

# The Role of Information and Communication Technologies (ICTs) in a Smart Sustainable City

Pradeep Agarwal<sup>1</sup>, Dr. Arvind K Sharma<sup>2,3,4</sup>

<sup>1,2</sup>Dept. of CSI, University of Kota, Rajasthan, India

<sup>3</sup>DAV Kota, Rajasthan, India

<sup>4</sup>PhD Supervisor, Career Point University, Rajasthan, Kota

**Abstract:** As a research domain, Smart city is only emerging area today. The concept of smart city has been gained importance in the past years, as a means of enabling services and applications available to the citizens, companies and authorities which are part of a system of the city. It aims at increasing citizen's quality of life and improving the efficiency and quality of the services provided by governing entities and businesses. In the context to Smart Cities, ICT Infrastructure is playing an important role that includes most aspects of ICT, both hardware and software. Smart City ICT infrastructure contains i.e. Network Infrastructure, Software Applications, Cloud Computing, Data Platforms, Access Devices and Communication related applications such as- Building Management, Smart Grids, Physical Safety, Security, Emergency Response, Traffic and Transportation. In this paper, we explore a conceptual framework that will help in the development of smart city services through Information and Communication Technologies (ICTs). The proposed framework integrates various technologies such as IoT, Cloud Computing, Mobile Computing, Pervasive Computing and Wireless Sensor Networks.

**Keywords:** Smart City, Smart Technology, ICT Framework

## I. INTRODUCTION

India is second most popular country in the world with 1.21 billion populations. By the end of 2050 the same will increase to 1.6. India also witnesses a substantial increase in the average size of urban areas. This has been made possible by a simultaneous upward shift in the urban technological frontier, so that a city could accommodate more inhabitants. Urban population is currently around 31 % of the total population. Contributing 60% of India GDP, it is also expected if urban scenario continues in the same speed, India will contribute about 75% national GDP by 2030. Lot of development in information technology took place. However, India fails in harnessing the role of IT in good governance while developing cities. Very little efforts have been done to devise a strategy for achieving urban growth in "Smart" sense for its metropolitan, municipal towns[1]. More than half of the World's population lives in urban areas [2,3]. India is also not the bar to this phenomenon since 31% population lives in urban area. This shift from a primarily rural to urban population is projected to continue for the next couple of decades. Such enormous and complex congregations of people inevitably tend to become unhealthy and disordered places [4]. Cities all over the

world exhibit complex dynamics. As cities grow, planners devise complex systems to deal with food supplies on an international scale, water supplies over long distances and local waste disposal, urban traffic management systems and so on; and the quality of all such urban inputs defines the quality of life of urban dwellers. Such Cities, megacities generate new kinds of problems, difficulty in waste management, scarcity of resources, air pollution, human health concerns, traffic congestions, and inadequate, deteriorating and aging infrastructures are among the more basic technical, physical, and material problems. The concept of Smart City embraces several definitions depending on the meanings of the word "Smart": intelligent city, knowledge city, ubiquitous city, sustainable city, digital city, etc. Many definitions of Smart City exist, but no one has been universally acknowledged yet. From literature analysis it emerges that Smart City and Digital City are the most used terminologies in literature to indicate the smartness of a city [5]. As discussed above, the concept of a smart city itself is still emerging, and the work of defining and conceptualizing it is still in progress [6][7].

## II. SEVERAL DEFINITIONS OF A SMART CITY

Several working definitions have been put forward and adopted in both practical and academic use. There is no standardized, commonly accepted set of terminologies or definitions that would help to describe a "Smart City". This section discusses some definitions of smart cities from different sources such as international organizations, governments and corporations.

1. A 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. [8]
2. A city that monitors and integrates conditions of all of its critical infrastructures, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens.[9]
3. A city "connecting the physical, the IT, the social, and the business infrastructure to leverage the collective intelligence of the city". [10]
4. A city striving to make itself "smarter" (more efficient, sustainable, equitable and liveable). [11]
5. A city "combining ICT and Web 2.0 technology with other organizational, design and planning efforts to dematerialize and speed up bureaucratic processes and help to identify new, innovative solutions to city management

complexity, in order to improve sustainability and livability.” [12]

6. “The use of Smart Computing technologies to make the critical infrastructure components and services of a city—(which include city administration, education, healthcare, public safety, real estate, transportation, and utilities)—more in intelligent, interconnected, and efficient”.[13]

7. Smart computing refers to a new generation of integrated hardware, software, and network technologies that provide IT systems and real-time awareness of the real World and advanced analytics and actions that optimize business processes [13].

8. The Natural Resources Defense Council [14] defines smarter in the urban context as more efficient, sustainable, equitable, and liveable.

9. Dirks and Keeling [15] consider a smart city as the organic integration of systems. The interrelationship between a smart city’s core systems is taken into account to make the system of systems smarter.

10. No system operates in isolation. In this sense, Kanter and Litow [16] consider a smarter city as an organic whole—a network and a linked system. The new intelligence of cities, then, resides in the increasingly effective combination of digital telecommunication networks (the nerves), embedded intelligence (the brains), sensors and tags (the sensory organs), and software (the knowledge and cognitive competence.

Analyzing different definitions of smart cities reveal that the different definitions emphasize different aspects of smart cities.

Smart cities can be identified along with the following dimensions:

- Smart Economy- Innovation and Competitiveness
- Smart Mobility- Transport and Infrastructure
- Smart Environment - Sustainability and Resources
- Smart People - Creativity and Social Capital
- Smart Living - Quality of Life and Culture
- Smart Governance - Empowerment and Participation

A smart city model is shown in figure 1 below.



Fig.1: A Smarty City Model

### III. FUNDAMENTAL FACTORS OF SMART CITY

This section discusses a set of fundamental factors of a smart city which make a city smart according to the literature. From the discussion of conceptual variants of smart city in the preceding section, we identify and clarify key conceptual components of smart city, and re-categorize and simplify them into three categories of core factors: technology (infrastructures of hardware and software), people (creativity, diversity, and education), and institution (governance and policy). Given the connection between the factors, a city is smart when investments in human/social capital and IT infrastructure fuel sustainable growth and enhance a quality of life, through participatory governance [17]. The core fundamental factors of a smart city are shown in fig. 2 below.

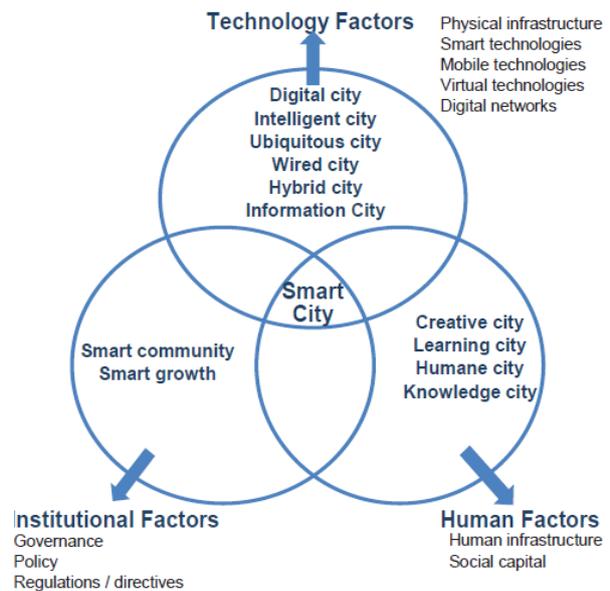


Fig.2: Fundamental Factors of a Smart City

#### 3.1 TECHNOLOGY FACTORS

Technology is key to being a smart city because of the use of ICT to transform life and work within a city in significant and fundamental ways [18]. A well-functioning infrastructure is absolutely necessary but not enough to become a smart city. IT Infrastructure and applications are prerequisites, but without real engagement and willingness to collaborate and cooperate between public institutions, private sector, voluntary organizations, schools and citizens there is no smart city [19]. Most studies on practices of smart city address issues of technological infrastructure and enabling technologies. The focus on infrastructure and technology stresses accessibility and availability of systems [20,21]. Contrasting with human infrastructure, technological infrastructures have other names such as physical infrastructure [22] and techno-ware. [23]

3.2 HUMAN FACTORS

The availability and quality of the IT infrastructure is not the only definition of smart city [24]. Importantly, other definitions stress the role of human infrastructure, human capital and education in urban development [25]. For urban development, Florida [26] suggested 3T (Tolerance, Technology and Talent), of which two are germane to people and their relationship. Smart people are an important component of smart city. The smart people concept comprises various factors like affinity to lifelong learning, social and ethnic plurality, flexibility, creativity, cosmopolitanism or open-mindedness, and participation in public life. Problems associated with urban agglomerations can be solved by means of creativity, human capital, cooperation among relevant stakeholders, and their bright scientific ideas: in a nutshell, “smart solutions” [24]. The label smart city therefore points to clever solutions by creative people. The category of human factors highlights creativity, social learning, and education. Smart city is a centre of higher education and smart workforce [27, 28].

The category of human factors also includes social inclusion of various urban residents in public services, soft infrastructure (knowledge networks, voluntary organizations, crime-free environments), urban diversity and cultural mix, social/human/relational capital, and knowledge base such as educational institutions and R & D capacities [29,30].

3.3 INSTITUTIONAL FACTORS

The support of government and policy for governance is fundamental to the design and implementation of smart city initiatives. This category comprises a variety of institutional factors drawing from the discussion of smart community or smart growth initiatives: not just supportive policies but also the role of government, the relationship between government agencies and non-government parties, and their governance. It is necessary to establish administrative environment (Initiatives, Structure and Engagement) supportive for smart city [31]. To enable smart city initiatives, the category should also include integrated and transparent governance, strategic and promotional activities, networking, and partnerships [32].

The transformation to smart city entails interactions of technological components with political, institutional and transitional components [33]. Political components represent endogenous political elements (directions, city council, city government, city mayor), harmonized by exogenous ones (international pressures, agenda, projects, strategies in prevalence) and verified by best practices. Institutional components are prerequisites as well. Institutional readiness such as removing legal and regulatory barriers is important. Transitional components comprise visions, leadership, and organizational transition in structure. A successful smart city can be built from top down or bottom up approaches, but active involvement from every sector of the community is essential. United efforts create synergy, which allows individual projects to build

upon each other for faster progress, resulting in the involved, informed and trained critical mass necessary for transformation of how the entire community carries out its work.

IV. RESEARCH METHODOLOGY

This paper has been exploratory in nature where pertinent information gathered from various secondary sources of data, such as, journals, books, websites, reports, etc. India’s Smart City Project India is witnessing a rapid pace of urbanization, which has been expected to continue in the coming decades.

According to recent studies and reports, by 2030:

- 40% of India’s population will be living in urban areas
- 68 cities will have a population of more than 1 million
- 70% of net new employment will be generated in cities

It is estimated that, on average, about 75% of the global economic production takes place in Cities, and Indian urban areas will also follow the trend and account for nearly 70% of the Country’s GDP by 2030.

By 2020, housing shortage will be reaching about 30 million dwelling units, 200 million new water connections will be required, 250 million people will have to be given access to sewage, 160 GW of power generating capacity will have to be added and the number of vehicles on our urban roads will increase by 5 times. Utilizing Smart Cities experience and technology accessible around the world, India can drive the much-needed transformation to a nation of Smart Cities. This might to be continued along two streams: The first includes: Modernization and overhauling of existing Cities in India, where the focus will be on developing and implementing practical solutions that can work ideally with legacy systems and infrastructures. The other stream will include the creation of new Smart Cities from the ground up by leveraging international best practices. In each case- as evident globally- along with requisite investment in all aspects of urban infrastructure, investment will be required in adapting ICT-enabled management systems and data-driven analytics and decision making in urban planning and operations.

4.1 ICT FRAMEWORK FOR SMART CITY

Smart city begins as Internet-based cyber city in computers and has been advanced to the current status [34]. The ICT framework for smart city development in India is shown in fig. 2.

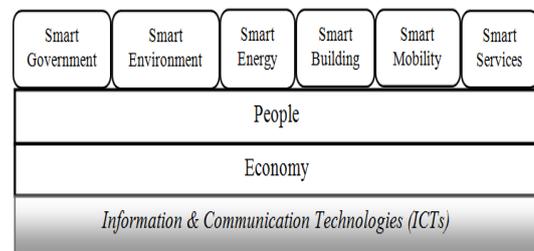


Fig.3: ICT framework for Smart City

This ICT framework consists of the six essential components such as: Smart Government, Smart Environment, Smart Energy, Smart Building, Smart Mobility [35-36], and Smart Services. The function of each component is summarised in the following table-1.

Table-1: Functions of Six Components

Component(s)	Function(s)
Smart Government	- Support necessary services to citizens - Management of various infrastructure
Smart Environment	- Environmentally-friendly factors - Green IT
Smart Energy	- Means Smart grid - Basic energy infrastructure
Smart Building	- Control automatically by sensors - Provide buildings with clean and economic environment
Smart Mobility	- Traffic services with more intelligences - Optimize the traffic flow
Smart Services	- Service type provided to citizen - Environment, learning, culture, etc

#### 4.2 CONCEPTUAL FRAMEWORK FOR SMART CITY

The smart city framework is comprehensive and holistic driven by the unique challenges faced due to rapid urbanization in India. In this paper, we have been presenting a conceptual framework for smart city development in India. The proposed conceptual framework for smart city development is shown in fig. 3. (Please refer to Appendix-A).

The following are the key objectives of smart city development in India:

- Smart cities can lead to sustainable development of the society.
- Participation of both government and people is required to make a smart city.
- Smart city should be helpful to reduce problems of transportation, pollution, unemployment and provide business opportunities to the public.

#### V. CONCLUSION

In Smart Sustainable City (SSC), ICT tools are acting as the “glue” between the different physical infrastructures. This paper states the several aspects regarding the new, still immature strategies of Smart city and Digital city. Need of the time is to transform modern cities into smart cities to avoid problems of unemployment, pollution, transportation etc. The primary goal of a Smart Sustainable City (SSC) is to achieve a sustainable urban environment without sacrificing comfort and convenience / quality of life of citizens through the use of Information and Communication Technologies (ICTs). In this paper, two frameworks such as- conceptual framework and ICT framework for the smart city development in India are presented.

#### VI. REFERENCES

- [1] Dr. T.N. Boob, Transformation of Urban Development in to Smart Cities: The Challenges , IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Vol.12, Issue 3 Ver. II (May-Jun 2015), PP 24-30
- [2] Dirks, S., Gurdgiev, C., & Keeling, M. (2010). Smarter Cities for Smarter Growth: How Cities Can Optimize their Systems for the Talent-Based Economy. Somers, NY: IBM Global Business Services.
- [3] Dirks, S., Keeling, M., & Dencik, J. (2009). How Smart is your City: Helping Cities Measure Progress. Somers, NY: IBM Global Business Services.
- [4] Johnson, B. (2008). Cities, Systems of Innovation and Economic Development. *Innovation: Management, Policy & Practice*, 10(2-3), 146-155.
- [5] Annalisa Cocchia, *Smart and Digital City: A Systematic Literature Review*, Springer International Publishing Switzerland 2016.
- [6] Boulton, A., Brunn, S. D., & Devriendt, L. (2011). *Cyber Infrastructures and “Smart” World Cities: Physical, Human, and Soft infrastructures*.
- [7] Taylor, P., Derudder, B., Hoyler, M., & Witlox, F. (Eds.), *International Handbook of Globalization and World Cities*. Cheltenham, UK: Edward Elgar. [http://www.neogeographies.com/documents/cyberinfrastructure\\_smart\\_world\\_cities](http://www.neogeographies.com/documents/cyberinfrastructure_smart_world_cities).
- [8] Hollands, R.G. (2008). Will the real smart city please stand up? *City*, 12(3), 303-320.
- [9] Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanović, N., & Meijers, E. (2007). *Smart Cities: Ranking of European Medium-Sized Cities*. Vienna, Austria: Centre of Regional Science (SRF), Vienna University of Technology. <http://www.smartcities>.
- [10] Hall, R. E. (2000). The Vision of a Smart City. In *Proceedings of the 2nd International Life Extension Technology Workshop*, Paris, France, Sept. 28.
- [11] Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszcak, J., & Williams, P. (2010). *Foundations for Smarter Cities*. IBM Journal of Research and Development, 54(4).
- [12] Natural Resources Defense Council. What are smarter cities, <http://smartercities.nrdc.org/about>.
- [13] Toppeta, D. (2010). *The Smart City Vision: How Innovation and ICT Can Build Smart, “Livable”, Sustainable Cities*. The Innovation Knowledge Foundation.
- [14] Washburn, D., Sindhu, U., Balaouras, S., Dines, R. A., Hayes, N. M., & Nelson, L. E. (2010). *Helping CIOs Understand “Smart City” Initiatives: Defining the Smart City, Its Drivers, and the Role of the CIO*. Cambridge, MA: Forrester Research, Inc.
- [15] Natural Resources Defence Council. What are Smarter Cities, Available from <http://smartercities.nrdc.org/about.defines-smarter-in-the-urban-context-as-more-efficient-sustainable-equitable-and-livable>.
- [16] Dirks, S., & Keeling, M. (2009). *A Vision of Smarter Cities: How Cities Can Lead the Way into a Prosperous and Sustainable Future*. Somers, NY: IBM Global Business Services.
- [17] Caragliu, A., Del Bo, C., & Nijkamp, P. (2009). *Smart Cities in Europe*. In *Proceedings of the 3rd Central European Conference in Regional Science (Kosice, Slovak Republic, Oct 7-9)*.
- [18] Hollands, R. G. (2008). Will the real smart city please stand up? *City*, 12(3), 303-320.
- [19] Lindskog, H. (2004). *Smart Communities Initiatives*. In *Proceedings of the 3rd IS One World Conference (Las Vegas, NV, Apr 14-16)*.

- [20] Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovi, N., & Meijers, E. (2007). *Smart Cities: Ranking of European Medium-Sized Cities*. Vienna, Austria: Centre of Regional Science (SRF), Vienna University of Technology.
- [21] Giffinger, R., & Gudrun, H. (2010). *Smart Cities Ranking: An Effective Instrument for the Positioning of Cities?* *ACE: Architecture, City and Environment*, 4(12), 7-25.
- [22] Boulton, A., Brunn, S. D., & Devriendt, L. (Forthcoming). *Cyberinfrastructures and "smart" world cities: Physical, human, and soft infrastructures*. In P. Taylor, B. Derudder, M. Hoyler & F. Witlox (Eds.), *International Handbook of Globalization and World Cities*. Cheltenham, U.K.: Edward Elgar.
- [23] Malek, J. A. (2009). *Informative global community development index of informative smart city*. In *Proceedings of the 8th WSEAS International Conference on Education and Educational Technology* (Genova, Italy, Oct 17-19).
- [24] Caragliu, A., Del Bo, C., & Nijkamp, P. (2009). *Smart cities in Europe*. In *Proceedings of the 3rd Central European Conference in Regional Science* (Košice, Slovak Republic, Oct 7-9).
- [25] Boulton, A., Brunn, S. D., & Devriendt, L. (Forthcoming). *Cyberinfrastructures and "smart" world cities: Physical, human, and soft infrastructures*. In P. Taylor, B. Derudder, M. Hoyler & F. Witlox (Eds.), *International Handbook of Globalization and World Cities*. Cheltenham, U.K.: Edward Elgar.
- [26] Florida, R. (2002). *The Rise of the Creative Class: And How It's Transforming Work, Leisure, Community and Everyday life*. New York: Basic Books.
- [27] Glaeser, E. L., & Berry, C. R. (2006). *Why are smart places getting smarter?* *Taubman Center Policy Briefs*, PB-2006-2.
- [28] Winters, J. V. (2010). *Why are smart cities growing? Who moves and who stays*. *Journal of Regional Science*, 20(10), 1-18.
- [29] Hollands, R. G. (2008). *Will the real smart city please stand up?* *City*, 12(3), 303-320.
- [30] Yigitcanlar, T., O'Connor, K., & Westerman, C. (2008a). *The making of knowledge cities: Melbourne's knowledgebased urban development experience*. *Cities*, 25(2), 63-72.
- [31] Yigitcanlar, T., & Velibeyoglu, K. (2008). *Knowledge-based urban development: The local economic development path of Brisbane, Australia*. *Local Economy*, 23(3), 195-207.
- [32] Odendaal, N. (2003). *Information and communication technology and local governance: Understanding the difference between cities in developed and emerging economies*. *Computers, Environment and Urban Systems*, 27(6), 585-607.
- [33] Mauher, M., Smokvina, V. (2006). *Digital to intelligent local government transition framework*. In *Proceedings of the 29th International Convention of MIPRO* (Opatija, Croatia, May 22-26).
- [34] S. H. Lee and D. W. Lee, "A Study on Digital Convergence and Smart City", *Journal of Digital Policy & Management*, vol. 11, no. 9, (2013), pp. 167-172.
- [35] L. Figueiredo, I. Jesus, J. A. T. Machado, J. R. Ferreria, J. L. Martins de Carvalho, "Towards the development of intelligent transportation Systems", *Proc. IEEE Intelligent Transportation Systems*, (2001), pp. 1206-1211.
- [36] F. Y. Wang, C. Herget, D. Zeng, "Developing and Improving transportation systems, The Structure and Operation", *IEEE Trans. Intelligent Transportation Systems*, Vol. 6, No.3, (2005), pp. 261-264.

*The Conceptual Framework for Smart City Development*

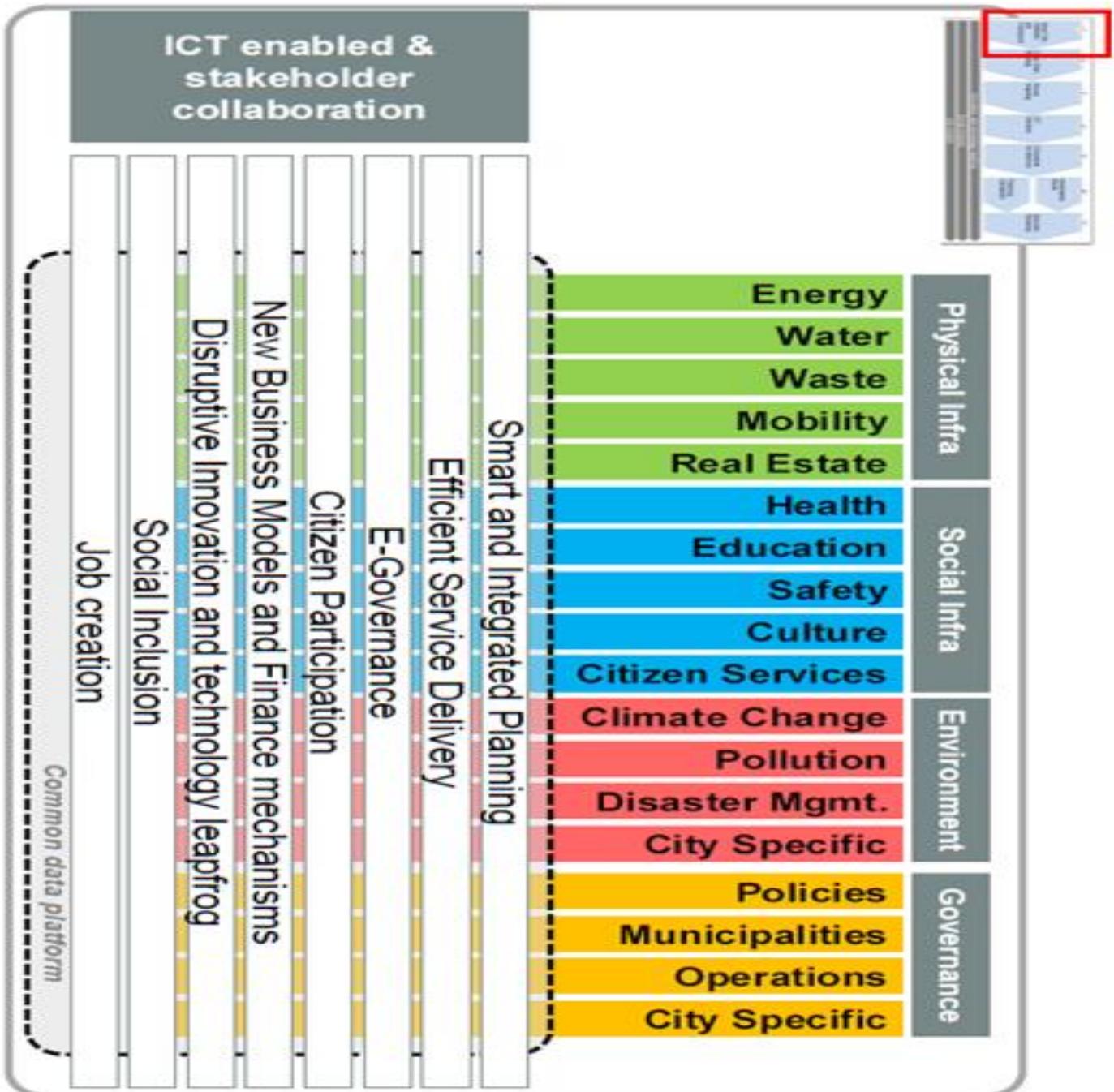


Fig.4: Conceptual Framework For Smart City Development