fertner, C, Kramar, H, Kawasaki, R, Pichler-Milanovic, N and **Meijers, EJ.** 2007. Smart cities. Ranking of European medium-sized cities, Final Report.

HABITAT III. 2016–1. Policy paper 1: The Right to the City and Cities for All. Retrieved from: https://uploads.habitat3.org/hb3/Habitat%20III%20Policy%20Paper%201.pdf (20.12.2019).

HABITAT III. 2016–2. Policy paper 2: Socio-Culture Urban Framework. Retrieved from: https://uploads.habitat3.org/hb3/Habitat%20III%20Policy%20Paper%202.pdf (20.12.2019).

Handy, S. 1996. Methodologies for exploring the link between urban form and travel behaviour. *Transportation Research Part D: Transport and Environment*, 1(2): 151–165, United. DOI: https://doi.org/10.1016/S1361-9209(96)00010-7

Höjer, M and **Wangel, J.** 2015. Smart sustainable cities: definition and challenges. In *ICT innovations for sustainability*: Springer International Publishing. DOI: https://doi.org/10.1007/978-3-319-09228-7_20

International Telecommunications Union (ITU). 2014. *Agreed definition of a smart sustainable city*. Focus Group on Smart Sustainable Cities.

Irvine, KN, Fuller, RA, Devine-Wright, P, Tratalos, J, Payne, SR, Warren, PH, … and **Gaston, KJ.** 2010. Ecological and psychological value of urban green space. *Dimensions of the sustainable city*, 215–237. DOI: https://doi.org/10.1007/978-1-4020-8647-2_10

Jabareen, YR. 2006. Sustainable urban forms: Their typologies, models, and concepts. *Journal of planning education and Research*, 26(1): 38–52. DOI: https://doi.org/10.1177/0739456X05285119

Jenks, M. 2005. *Future forms and design for sustainable cities*. Routledge. DOI: https://doi.org/10.4324/9780080455525

Kaplan, A and **Haenlein, M.** 2019. Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence. *Business Horizons*, 62(1): 15–25. DOI: https://doi.org/10.1016/j.bushor.2018.08.004

Khan, MA-u-d, Uddin, MF and **Gupta, N.** 2014. Seven V's of big data understanding big data to extract value. In: *Proceedings of the 2014 zone 1 conference of the American Society for Engineering Education*. DOI: https://doi.org/10.1109/ASEEZone1.2014.6820689

Khan, M, Islam, MZ and **Hafeez, M.** 2012. Evaluating the performance of several data mining methods for predicting irrigation water requirement. In *The 10th Australasian Data Mining Conference: AusDM 2012* (pp. 199–208). Australian Computer Society Inc.

Kirwan, CG and **Zhiyong, F.** 2020. Smart cities and artificial intelligence: convergent systems for planning, design, and operations. Elsevier.

Kitchin, R. 2014. The real-time city? Big data and smart urbanism. *Geo Journal*, 79: 1–14. DOI: https://doi.org/10.1007/s10708-013-9516-8

Lynch, K. 1981. *A theory of good city form*. Cambridge, MA: MIT Press.

McCarthy, J. 2007. *What is artificial intelligence?*Stanford University, Stanford: Computer Science Department.

Neirotti, P, De Marco, A, Gagliano, AC, Mangano, G and **Scorrano, F.** 2014. Current trends in Smart City initiatives: Some stylised facts. *Cities*, 38: 25–36. DOI: https://doi.org/10.1016/j.cities.2013.12.010

Neuman, M. 2005. The compact city fallacy. *Journal of planning education and research*, 25(1): 11–26. United States: Sage Publications; Thousand Oaks, CA. Oxford Press. DOI: https://doi.org/10.1177/0739456X04270466

Provost, F and **Fawcett, T.** 2013. *Data Science for Business*. Sebastopol, California.: O'Reilly Media, Inc.

Salim, H and **Basee, D.** 2023. Towards Smart Sustainable Iraqi Cities: Problems and Potentials, India: Center for Cities. *University of Moratuwa. ISVS e-journal*, 10(4).

Wheeler, SM and **Beatley, T.** 2010. (Eds.). *The Sustainable Urban Development Reader*. London, UK; New York, NY, USA: Routledge.

Williams, K, Jenks, M, Jenks, M and **Burton, E.** (eds.) 2000. *Achieving sustainable urban form*. Taylor & Francis.

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