

Identifying and Analysing Keywords Relevant to the Concept of Smart City

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Article Info:

Article history:

Received 25 February 2018

Received in revised form

2 March 2018

Accepted 15 March 2018

Available online 20 March 2018

Keywords: Expert Opinion; Idea Engineering Workshop; Keywords; Literature Review; Smart City; Scopus; Sustainability

Abstract

Researchers have defined 'Smart City' in many different ways, and its definition varies with and depends on the context. There is a need to define Smart City needs to properly framed. In this paper, 'Smart City' concept has been investigated. An extensive literature review conducted and definitions for Smart City are cited. Then the keywords of Smart City from these definitions and other research sources have been identified. Keywords are grouped into nine perspectives of smart city: Technology Perspective, Citizen Perspective, Infrastructure Perspective, Capability Perspective, Resources Perspective, Environment Perspective, Economy Perspective, Livability Perspective, and Sustainability Perspective. Keywords and views of Smart City have been further investigated using citations at Scopus. Based on a literature review, analysis of citation at Scopus and outcomes of brainstorming sessions during the idea engineering workshop, a new definition is developed and presented. Observed that the word Smart City is mostly documented in social sciences domain, which implies that idea of Smart City may be in the conceptual stage and extensive work is required to develop its success model.

1. Introduction

Cities as an important aspect of urban development have always been an attraction to the citizens as the cities provide more opportunities for employment and business, good facilities, and availability of resources, etc. It is due to the attraction towards the cities that more and more people dwell in the cities. As the cities become more and more populated the need to organise resources, transportation, services, infrastructure, etc. also increases. A city needs to become smart, so to provide a sustainable quality lives to its inhabitants.

Keeping in view the current scenario, we need to identify ways towards managing newer challenges/threats in developing these Smart cities. Globally smart cities have initiated to see forward for solutions enabling mixed land uses, transportation linkages, and public services of high-quality with long-lasting economic growth (V. Albino, et al. 2015).

1.1 Need for the Research

In India and also in other major developing countries the government wants to develop cities which can connect the customers and give them an extensive competitive advantage regarding living conditions. This research is being undertaken to understand the operational definition of a smart city. We have found from the research gaps that a very clear cut (most appropriate) definition of the smart cities (including all important aspects) is not available. Mostly cities are linked to some major issues as required by the government of population. A success model of the same is not available. The clarity of this definition will necessarily make the effective implementation of Smart City (SMC) concept in the Indian context.

1.2 Objectives of research

Main objectives of this article are as follows:

- To understand about SMC by carrying out extensive literature review
- To identify research status in area of SMC
- To identify different definitions of SMC based on the literature reviewed To identify the keywords related to SMCs and grouping them into smart city perspectives

- To analyse the keywords and perspectives of SMC using Scopus database
- Establishing a definition of SMC in Indian context

1.3 Organization of the paper

Section 1 deals with an introduction; the need for research; objectives of research; and organisation of paper. Section 2 deals with the methodology used in the article. Section 3 deals with definitions of SMC. In section 4 status of research in SMC area has been investigated through bibliometrics analysis. In section 5 the keywords have been identified and analysed using the statistical technique. Section 6 presents findings of the paper. Section 7 shows a definition of a smart city, section 8 offers discussions, and section 9 gives concluding remarks and future research scope.

2. Methodology

The method used to attain objectives of paper is presented in the form of the flowchart as shown in Figure 1. The first step is to collect all the definitions of Smart City as obtained through extensive literature review. Next step is to analyse these definitions to find out the keywords that have been used again and again by the researchers in forming the definitions of Smart City. These keywords are then to group into different perspectives of Smart City. Now the next step is to analyse the definitions, keywords and views of Smart City through literature review, Scopus Database, and Idea Engineering Workshop, to construct a definition of SMC. Then this definition of SMC is to be further analysed by Idea Engineering Workshop for any improvement. If the definition is found to be satisfactory, then it is to be finalised and presented.

3. SMC Definitions

Presented the review of available literature noted on smart cities and Tabulated the relevant definitions been tabulated in Table 1.

4. Status of research on Smart City through bibliometrics analysis

Figure 2a shows the literature trend of SMC from the year 1990 to the year 2016. Figure 2b shows subject area wise percentage distribution of SMC literature from the year 1990 to 2016. Figure 2c shows a country-wise depiction of the number of documents related to SMC. Table 2 lists top ten authors, based on the number of documents related to SMC.

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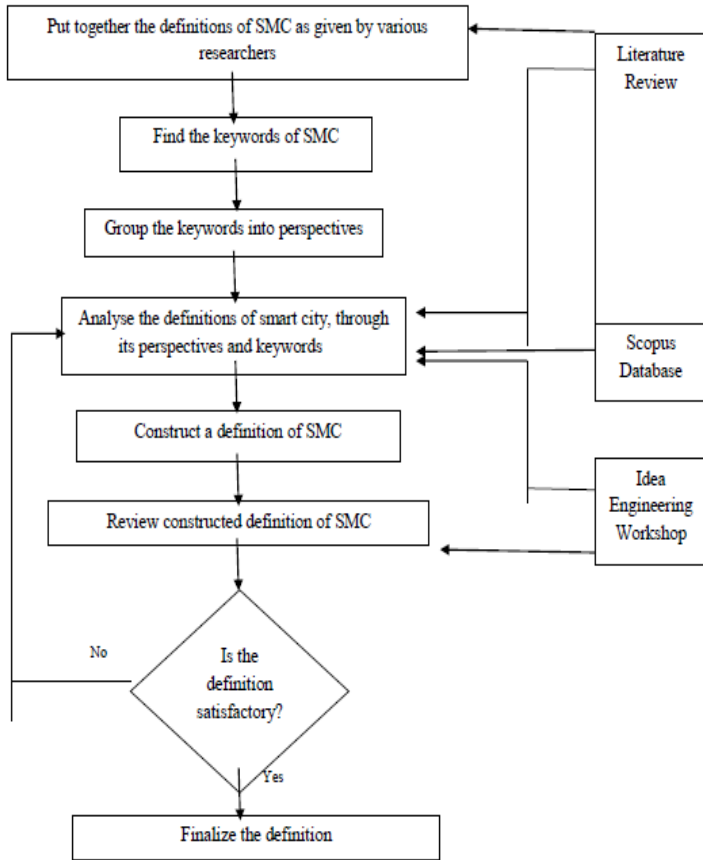


Fig. 1: Methodology Flowchart

Figure 2b shows that most of the documents in which the term SMC is cited belong to the area of social sciences, computer science and engineering. Observed from Figure 2c, that most of the literature on the smart city originated from United States, United Kingdom and China. Only two thousand documents originated from India.

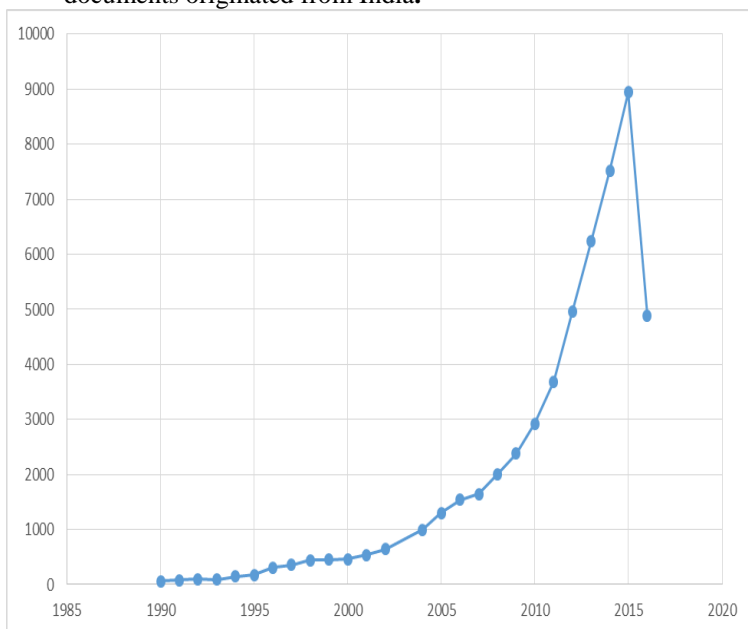


Fig.2(a): Smart City Frequency

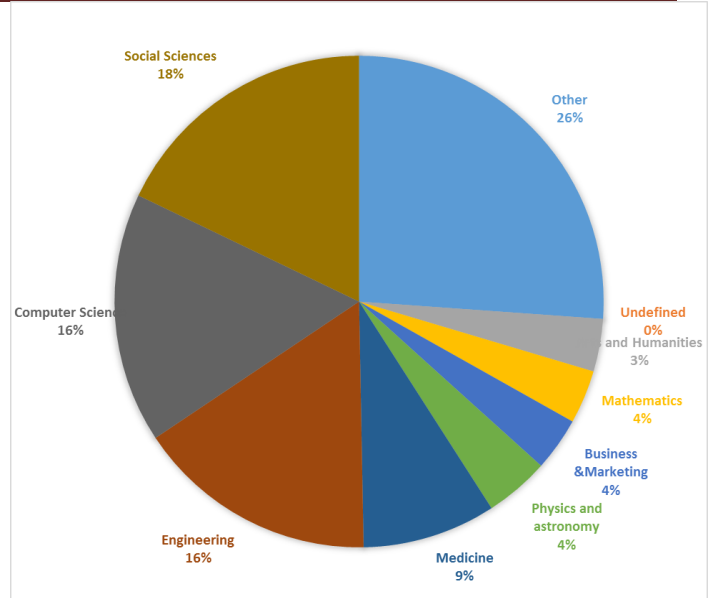


Fig.2(b): Subject area wise percentage distribution of Smart City literature from the year 1990 to 2016

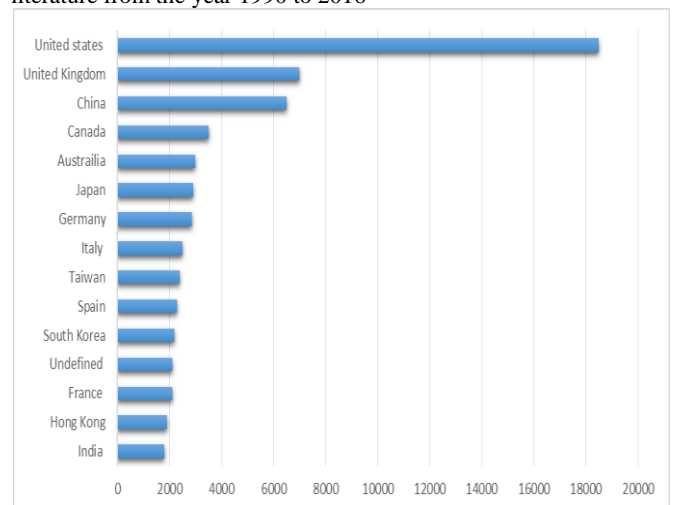


Fig.2(c): Country wise depiction of the number of documents related to Smart City (Only top 15 shown)

Table 2: Top ten authors, based on the number of documents related to Smart City

S. No.	Authors	Citations
1	Bocci, A.	640
2	Brandt, A	630
3	Qian, J.	620
4	Zieminska, D.	610
5	Acharya, B.S	605
6	Deniov, S.P	600
7	Schamberger, R.D.	595
8	Sawyer, L	590
9	Neal, H.A	580
10	Shabalina	580

Table 1: Definitions of SMCs obtained through Literature review

Definition	Reference	Keywords
1. "Smart technologies (like ICT such as connected mobile terminals, sensors, and actuators) monitoring and integrating infrastructure have been found important."	Hall, R. E. , 2000	Information and Communication Technology; Connected mobile terminals; Sensors and actuators; Integration; Infrastructure
2. "City monitoring and integrating conditions of key infrastructural facilities (such as major buildings, bridges, roads, rails, tunnels, subways, seaports, airports, communications, power and water) may play important role towards optimizing its resources, planning its preventive maintenance activities, and monitoring aspects related to security and most importantly maximizing services to citizens"	Hall, R. E., 2000	Monitoring; Integration; Resource Optimisation; Preventive maintenance activities; security aspects; services to its citizens
3. "City connecting physical infrastructure, IT infrastructure, business infrastructure and social infrastructure to leverage the collective intelligence of city."	J. Hartley, 2005	Infrastructure Connectivity; Collective Intelligence
4. "City empowering inhabitants towards participating in decisions and shaping smart cities."	Partridge, H., 2004	Citizen Empowerment; Decision making
5. "City well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens."	Giffinger et al., 2007	Performing; economy; People; Environment; Living; Governance; Mobility; Independent Citizens; Awareness; Self-decisive
6. "Several research projects have focused on smart city indicators. These are often grouped into clusters, the more common ones being smart people, smart environment, smart economy, smart living, smart governance, and smart mobility."	European Union, 2014 R. Giffinger et al., 2007	People; Environment; Economy; Living; Governance; Mobility
7. "Adapt to the changing needs of users."	Mars-Maestre et al, 2008	Adaptation; Users
8. "A city with a high degree of economic competitiveness is considered as having one of the primary drivers for a smart city."	R. Giffinger et al., 2008	Economic competitiveness
9. "A city that connects the physical infrastructure, IT infrastructure, social infrastructure, and business infrastructure by utilising the intelligence data set that belongs to the city."	Eger, 2009	Connectivity; Intelligence data set; Physical infrastructure; IT infrastructure; Social Infrastructure; Business infrastructure
10. "City built to create itself "smarter" (more livable, efficient, equitable and sustainable)"	Ingram et al., 2009.	Efficient; Sustainable; Equitable; Liveable
11. "City connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city."	Harrison et al., 2010	Connectivity of Infrastructure; Physical Infrastructure; IT Infrastructure; Social Infrastructure; Business Infrastructure; Collective Intelligence
12. "A city combining ICT and Web technology with other organisational, design and planning efforts to dematerialize and speed up bureaucratic processes and help to identify new, innovative solutions to city management complexity, to improve sustainability and livability."	Toppeta, 2010	Combining; Information communication technology; Web Technology; Organisational efforts; Design efforts; Planning; Dematerialize; Bureaucratic processes; Innovative solutions; Management complexity; Sustainability; Livability
13. "Link smart economy (competitiveness), smart people (social and human capital), smart governance (participation), smart mobility (transport and ICT), smart environment (natural resources) and smart living (quality of life)"	Giffinger & Haindlmaier 2010	Linkage; 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)
14. "Usage of technologies related to Smart Computing towards making critical infrastructure components and services of a city (such as education, city administration, public safety, healthcare, transportation, real estate utilities that are more efficient, intelligent and better interconnected)"	Washburn et al., 2010	Smart Computing technologies; critical infrastructure; administration; education; healthcare; public safety; real estate; transportation; utilities; intelligent; interconnected; efficient
15. "The integration of technology into a strategic approach to sustainability, citizen well-being, and economic development."	Pike , 2011	Integration; Technology; sustainability; citizen well-being; economic development
16. "SMC will take advantage of communications and sensor capabilities sewed into the cities' infrastructures to optimise electrical, transportation, and other logistical operations supporting daily life, thereby improving the quality of life for everyone."	Chen, 2010	communications and sensor capabilities; infrastructures; optimise; electrical; transportation; logistical operations; quality of life
17. "City that is intelligently responding to various kinds of needs including environmental protection, daily livelihood, city services public safety, and activities related to commercial and industrial;	K. Su, et al, 2011.	Intelligent responses; city services; industrial and commercial activities; daily livelihood; environmental protection; public safety
18. "City to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality	A. Caragliu, et al., 2011	Investments; high quality of life; wise management; natural resources; participatory governance; human and social capital; traditional

of life, with a wise management of natural resources, through participatory governance.”		(transport); modern (ICT) communication infrastructure; fuel sustainable economic growth
19. “An SMC is based on intelligent exchanges of information that flow between its many different subsystems. This flow of information is analysed and translated into citizen and commercial services. The city will act on this information flow to make its wider ecosystem more resource efficient and sustainable. The information exchanged is based on a smart governance operating framework designed to make cities sustainable.”	Gartner, 2011	intelligent exchanges of information; citizen; commercial services; wider ecosystem; resource efficient; sustainable; smart governance; sustainable
20. “The application of complex information system to integrate the operation of urban infrastructure and services such as building, transportation, electrical and water distribution and public safety.”	C. Harrison & Donnelly, 2011.	Electrical and water distribution; public safety; complex information system; integrate; urban infrastructure and services; building; transportation
21. “SMCs are cities that have a high quality of life; those that pursue sustainable economic development through investments in human and social capital, and traditional and modern communications infrastructure (transport and information communication technology); and manage natural resources through participatory policies. Smart cities should also be sustainable, converging economic, social, and environmental goals.”	Thuzar, 2011	High quality of life; sustainable economic development; investments; human and social capital; Traditional and modern communications infrastructure (transport and information communication technology); manage natural resources; participatory policies; sustainable; converging economic, social, and environmental goals
22. “SMC infuses information into its physical infrastructure to improve conveniences, facilitate mobility, add efficiencies, conserve energy, improve the quality of air and water, identify problems and fix them quickly, recover rapidly from disasters, collect data to make better decisions, deploy resources effectively, and share data to enable collaboration across entities and domains”	Nam and Pardo, 2011	infusion of information; physical infrastructure; conveniences; facilitate mobility; add efficiencies; conserve energy; improve the quality of air and water; identify problems and fix them quickly; recover rapidly from disasters; collect data; better decisions; deploy resources effectively; share data to enable collaboration
23. “The application of information and communications technology (ICT) with their effects on human capital/education, social and relational capital and environmental issues often indicated by the notion of the smart city.”	Lombardi et al., 2012	information and communications technology (ICT); human capital; education; social; relational capital; environmental issues
24. “SMC are the result of knowledge-intensive and creative strategies aiming at enhancing the socio-economic, ecological, logistic and competitive performance of cities. Such smart cities are based on a promising mix of human capital (e.g. skilled labour force), infrastructural capital (e.g. high-tech communication facilities), social capital (e.g. intense and open network linkages) and entrepreneurial capital (e.g. creative and risk-taking business activities)”	Kourtit and Nijkamp, 2012	knowledge-intensive; creative strategies; socio-economic; ecological; logistic; competitive performance; a mix of human capital (e.g. skilled labour force); infrastructural capital (e.g. high-tech communication facilities); social capital (e.g. intense and open network linkages); entrepreneurial capital (e.g. creative and risk-taking business activities)
25. “SMC, according to ICLEI, is a city that is prepared to provide conditions for a healthy and happy community under the challenging conditions that global, environmental, economic and social trends may bring.”	Guan, 2012	healthy and happy community; global trends; environmental trends; economic trends; social trends
26. “SMCs may be recognised as smart devices, networks of sensors, ICT integration in all aspects of human life and real-time data; and using new thinking paradigms, SMCs need to do all about economy and governance.”	Cretu, 2012	Governance; economy; new thinking paradigms; networks of sensors; smart devices; real-time data; ICT integration; human life.
27. “Being SMC means using all available technology and resources in an intelligent and coordinated manner to develop urban centres that are at once integrated, habitable, and sustainable.”	Barrionuevo et al., 2012	Technology; resources; intelligent; coordinated; urban centres; integrated; habitable; sustainable
28. “Average Technology sized attractive community with attributes such sustainability, interconnect-ability, comfort, and security.”	Lazaroiu and Roscia, 2012	Technology; interconnected; sustainable; comfortable; attractive; secure
29. “Smart City is a city to use ICT in improving participatory process and governance to determine the appropriate public services and transport investment, which can ensure the social and economic development sustainable, improving the life’s quality and natural resources management.”	Ludlow, 2012.	ICT; Governance; public services; transport; social; economic; sustainable; quality of life; natural resources
30. “Cities using ICTs to served their citizens by providing services.”	Madakam, Somayya, and R. Ramaswamy, 2013	Information and communication technologies; services; citizens
31. “Supporting innovation and low-carbon economy; SMC utilises ICTs to become increasingly intelligent and efficient in smart usage of resources towards aiming at energy and cost savings, improved delivery of service and life’s quality, and reduced environmental footprint.”	Madakam, Somayya, and R. Ramaswamy, 2013	Information and Communication Technologies (ICT); Intelligent; Efficient; Resources; cost and energy savings; service delivery; quality of life; environmental footprint; innovation; Low carbon economy.

32. "SMC should enable every citizen to engage with all the services on offer, public as well as private, in a way best suited to his or her needs. It brings together hard-infrastructure, social capital including local skills and community institutions, and (digital) technologies to fuel sustainable economic development and provide an attractive environment for all."	Department for Business Innovation & Skills, 2013	Citizen; services; hard infrastructure; social capital(local skills and community institutions); digital technologies; sustainable economic development; attractive environment
33. ""SMCs" are often attractive locations to live, work and visit; in fact, concept of SMC moves beyond transactional relationships between service provider and citizen; essentially enabling and encouraging citizen to become more participative and active by providing feedback regarding services' quality, built environment, state of roads, adopting more healthy sustainable lifestyle, supporting minority groups and volunteering for societal activities, providing better employment"	Department for Business Innovation & Skills, 2013	transactional relationships; citizen; service; encouraging the citizen; participative member; feedback; quality of services; the state of roads; built environment; sustainable; healthy lifestyle; social activities; supporting minority groups; Employment; attractive locations
34. "Cities having deployed or currently piloting ICT solutions integration across different functional areas (three or more in numbers)"	L. Arrowsmith, 2014.	Integration; ICT
35. "SMC understanding as certain intellectual ability addressing several innovative socio-economic aspects and socio-technical of growth These issues lead to SMC conceptions as: <ul style="list-style-type: none"> • "Interconnected" referred to revolution of broadband economy, • "Intelligent" declaring capacity to create added value information from processing of real-time data from sensors and activators, • "Green" referring to urban infrastructure for environment protection and reduction of CO2 emission, • Whereas terms "innovating" and "knowledge" cities interchangeably relates to city's ability to raise innovation based on knowledgeable and creative human capital." 	Zygiaris 2013	intellectual ability; innovative; socio-technical; socio-economic; green urban infrastructure; environment protection; CO2 emission; Interconnected; broadband economy; intelligent; added value information; real-time data; sensors and activators; innovating knowledge; innovation; knowledgeable; creative human capital
36. "A smart city is one of solution that may be utilised towards solving problems and challenges of the city. SMC is a concept in managing resources effectively and efficiently to maximise service to its citizens."	Samsun, et al. 2014,	manage resources effectively and efficiently; service; citizens
37. "SMCs are required to identify and implement linkages among various fields of action such as energy, mobility, governance, buildings, urban planning and stakeholder processes."	Smart City Schweiz , 2014b	Link; Mobility; Energy; Buildings; Governance; stakeholder processes; urban planning
38. "SMC is enabled by usage of ICTs towards improving competitiveness and ensuring enhanced sustainable future through spaces, symbiotic people networks, technologies, businesses, infrastructures, energy, consumption."	The European Union, 2014	ICT technologies; Competitiveness; sustainable future; symbiotic networks; people; businesses; technologies; infrastructures; consumption; energy; spaces
39. "SMCs are envisioned as creating a better and more sustainable city, in which people's quality of life is improved, while their environment is more liveable and their economic prospects are stronger."	J.H. Lee et al. 2014	sustainable city; quality of life; environment; Liveable; economic prospects
40. "An innovative city that uses information and communication technologies and other means to improve the quality of life, the efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations on economic, social and environmental aspects."	ITU 2014b.	Innovative city; information and communication technologies; quality of life; efficiency; urban operation; services; competitiveness; economic; social; environmental
41. "This concept is based on the adoption of ICT in a way to increase global competitiveness and revitalise economic opportunities."	Tannaz & Umberto, 2015	ICT; economic opportunities
42. "The current scenario requires cities to find ways to manage new challenges. Cities worldwide have started to look for solutions which enable transportation linkages, mixed land uses, and high-quality urban services with long-term positive effects on the economy. For instance, high-quality and more efficient public transport that responds to economic needs and connects labour with employment is considered an essential element for city growth. Many of the new approaches relate to public services that are based on harnessing technologies, including ICT."	V. Albino, et al. 2015	manage new challenges; transportation linkages; mixed land uses; high-quality urban services; economy; public transport; economic needs; connects; employment; urban services; harnessing technologies; including ICT
43. "Smart City is a next level of the 'intelligent digital city'. The concept of SC is driven by the next generation of technology dimensions by using Information and Communication Technologies (ICTs) infrastructure to build and integrate critical infrastructures	A. Halepoto, et al., 2015	Digital; intelligent; technology; Information and Communication Technologies (ICTs) infrastructure; Build; Integrate; Infrastructures; Services; spatial information; intelligent sensing

and services for the cities. SC utilises spatial information and intelligent sensing technologies to integrate and collaborate with urban information systems to efficiently manage the city resources to develop a sustainable city.”		technologies; collaborate; urban information systems; efficiently manage; resources; sustainable
44. “Smart cities seen as systems of interwoven, ICT enriched systems ubiquitous in urban environments. Smart city planning is a practice that utilises digital data for normative, policy-based objectives like sustainable urban development.”	Susa and Aija, 2015	Interwoven; ICT; urban environments; planning; digital data; policy-based objectives; sustainable development
45. “In India, the concept of a 'smart city' is perceived as advanced, something more suited for cities of developed nations. After all, it entails the application of sustainable solutions to overcome difficult problems and involves the use of sophisticated and expensive technology developed by the private sector.”	Rumi and Kristian, 2015	Advanced; sustainable solutions; sophisticated and expensive technology
46. “It designates those cities which are governed by the pervasive use of manifold digital devices, and most notably sensors, with the aim of providing more accurate data intelligence for better decision-making.”	Martin and Tomás, 2015	manifold digital devices; sensors; data intelligence; Decision-making.
47. “A city may be considered smart when investments in human and social capital, infrastructures and services are incorporated into ICT services to drive inventive ways to deal with practical development towards sustainable economic growth.”	Pinaki& Mahesh, 2015	Investments; human and social capital; infrastructures; services; ICT; Inventive; practical development; sustainable; economic growth
48. “A city striving to make itself “smarter” (more efficient, sustainable, equitable, and livable)”	Natural Resources Defense Council.	Efficient; Sustainable; Equitable; livable
49. “An inclusive description of a smart city would be that it is an urban structure that utilises information and communication technologies to enhance livability, improve workability, maximise sustainability and transform the practices of governance, urban planning and management. A more data-focused definition is that it is a city that can produce, collect and analyse data to enable ‘intelligent’ decisions and predictive analysis for better planning and development.”	Salem, F. 2016	urban structure; utilises information and communication technologies; livability; workability; sustainability; governance; urban planning and management; produce, collect and analyse data; intelligent decisions; predictive analysis; planning; development.
50. “Smart City should be a city, where the information and data are collected from the different kind of sources and with different kind of systems. These data should be effectively collected and distributed only to the authorised individuals. These data are after analysed and used for making the city processes more effective. This should lead to the improvement in the various interest areas of the city. Considering the IoT concept, the several parameters should be considered: power and cost efficiency (millions of devices are considered), security (personal, trade and critical data might transmit), technology performance (urban areas, closed environment) and many others. Several communication technologies might be used for this task.”	Radek and Pavel	information and data; effective; IoT concept; power and cost efficiency; security (personal, trade and critical data might transmit); technology performance (urban areas, closed environment); communication technologies

As observed from Table 2, top contributor in the literature work on the smart city is the Bocci, A., Brandt, A., Qian, J., Zieminska, D.

5. Identification and Categorization of Keywords

AS evident from Table 1, the information and communication technology, sustainability, services to citizens, integration of infrastructure, effective utilisation of resources, livable environment, are the important keywords of an SMC. Further, observed that keywords identified in Table 1 have been huge in number. These keywords are grouped into nine perspectives and depicted below:

- Technology Perspective
- Citizen Perspective
- Infrastructure Perspective
- Capability Perspective
- Resources Perspective
- Environment Perspective
- Economy Perspective

- Livability Perspective
- Sustainability Perspective

Table 3 presents the keywords associated with Technology perspective of SMC. The frequency of keywords, as appeared in Smart City definitions from literature, is also shown.

Observation: As evident from the above Table 3 that Information & Communication Technology is cited for twenty times in referred literature of SMC. It has the highest frequency among all the keywords in Technology Perspective of SMC.

Figure 3 shows the literature trend of the term Technology as it is utilised in the context of SMC from the year 1990 to the year 2016, available on Scopus database.

Table 4 presents the keywords associated with Citizen Perspective of SMC. The frequency of keywords alongwith egs, as appeared in SMC definitions from literature, is also shown

Table 3: Keywords Categorised under Technology Perspective

Keywords	Reference	Frequency
ICT (Information & Communication Technology)	Hall, R. E (2000), Toppeta, (2010), A. Caragliu, et al (2011), Thuzar (2011), Lombardi et al. (2012), Ludlow, (2012), Madakam, et al.(2013), L. Arrowsmith, (2014), European Union, (2014), ITU (2014b), V. Albino, et al (2015), Tannaz& Umberto(2015), A. Halepoto, et al (2015), Susa and Aija (2015), Pinaki & Mahesh, (2015), Pinaki & Mahesh, (2015), Radek and Pavel, Salem, F. (2016), Cretu (2012), Kourtit and Nijkamp (2012)	20

Smart digital devices, Sensors and Actuators	Hall, R. E (2000), Chen (2010), Cretu (2012), Zygiaris (2013), Martin and Tomás (2015), A. Halepoto, et al. (2015)	6
Intelligence data set, data collection and sharing	Eger (2009), Nam and Pardo (2011), Cretu (2012), Zygiaris (2013), Susa and Aija (2015), Martin and Tomás(2015), Salem, F. (2016)., Radek and Pavel, Valerio, L., Passarella, et al. (2016)	10
Web technology	Toppeta, (2010), Radek and Pavel, Kourtit and Nijkamp (2012), Pardo and Nam, (2016), Sun et al. (2016), Zhu et al. (2016).	6
Smart digital sophisticated Computing technologies	Giffinger & Haindlmaier (2010), Pike(2011), Lazaroiu and Roscia (2012), Barrionuevo et al. (2012), Department for Business Innovation & Skills, 2013, European Union, (2014), A. Halepoto, et al. 2015, Rumi and Kristian (2015)	8
Information knowledge system	C. Harrison & Donnelly, (2011), Gartner (2011), Nam and Pardo (2011), Zygiaris (2013), A. Halepoto, et al. (2015), Kourtit and Nijkamp (2012)	8
Total		57

Table 4: Keywords Categorised under Citizen Perspective

Keywords	Reference	Frequency
Services	Hall, R. E (2000), Pinaki & Mahesh, (2015), A. Halepoto, et al (2015), V. Albino, et al (2015), ITU (2014b), Samsun, et al (2014), Department for Business Innovation & Skills, (2013), Madakam, et al. (2013), Ludlow, (2012), Gartner (2011), Nam and Pardo (2011)	11
Citizen Empowerment, Awareness	Partridge, H. (2004), Giffinger et al. (2008), Department for Business Innovation & Skills, (2013), Vlachokyriakos, et al. (2016), Chiodi, S. I. (2016), Degbelo et al. (2016), Prado et al. (2016).	7
Smart, independent citizens	European Union, (2014), Giffinger, et al. (2007), Giffinger & Haindlmaier (2010), Gartner (2011), Mars-Maestre, et al. (2008), Madakam et al.(2013), Department for Business Innovation & Skills, (2013), Samsun, et al. (2014)	8
Governance	European Union, (2014), Giffinger, et al. (2007), Giffinger&Haindlmaier (2010), Gartner (2011), Cretu (2012), Ludlow, (2012), Smart City Schweiz (2014b), Salem, F. (2016), A. Caragliu,et al (2011), Washburn, et al. (2010), Thuzar (2011), Department for Business Innovation & Skills, (2013), Anthopoulos, & Reddick, (2016)	13
Human and Social Capital	A. Caragliu, et al *2012), Thuzar (2011), Lombardi et al. (2012), Lombardi et al. (2012), Guan (2012), Ludlow, (2012), Department for Business Innovation & Skills, (2013), Zygiaris (2013), ITU (2014b), Pinaki & Mahesh, (2015), Kourtit and Nijkamp (2012)	11
Education	Washburn et al. (2011), Lombardi et al. (2012), Meijer & Bolívar (2016), Kantarci et al. (2016).	4
public safety	Washburn et al. (2013), K. Su, et al (2011), C. Harrison & Donnelly, (2011), Lazaroiu and Roscia (2012), Hall, R. E (2000), Radek and Pavel	6
healthy and happy community	Guan (2012), Washburn et al. 2012, Pike(2011), Yau et al. (2016), Prado et al. (2016), Irungbam, R. S. (2016).	6
Employment	Department for Business Innovation & Skills, 2013, V. Albino, et al. (2015), Kim et al.(2016), Batty, M. (2016), Wall & Stavropoulos (2016)	5
Total		69

As evident from the Table 4, “Governance” has been cited thirteen times, and “Services” and “Human and Social Capital” have been cited for eleven times in referred literature of SMC. They have the highest frequency among all the keywords in Citizen Perspective of SMC.

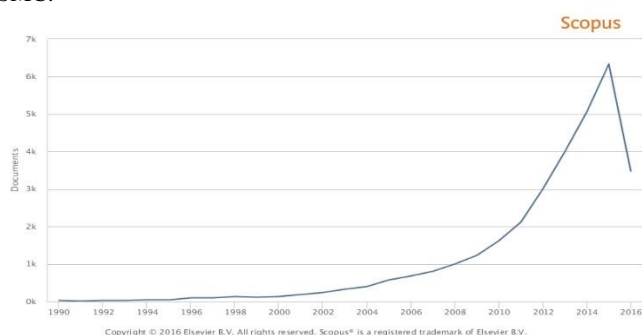


Fig. 3: Frequency of the term Technology with Smart City

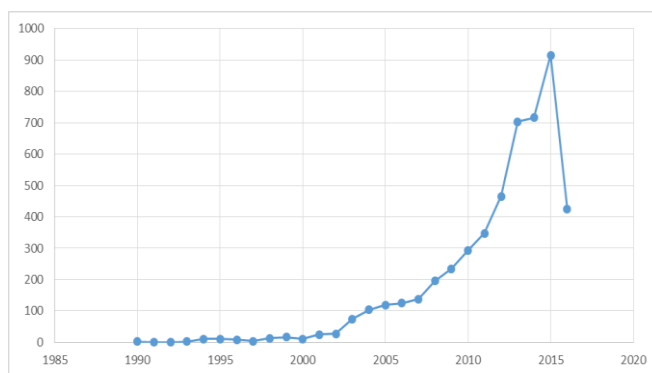


Fig.4: Frequency of the term Citizen with Smart City
Figure 4 shows the literature trend of the term Citizen as it is utilised in the context of SMC from the year 1990 to the year 2016, available on Scopus database.

Figure 4, depicts that the numbers of smart city documents which have used the term “Citizen” are on a constant rise in numbers, this shows more concern for the citizen-centric design.

Table 5 presents the keywords associated with Infrastructure perspective of SMC. The frequency of keywords, as appeared in SMC definitions from literature, is also shown.

Table 5: Keywords Categorised under Infrastructure Perspective

S.No	Keyword	Reference	Frequency
1	Infrastructure Connectivity	Hall, R. E (2000), European Union, (2014), A. Halepoto et al. (2015), Pinaki & Mahesh, (2015), Chen (2010), J. Hartley, (2005)	6
2	Physical infrastructure	Eger (2009), Harrison, et al (2010), Nam and Pardo (2011), Department for Business Innovation & Skills, (2013)	4
3	IT infrastructure	Eger (2009), Harrison et al. (2010), Bulkeley et al. (2016), Giordano et al. (2016), Tiwari, A. (2016)	5
4	Social infrastructure	Eger (2009), Harrison, et al (2010), Hashem, (2016), Raj & Dwivedi (2016)	4
5	Business infrastructure	Eger (2009), Washburn et al. (2010), K. Su, et al (2011), Harrison, et al. (2010)	4
6	transportation & logistical operations	Chen (2010), C. Harrison & Donnelly, (2011), Washburn, et al.(2010), Giffinger & Haindlmaier (2010)	4
7	green urban infrastructure	Zygiaris (2013), C. Harrison & Donnelly, (2011), Smart City Schweiz (2014b), Salem, F. (2016).	4
Total			30

As evident Table 5, “Infrastructure Connectivity” is cited for six times in the referred literature of SMC. It has the highest frequency among all the keywords in Infrastructure Perspective of Smart City. Figure 5 shows the literature trend of the term Infrastructure in the context of SMC from the year 1990 to the year 2016, available on Scopus database.

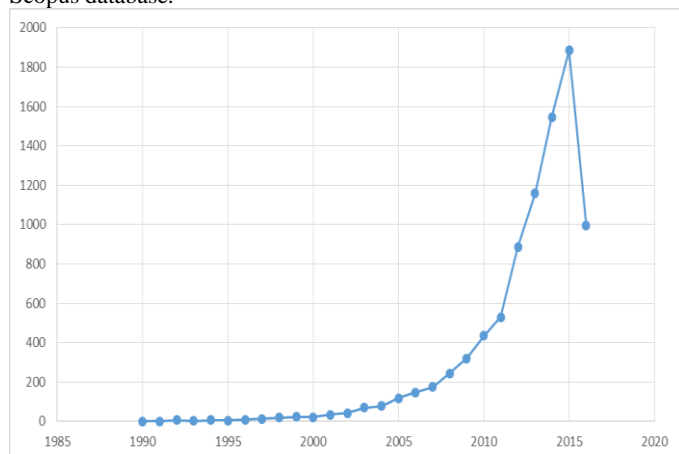


Fig. 5: Frequency of the term Infrastructure with Smart City

Table 6 presents the keywords associated with Capability perspective of SMC. The frequency of keywords, as appeared in SMC definitions from literature, is also shown.

Table 6: Keywords Categorised under Capability Perspective

Keyword	Reference	Frequency
Advanced Monitoring	Hall, R. E. (2000), Rumi and Kristian (2015), Bowerman et al. (2000), Filipponi, L., Vitaletti et al. (2010), Al-Hader & Rodzi (2009), Unnithan et al. (2016), Misra, A. (2016), Obringer et al. (2016).	8
Integration	Hall, R. E (2000), C. Harrison & Donnelly, (2011), Barrionuevo et al. (2012), L. Arrowsmith, (2014), A. Halepoto, et al (2015)	6
Preventive maintenance	Hall, R.E(2000), Salem, F. (2016), Termizi et al. (2016)	3
Decision making	Partridge, H. (2004), Giffinger, et al (2008), Nam and Pardo (2011), Martin and Tomás (2015), Salem, F. (2016), Ingram, et al. (2009), Alawadhi & Scholl (2016)	7
Adaptive	Mars-Maestre et al. (2008), Nam and Pardo (2011), Poxrucker et al. (2016), Ramaswami et al.(2016)	4
Strategic Management	Toppeta, (2010), V. Albino et al. 2015, Salem, F. (2016)A. Caragliu et al. 2011, Kourtit and Nijkamp (2012), Susa and Aija 2015, Smart City Schweiz (2014b), Susa and Aija 2015	9
Innovative	Toppeta, (2010), Zygiaris (2013), ITU (2014b), Vestergaard et al. (2016)	5
Interconnected	Washburn, et al. 2011, Zygiaris (2013), Meijer & Bolívar (2016), Strasser & Albayrak (2016), Barrionuevo et al. (2012), Mao et al. (2016)	6
Disaster Management	Nam and Pardo (2011), Yim et al. (2015), Palmieri et al. (2016), Zhao et al. (2016)	4
Competitive performance	Kourtit and Nijkamp (2012), Giffinger, et al (2007), European Union, (2014), ITU (2014b), Pinaki & Mahesh, (2015), Madakam et al. (2013)	6
Intelligent	Madakam et al. (2013), Zygiaris (2013), A. Halepoto, et al. (2015), Barrionuevo et al. (2012), K. Su, et al 2011, Washburn, et al. (2010), J. Hartley, (2005), Harrison, et al. 2010, Boes et al.(2016), David et al. (2015)	11
Efficient	Madakam et al.(2013), Radek and Pavel, Washburn et al. (2012), A. Halepoto, et al. (2015), Ingram, et al., (2009), Nam and Pardo (2011)	7
Total		82

As evident from the above Table 6 that “Advanced Monitoring” and “Intelligent” have been cited for eight and eleven times respectively in referred literature of Smart Cities. These keywords have the highest frequency among all the keywords in Capability Perspective of SMC.

Figure 6 shows the literature trend of the term Capability as it is utilised in the context of SMC from the year 1990 to the year 2016, available on Scopus database.

Table 7 presents the keywords associated with Resources perspective of SMC. The frequency of keywords, as appeared in Smart City definitions from literature, is also shown.

Table 7 shows that “Manage resources effectively and efficiently” has been cited for eight times in referred literature of SMC. It has the highest frequency among all the keywords in Resources Perspective of SMC.

Figure 7 shows the literature trend of the term “Resources” as it is utilised in the context of SMC from the year 1990 to the year 2016, available on Scopus database.

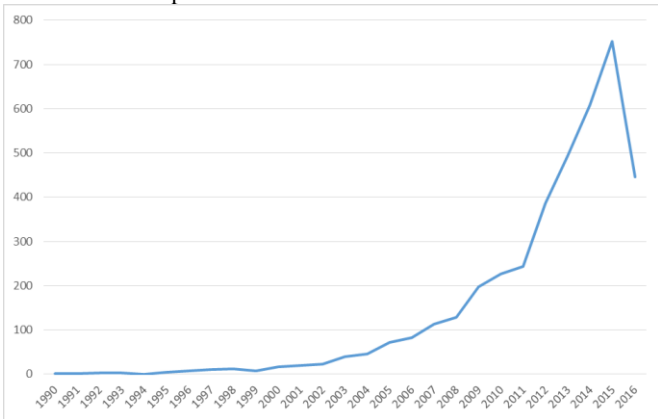


Fig. 6: Frequency of the term Capability with Smart City

Table 7: Keywords Categorised under Resources Perspective

Keyword	Reference	Frequency
Energy conservation	Nam and Pardo (2011), Kaur et al. (2016), Kudo & Granier (2016), Smart City Schweiz (2014b), European Union, (2014)	5
Natural resources	Ludlow, (2012), Department for Business Innovation & Skills, (2013), Barrionuevo et al. (2012), A. Caragliu, et al (2011),A. Halepoto, et al (2015)	5
Manage resources effectively and efficiently	Samsun et al. (2014), Radek and Pavel, ITU (2014b), Thuzar (2011), Nam and Pardo (2011), Gartner (2011), Hall, R. E (2000), V. Albino, et al., (2015)	8
Total		18

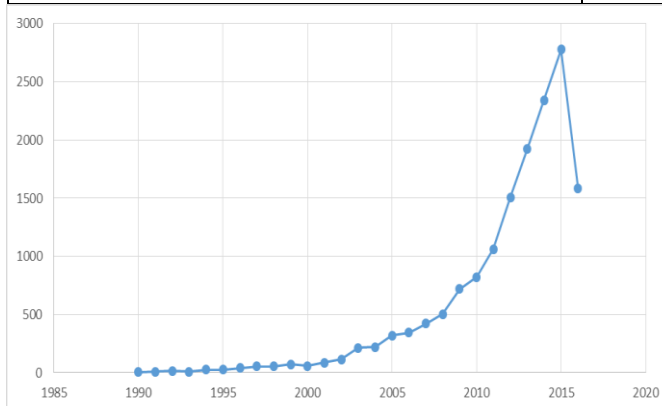


Fig.7: Frequency of the term Resources with Smart City

Table 8: Keywords Categorised under Environment Perspective

Keyword	Reference	Frequency
Environment	The European Union,(2014), Giffinger et al. 2007, Giffinger &	12

	Haindlmaier (2010), Lombardi et al. (2012), Guan (2012), J.H. Lee, et al. 2014, ITU 2014b, Susa and Aija 2015, Zygiaris (2013), K. Su, et al 2011, Thuzar (2011), Madakam et al. (2013)	
Ecological	Kourtit and Nijkamp (2012), Mao et al. (2016), Zhang et al. (2016), Gartner (2011), Curry et al. (2016)	5
Low carbon	Madakam et al. (2013), de Jong et al. (2015), Kylili et al. (2015), Digiesi et al. (2015), Zygiaris (2013)	5
Total		22

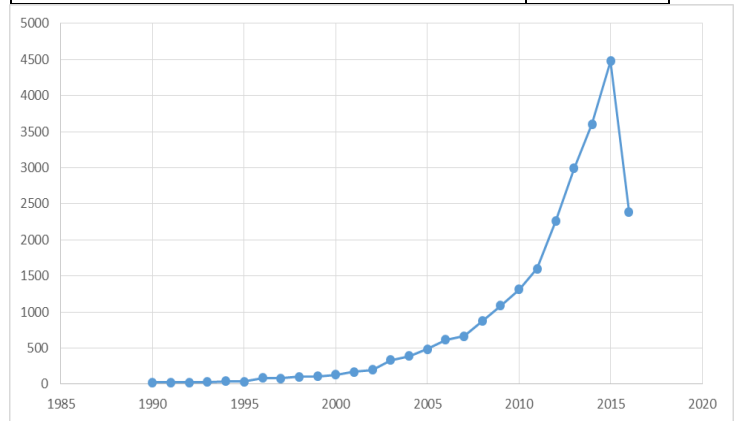


Fig. 8: Frequency of the term Environment with Smart City

Table 9 Keywords Categorised under Economic Perspective

Keyword	Reference	Frequency
Economy	European Union, (2014), Giffinger, et al (2007), Cretu (2012), Ludlow, (2012), ITU 2014b,V. Albino et al. (2015), Giffinger & Haindlmaier (2010), Guan (2012), J.H. Lee et al. (2014)	9
Economic competitiveness	Giffinger, et al. 2008, Liao et al. (2017), Romero et al. (2016),	4
socio-economic	Kourtit and Nijkamp (2012), Meijer & Bolívar (2016), Zygiaris (2013)	3
economic needs	V. Albino, et al 2015, Haarstad, H. (2016), Pardo & Nam (2016).	3
economic opportunities	Tannaz & Umberto(2015), Ramaswami (2016),Tan (2016)	3
economic growth	Pinaki& Mahesh,2015, Bulkeley et al. (2016), Anthopoulos et al. (2016), Batty, M. (2016).	4
Total		25

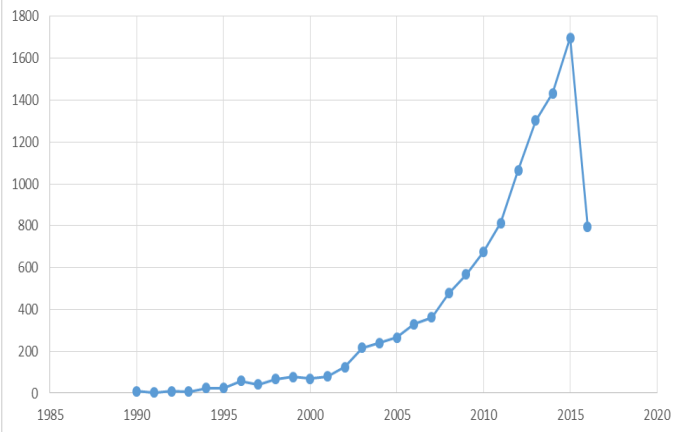


Fig. 9: Frequency of the term Economy with Smart City

Figure 8 shows the literature trend of the term Environment in the context of SMC from the year 1990 to the year 2016, available on Scopus database.

Table 9 presents the keywords associated with Economy perspective of SMC. The frequency of keywords, as appeared in Smart City definitions from literature, is also shown.

Table 9 depicts that “Economy” is cited nine times in referred literature of Smart Cities. It has the highest frequency among all the keywords in Economy Perspective of Smart City.

Figure 9 shows the literature trend of the term Economy as it is utilised in the context of SMC from the year 1990 to the year 2016, available on Scopus database.

Table 10 presents the keywords associated with Livability perspective of SMC. The frequency of keywords, as appeared in Smart City definitions from literature, is also shown.

Table 10 shows that “Livable” is cited ten times in referred literature of Smart Cities. It has the highest frequency among all the keywords in “Livability” Perspective of Smart City.

Figure 10 shows the literature trend of the term Livability as it is utilised in the context of SMC from the year 1990 to the year 2016, available on Scopus database.

Table 11 presents the keywords associated with Sustainability perspective of SMC. The frequency of keywords, as appeared in Smart City definitions from literature, is also shown.

Table 11: Keywords Categorised under Sustainability Perspective

Keyword	Reference	Frequency
Live able	Ingram, et al , 2009,Toppeta, (2010), Natural Resources Defense Council, Salem, F. (2016),J.H. Lee, et al 2014,Barrionuevo et al. (2012), European Union,(2014), Giffinger, et al 2007,Giffinger&Haindlmaier (2010), K. Su, et al2011.	10
the high quality of life	A. Caragliu, et al 2011,Thuzar (2011),Chen (2010),Ludlow, 2012,Madakam et al.(2013),J.H. Lee, et al 2014,ITU 2014b,V. Albino et al. 2015, Lazaroiu and Roscia (2012)	9
healthy lifestyle	Department for Business Innovation &Skills, 2013, Sharma, T. (2016), Urzaiz et al. (2015), Hollands (2015), Gil-Garcia et al. (2015)	5
attractive locations	Department for Business Innovation & Skills, 2013, Lazaroiu and Roscia (2012), Batty, M. (2016).	3
Total		27
Sustainable	Ingram,et al., 2009, Toppeta, (2010), Pike(2011), A. Caragliu,et al 2011, Gartner (2011), Thuzar (2011), Lazaroiu and Roscia (2012), Barrionuevo et al. (2012), Ludlow, 2012, Department for Business Innovation & Skills, 2013, A. Halepoto, et al 2015, Pinaki &Mahesh,2015, Salem, F. (2016), Natural Resources Defense Council, J.H. Lee, et al 2014	14
sustainable future	European Union, (2014), Pereira, V., & Fernandes, F. (2016), Lambrechts, J., & Sinha, S. (2016)	5
sustainable development	Susa and Aija 2015, Rumi and Kristian2015	4
Total		23

We observe from the above Table 11 that “Sustainable” is cited for fourteen times in referred literature of Smart Cities. It has the highest frequency among all the keywords in Sustainability Perspective of Smart City.

Figure 11 depicts the literature trend of the term Sustainability as it is utilised in the context of SMC from the year 1990 to the year 2016, available on Scopus database.

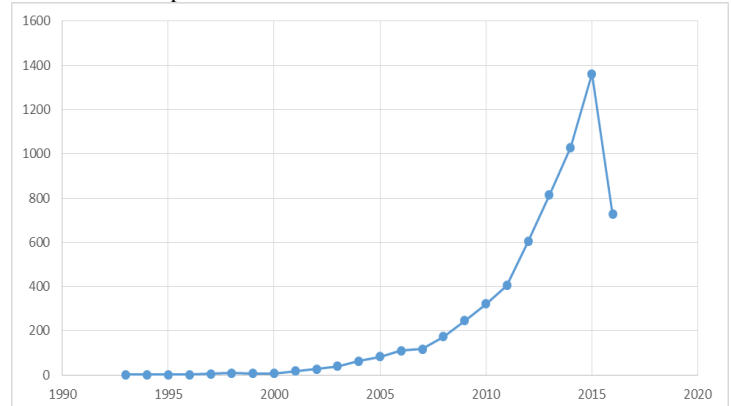


Fig.11: Frequency of the term “Sustainability” with “Smart City.”

Table 10: Keywords Categorised under Livability Perspective

Keyword	Reference	Frequency
Live able	Ingram, et al , 2009,Toppeta, (2010), Natural Resources Defense Council, Salem, F. (2016),J.H. Lee, et al 2014,Barrionuevo et al. (2012), European Union,(2014), Giffinger, et al 2007,Giffinger&Haindlmaier (2010), K. Su, et al2011.	10
the high quality of life	A. Caragliu, et al 2011,Thuzar (2011),Chen (2010),Ludlow, 2012,Madakam et al.(2013),J.H. Lee, et al 2014,ITU 2014b,V. Albino et al. 2015, Lazaroiu and Roscia (2012)	9
healthy lifestyle	Department for Business Innovation &Skills, 2013, Sharma, T. (2016), Urzaiz et al. (2015), Hollands (2015), Gil-Garcia et al. (2015)	5
attractive locations	Department for Business Innovation & Skills, 2013, Lazaroiu and Roscia (2012), Batty, M. (2016).	3
Total		27

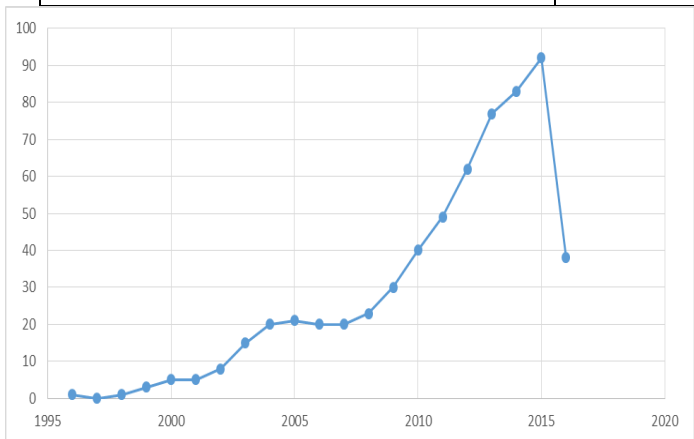


Fig. 10: Frequency of the term Livability with Smart City

Table 8 presents the keywords associated with Environment perspective of SMC. The frequency of keywords, as appeared in Smart City definitions from literature, is also shown.

As evident from the Table 8 that Environment has been cited for twelve times in referred literature of Smart Cities. It has the highest frequency among all the keywords in Environment Perspective of Smart City.

6. Findings

Following are the findings from the literature review and bibliometric study performed throughout the paper.

- Table 2 shows that since the year 1990 the term 'Smart City' is cited in more than fifty thousand documents.
- Table 3 depicts that "Information & Communication Technology" is cited for twenty times in the referred literature of SMC. It has the highest frequency among all the keywords when Technology Perspective of SMC is considered.
- Numbers of SMC documents which have used the term Technology are on a constant rise in numbers. This shows that technology has major role to play in smart cities.
- Table 4 shows that "Governance" has been cited thirteen times, and "Services" and "Human and Social Capital" have been cited for eleven times in referred literature of Smart Cities. They have the highest frequency among all the keywords in Citizen Perspective of Smart City.
- As evident the numbers of smart city documents which have used the term "Citizen" are on a constant rise in number, thus Smart cities developers/researchers give more focus on citizens.
- It is evident from the Table 5 that "Infrastructure Connectivity" has been cited for six times in referred literature of Smart Cities. It has the highest frequency among all the keywords in Infrastructure Perspective of Smart City.
- Table 6 shows that "Advanced Monitoring" and "Intelligent" have been cited for eight and eleven times respectively in referred literature of Smart Cities. These keywords have the highest frequency among all the keywords in Capability Perspective of Smart City.
- Table 7 shows that "Manage resources effectively and efficiently" has been cited for eight times in referred literature of Smart Cities. It has the highest frequency

among all the keywords in Resources Perspective of Smart City.

- Table 8 shows that "Environment" is cited for twelve times in referred literature of Smart Cities. It has the highest frequency among all the keywords in Environment Perspective of Smart City.
- As evident from the Table 9 that "Economy" is cited for nine times in referred literature of Smart Cities. It has the highest frequency among all the keywords in Economy Perspective of Smart City.
- Table 10 depicts that "Livable" has been cited for ten times in referred literature of Smart Cities. It has the highest frequency among all the keywords in "Livability" Perspective of Smart City.
- Table 11 depicts that "Sustainable" is cited for fourteen times in referred literature of Smart Cities. It has the highest frequency among all the keywords in Sustainability Perspective of Smart City.

7. Consolidating the Definition of smart city

Smart City definition involving all the important keywords is presented as follows:

"A city which is intelligent, innovative and knowledgeable, which utilises its resources and infrastructure in an optimum manner with the help of advanced technologies (like information and communication technology) to provide a high quality of life and services to its citizens who are participative and devoted to sustainable development."

7.1 Discussions

From SMC literature, definitions of SMC were analysed for keywords further grouped into smart city perspectives. Scopus Database was used to analyse the perspectives of the smart city by their frequency of appearing in the Scopus documents. Table 12 gives the importance and implications of the findings of the paper.

Table 12: Implications of findings

S. No.	Finding/s	Importance/ Utility of the finding	Implications /Applications	
			Academics	Industry
1	Since the year 1990, term SMC has been cited in more than fifty thousand documents.	'Smart City' has been emerging as a very important research area	It will open up new perspectives/dimensions for future research.	It will help industry to understand the requirements for Smart City development
2	Information & Communication Technology has been cited for twenty times in referred literature of Smart City definitions. It has the highest frequency among all the keywords in Technology Perspective of Smart City.	ICT has been observed as an important enabler for Smart City development and required to be included in policy planning for implementation of 'Smart City' concept.	Academics may focus on the Technological perspective of Smart City development and work towards developing ICT based technologies suited for SMC development.	The industry may develop technology and products in accordance to fulfil the technical infrastructure requirements for SMC development.
3	Smart City documents which have used the term 'Technology' are on a constant rise in numbers.	As technology is advancing, new opportunities and ideas arise for the development of Smart City.	Engineering research has constantly been increasing as new and innovative technologies are required for Smart City development.	It seems helpful to the industry in their project planning as to what kind of products may be required in the development of Smart City.
4	"Governance" has been cited thirteen times, and "Services" and "Human and Social Capital" have been cited for eleven times in referred literature of Smart Cities. They have the highest frequency among	It implies the application of Smart laws for SMC development.	Research required in area of Governance	E-governance products may be developed

	all the keywords in Citizen Perspective of Smart City.			
5	Smart City documents which have used the term Citizen are on a constant rise in numbers.	It shows that the citizens are very important part of Smart City. They are the customers and involving them in Smart City development is becoming necessarily important.	It will help social scientist to perform research on the involvement of citizens in Smart City development.	Citizen-oriented products need to be developed.
6	Infrastructure Connectivity has been cited for six times in referred literature of Smart Cities. It has the highest frequency among all the keywords in Infrastructure Perspective of Smart City.	Connected infrastructure is crucial to have Smart mobility.	Researchers can work on vehicle routeing problems for Smart mobility.	Infrastructure connectivity requires new infrastructure as well as remodelling of infrastructure which opens up opportunities for infrastructure industry.
7	“Advanced Monitoring” and “Intelligent” have been cited for eight and eleven times respectively in referred literature of Smart Cities. These keywords have the highest frequency among all the keywords in Capability Perspective of Smart City.	Surveillance and monitoring ensure safety for the citizens. An intelligent city will utilise its resources in a smart manner which leads to sustainable development.	Managing of big data is a challenge which is generated from monitoring systems and other ICT based technologies employed in Smart City. Researchers may work on findings ways to manage this big data.	The industry may develop products for advanced monitoring and surveillance systems.
8	“Resource Management” has been cited for eight times in referred literature of Smart Cities. It has the highest frequency among all the keywords in Resources Perspective of Smart City.	Smart management of resources is important for developing Smart City to be sustainable. The future of Smart City depends upon the effective and efficient utilisation of its resources.	Research in the area of resource management for Smart City.	Smart tools and equipment for proper utilisation of resources.
9	The word environment has been cited for twelve times in referred literature of Smart Cities. It has the highest frequency among all the keywords in Environment Perspective of Smart City.	Environment drives livability of the Smart City. It needs careful attention while developing a Smart City.	Research in the area of environmental issues and impact on climate while developing Smart City.	Pollution control tools and products with no or less environmental effects need to be developed
11	“Livable” has been cited for ten times in referred literature of Smart Cities. It has the highest frequency among all the keywords in “Livability” Perspective of Smart City.	A city is considered smart only if the citizens prefer to live in it.	The scope of research for social scientists as well.	To develop Luxury-oriented products
12	“Sustainable” has been cited for fourteen times in referred literature of Smart Cities. It has the highest frequency among all the keywords in Sustainability Perspective of Smart City.	A city is smart if it maintains its smartness in the future as well. Therefore sustainable development if necessary while developing Smart City.	Sustainability is a broad area of research, and the research may be done keeping Smart City development in view.	Sustainable product development is required.
13	Definition of SMC: ‘A city which is intelligent, innovative and knowledgeable, which utilises its resources and infrastructure in an optimum manner with the help of advanced technologies (like information and communication technology) to provide a high quality of life and services to its citizens who are participative	This definition captures all the important perspectives of Smart City.	Smart City development may be evaluated by extent of complying to the definition	Smart City development may be evaluated by extent of complying to the definition

	and devoted to sustainable development.'			
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8. Concluding remarks and future research scope

In this paper, investigations have been made to understand the research direction in smart city using literature review & bibliometric study using Scopus database. A large number of cited definitions of SMC have been examined for keywords. Nine perspectives of Smart City namely Technology Perspective, Citizen Perspective, Infrastructure Perspective, Capability Perspective, Resources Perspective, Environment Perspective, Economy Perspective, Livability Perspective, and Sustainability Perspective, were analysed using Scopus Database. Based on which, we conclude that this paper will help policy planners to move in a well-directed way for developing smart cities in India. This article may help our policy planners in identifying the major issues that will be involved, and it will help in determining requirements for Smart City in India.

Researchers will benefit from this paper as it contains important data about SMCs. They may use this data to model SMC theoretically and see how different factors affect each other to develop a framework for SMC in Indian view. We observe that the word SMC has the maximum frequency in documented from social sciences domain, which implies that idea of Smart City is in the conceptual stage and a success model for the same needed. As for future research scope, some index may be created to measure smartness of an SMC.

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