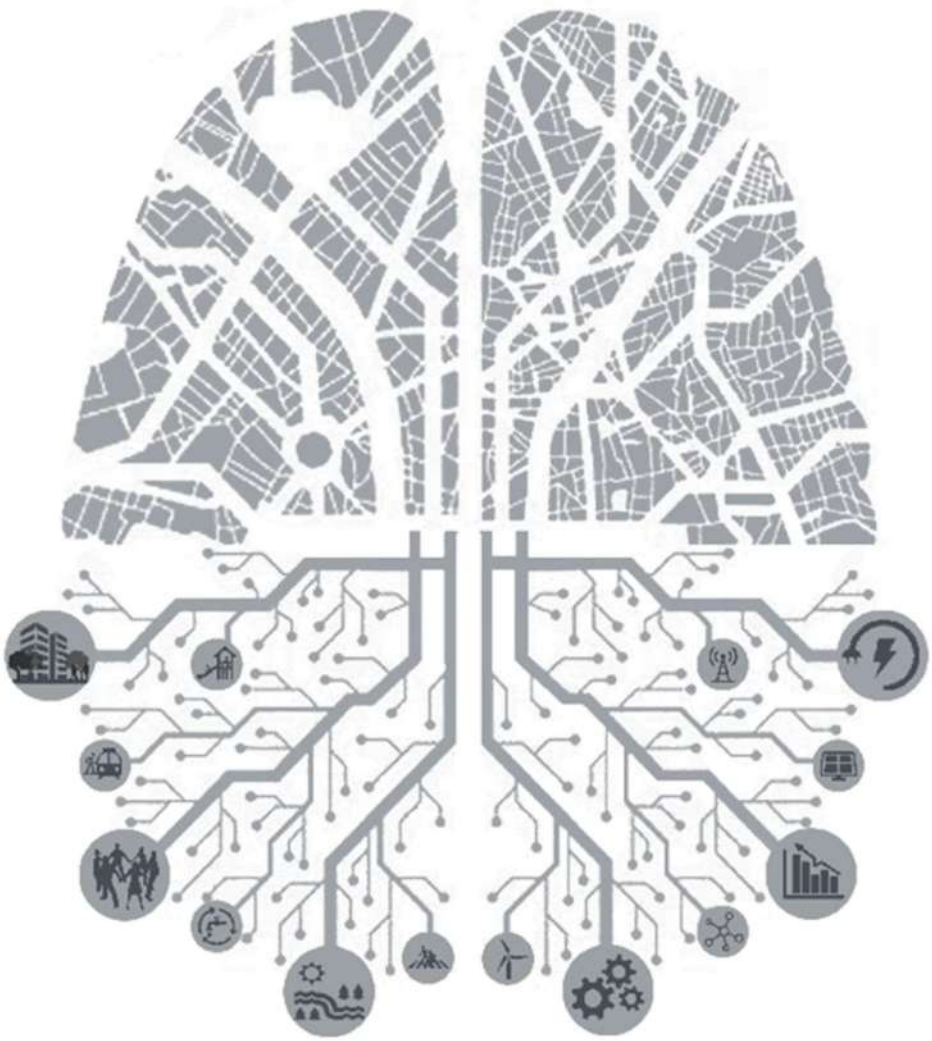
TECHNICAL REPORT

IoT/ICT ENABLEMENT IN SMART CITIES

DESIGN AND PLANNING SMART CITIES WITH IoT/ICT

TEC-TR-IOT-M2M-006-02

M2M SMART CITY WORKING GROUP



ISO 9001:2008

TELECOMMUNICATION ENGINEERING CENTRE
DEPARTMENT OF TELECOMMUNICATIONS
MINISTRY OF COMMUNICATIONS
GOVERNMENT OF INDIA

RELEASE 2.0 **January, 2019**

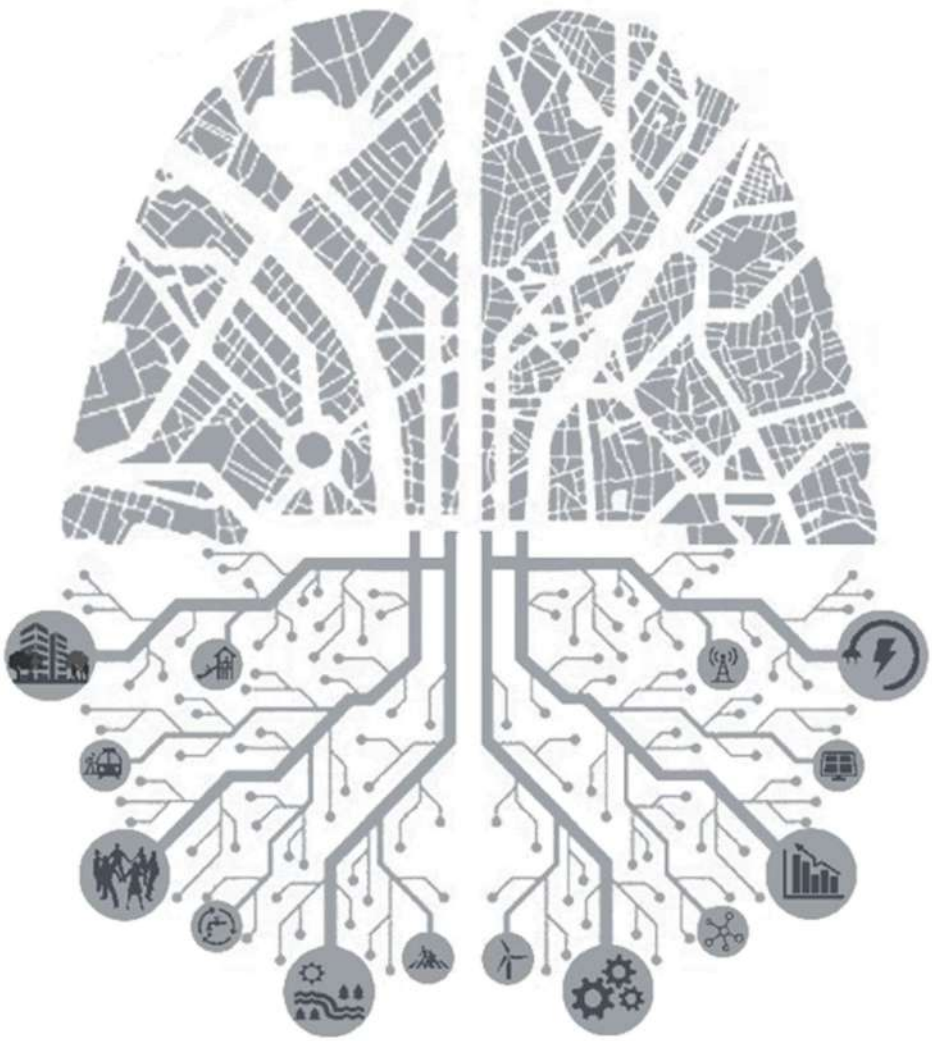
TECHNICAL REPORT

IoT/ICT ENABLEMENT IN SMART CITIES

DESIGN AND PLANNING SMART CITIES WITH IoT/ICT

TEC-TR-IOT-M2M-006-02

M2M SMART CITY WORKING GROUP



ISO 9001:2008

TELECOMMUNICATION ENGINEERING CENTRE
DEPARTMENT OF TELECOMMUNICATIONS
MINISTRY OF COMMUNICATIONS
GOVERNMENT OF INDIA

RELEASE 2.0 **January, 2019**

Release History

Date	Release	Document No.	Description
20/11/2015	R1.0	TEC-TR-S&D-M2M-006-01	ICT Deployments and Strategies for India's Smart Cities: A Curtain Raiser
08/01/2019	R2.0	TEC-TR-IoT-M2M-006-02	Design & Planning Smart Cities with IoT/ ICT

Important Notice

Individual copies of the present document can be downloaded from **http://www.tec.gov.in/technical-reports/.**

Users of the present document should be aware that the document may be subject to revision or change of status.

Any comments / suggestions may please be sent to **m2mreports.tec@gov.in**

About Front Cover

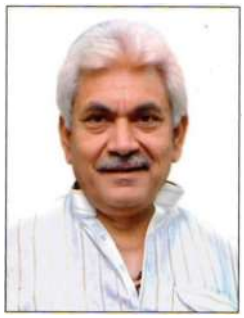
Multiple interpretations of the cover page are possible.

From the authors' perspective, the cover image of a brain is a juxtaposition of the myriad pathways of a city in the top half and the interconnection between various services in the bottom half. Similarly, just as the left hemisphere of brain is the logical and methodical side and the right hemisphere the creative, imaginative and social side. Smaller graphics depict corresponding social and functional services required in a city.

The two hemispheres are tied together by bundles of nerve fibres, creating an information and communication highway. Although the two sides function differently, they work together and complement each other. It is more complex than obviously seen; the boundaries of disciplines, verticals, functions blending seamlessly. Cities need to function in a similar manner, fusing technological elements with functional, social and emotional elements; promoting a multi-disciplinary constitution to become a truly liveable and smart city.

Disclaimer

The information contained is mostly compiled from different sources and no claim is being made for it being original. Every care has been taken to provide correct and up to date information along with references thereof. However, neither TEC nor the authors shall be liable for any loss or damage what so ever, including incidental or consequential loss or damage, arising out of, or in connection with any use of or reliance on the information in this document. In case of any doubt or query, readers are requested to refer to the detailed relevant documents.



सत्यमेव जयते

मनोज सिन्हा
MANOJ SINHA
संचार राज्य मंत्री (स्वतंत्र प्रभार)
एवं
रेल राज्य मंत्री, भारत सरकार
Minister of State (Independent Charge)
for Communications
and
Minister of State for Railways
Government of India

Message

I am glad to note that Telecommunication Engineering Centre (TEC) is publishing a Technical Report on "Design and Planning Smart Cities with IoT/ICT".

M2M/IoT and ICT are destined to change the way citizens live and control their surroundings. They will help in improving the quality of lives of people by revolutionizing the processes that businesses, governments and consumers use to interact with the physical world.

Such technical reports will be beneficial for the development of a robust eco-system for the design and planning of Smart Cities. I appreciate the efforts put in by Telecommunication Engineering Centre in publishing this report. I wish them success in their endeavours.

Kind regards,

Manoj Sinha

(MANOJ SINHA)

Room No. 105, Sanchar Bhawan, 20 Ashoka Road, New Delhi - 110 001
Phone : 91-11-23739191, 23372177 Fax : 91-11-23723330

अरूणा सुंदरराजन, आई.ए.एस
सचिव
Aruna Sundararajan, I.A.S.
Secretary

सत्यमेव जयते

भारत सरकार
संचार मंत्रालय
दूरसंचार विभाग
Government of India
Ministry of Communications
Department of Telecommunications

Message

I am extremely happy to note that Telecommunication Engineering Centre (TEC) is bringing out the Technical Report on "Design and Planning Smart Cities with IoT/ICT"

I am aware that IoT division, TEC has already released eleven Technical Reports covering various verticals viz. Automotive, Power, Health, Safety & Surveillance, Smart Homes, Communication Technologies in M2M/ IoT domain etc. These verticals will work as a pillar in Smart cities and in turn improve the quality of life. Eco-system is to be developed for connecting five Billion devices by 2022 as per NDCP 2018.

Around 100 cities across India have been selected for converting them in to Smart cities. I hope that this Technical Report will help city administrations in designing and planning of selected Smart Cities in a more holistic way.

I appreciate the efforts put in by Telecommunication Engineering Centre in bringing out this report. I wish them success in all their endeavours.

(Aruna Sundararajan)

संचार भवन, २०, अशोक रोड, नई दिल्ली - ११०००१ / Sanchar Bhawan, 20, Ashoka Road, New Delhi-110001
Tel. : 011-23719898 Fax : 011-23711514, E-mail : secy-dot@nic.in

रवि कान्त
सदस्य (सेवाऐं)
RAVI KANT
Member (Services)

सत्यमेव जयते

भारत सरकार
संचार मंत्रालय
दूर संचार आयोग, दूर संचार विभाग
संचार भवन, 20, अशोका रोड़, नई दिल्ली-110001
Government of India
Ministry of Communications
Telecommunications Commission
Department of Telecommunications
Sanchar Bhawan, 20, Ashoka Road,
New Delhi - 110001
Ph.: 23714644 • Fax : 23755172
E-mail : members-dot@nic.in

Message

I am happy to note that Telecommunication Engineering Centre (TEC) is bringing out a Technical Report on "Design and Planning Smart Cities with IoT/ICT". This report is in continuation to the previous report on Smart City, "ICT Deployments and Strategies for India's Smart Cities: A Curtain Raiser".

I feel good that IoT division, TEC has continued the excellent work in M2M/ IoT domain, as eleven Technical Reports covering various verticals viz. Automotive, Power, Health, and Smart Home etc. have already been released in the last 2-3 years. Emerging points such as 13 digit numbering scheme, Embedded SIM, IPv6/ dual stack for devices / Gateways to be connected directly to PSTN / PLMN, spectrum for low power wireless technologies, sharing of data across verticals etc are being used as a standards / policy items for the development of eco-system in IoT domain.

As M2M / IoT verticals will work as a pillar to the Smart Cities, the work being carried out by TEC in IoT domain will be quite useful in developing eco-system for IoT domain and in turn for the Smart Cities.

This technical report of TEC is a good step and will certainly help city administrators to take various effective measures in designing and planning of Smart Cities.

19.12.18

(Ravi Kant)

हिन्दी का मान : राष्ट्र का सम्मान

Shiwa Shankar Singh
Member (Technology)

सत्यमेव जयते

भारत सरकार
संचार मंत्रालय,
दूरसंचार विभाग
संचार भवन, 20, अशोका रोड़,
नई दिल्ली-110 001
Government of India
Ministry of Communications
Department of Telecommunications
Sanchar Bhawan, 20, Ashoka Road,
New Delhi - 110 001
WEBSITE : www.dot.gov.in

Message

I am pleased to note that Telecommunication Engineering Centre (TEC) is bringing out a Technical Report on "Design and Planning Smart Cities with IoT/ICT".

It is an established fact that smart cities need to talk to each other to efficiently utilize the resources and efforts, as data generated by one smart city may be useful for other smart cities. This can be achieved by using a standardized service platform in all smart cities.

If we can take into account all the factors required for planning and designing smart cities as excellently explained through three approaches (Design Thinking, System Thinking and Futures Thinking) in this technical report, we can develop Smart cities in an efficient manner not only for the present but also for the future.

I appreciate the efforts of Telecommunication Engineering Centre specially its IoT Division and the Working Group members for bringing out this technical report in a very timely manner. I wish them success in all their endeavors.

02-01-2019

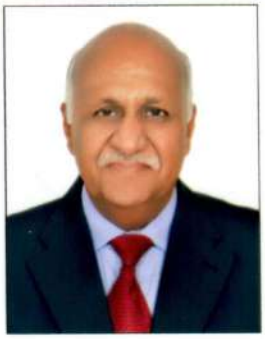
(Shiwa Shankar Singh)

M.P. Singhal
वरिष्ठ उप महानिदेशक
Sr. Deputy Director General
Tele : 23320252 Fax : 23329088
e-mail : srddg.tec@gov.in
www.tec.gov.in

सत्यमेव जयते

भारत सरकार
दूरसंचार विभाग
दूरसंचार अभियांत्रिकी केन्द्र
खुर्शीद लाल भवन, जनपथ, नई दिल्ली–110001

Government of India
Department of Telecommunications
Telecom Engineering Centre
Khurshid Lal Bhawan, Janpath, New Delhi-110001
ISO 9001:2008



FOREWORD

TEC is a technical body representing the interest of Department of Telecom, Government of India. It provides technical support to DoT and prepare specifications and standards for Telecom network equipment, services and interoperability including for M2M/IoT domain. TEC has also been mandated to interact with multilateral agencies like APT, ETSI and ITU etc. for standardization.

TEC proactively takes up development of specifications & standards based on studies and on interaction with concerned stakeholders. Development of specifications & standards is a transparent process with active participation of stakeholders. Certification of telecom products as per Essential Requirements is also one of its major activities under MTCTE, which has been mandated by Government of India.

M2M systems have been in use for some time past in various sectors such as Automotive, Health Industrial sectors etc. However, the use of M2M/IoT technology, devices & application are generally proprietary in nature as standards have started involving in the recent past. It is well known fact that a variety of social and economic activities are interwoven in today's digital world, and it is possible to link them through networks and applications to achieve greater efficiency and development of new services. This can be achieved through interoperability among M2M/IoT devices, networks & applications in a secure manner, which will require standardization and development of harmonized specifications.

Towards achieving this objective, TEC in consultation with stake-holders from government, industry, standards bodies and sector-users, took up study in IOT/M2M domain since 2014. IoT Division of TEC has released 11 (eleven) Technical Reports related to various verticals such as Power, Automotive, Health Management, Safety and Surveillance, V2V/V2I Radio Communication, Embedded SIM, Smart Homes etc.

These Technical Reports (TRs) are available on TEC website (www.tec.gov.in/technical-reports/).

A number of actionable points emerged from these technical reports; some of the important are 13-digit Numbering scheme on SIM based devices / Gateways, Embedded SIM, IPv6 / dual stack, spectrum for low power wireless devices, Multiprotocol gateways etc.

The Working Group for study on Smart Cities was formed in TEC consisting of members from Government, Industry, Academia, OEMs, TSPs and Standardization bodies. More than 25 audio conferences calls, two formal meetings and around 15 informal meetings were arranged by IoT division of TEC for discussion, finalizing and drafting the content of this document named "Design and Planning of Smart Cities with IoT/ICT".

The report provides relevant and reliable guidance to the Industry stakeholders by citing many practical Use Case examples that can be applied to smart city projects, in order to plan standardized IoT deployments in a secure and sustainable manner. I hope that the working group members and industry stake holders will provide their continued support to TEC to carry out further study and work in IOT/M2M which will continually enrich our knowledge, systems and processes, such that the country can take a leadership position in the emerging global IoT Economy and Ecosystem.

(M.P. Singhal)

List of Contents

List of Tables

List of Figures

List of Contributors

A. Joint Working Group (JWG) Chairman

Name	Designation	Organization	E-mail address
M P Singhal	Sr. DDG	Telecommunication Engineering Centre (TEC)	srddg.tec@gov.in

B. Joint Working Group (JWG) Vice Chairman

Name	Designation	Organization	E-mail address
Sushil Kumar	DDG (IoT)	TEC	ddgsd.tec@gov.in

C. Working Group (WG)

Designation	Name	Organization	E-mail address
Chairman	Bipin Pradeep Kumar	Gaia Smart Cities	bipin@gaia.in
Rapporteur	Raunaque Mujeeb Quaiser	STMicroelectronics	raunaque.quaiser@st.com
Co-Rapporteur	Rajeev Kumar Tyagi	Director (IoT)	dirsd1.tec@gov.in

D. Primary Authors / Drafting committee

Name	Organization	E-mail address
Bipin Pradeep Kumar	Gaia Smart Cities	bipin@gaia.in
Ratan J. Batliboi	Ratan J Batliboi-Consultants Private Limited	rjbwork@gmail.com; smartcities@rjbx.in
Ms. Amrita Chowdhury	Gaia Smart Cities	amrita@gaia.in
Ms. Ritu Mohanty	Ratan J Batliboi-Consultants Private Limited	smartcities@rjbx.in; mohantyritu@gmail.com
Ms. Ritika Sebastian	Ratan J Batliboi-Consultants Private Limited	smartcities@rjbx.in
Raunaque M Quaiser	STMicroelectronics	raunaque.quaiser@st.com
Sushil Kumar	TEC	ddgsd.tec@gov.in

E. Contributors

S. No	Name	Organization	E-mail address
1	Sushil Kumar	TEC	ddgsd.tec@gov.in
2	Bipin Pradeep Kumar	Gaia Smart Cities	bipin@gaia.in
3	Ms. Namrata Singh	TEC	adet.tec@gov.in

4	Aurindam Bhattacharya	C-DOT	aurindam@cdot.in
5	Ms. Anupama Chopra	C-DOT	anupama@cdot.in
6	Ms. Shraddha Waman	RJB-CPL	smartcities@rjbx.in
7	Ms. Sudipta Iyer	RJB-CPL	smartcities@rjbx.in
8	Naveen H N	Open-Silicon	navmys@gmail.com
9	Sharad Arora	Sensorise Digital Services Pvt Ltd	sharad.arora@sensorise.net
10	Alok Mittal	STMicroelectronics	alok.mittal@st.com
11	Ms. Nupur Shrivastava	RJB-CPL	smartcities@rjbx.in
12	Jeremy Vaz	RJB-CPL	smartcities@rjbx.in
13	Narang N Kishore	Narnix Technolabs	kishor@narnix.com
14	Dinesh Chand Sharma	ETSI	dinesh.chand.sharma@eustandards.in
15	Ajay Kumar Mittal	Ex Sr.DDG TEC	akmittal77@gmail.com
16	Sriganesh Rao	TCS	sriganesh.rao@tcs.com
17	Ms. Leena Chandran Wadia	Freelancer	leena.wadia@gmail.com
18	Rajendre Bendre	Freelancer	raju_bendre@hotmail.com
19	Hem P Thukral	E&Y	hem.thukral@in.ey.com
20	Ms Aastha Sayal	Gaia Smart Cities	aastha@gaia.in
21	Rajeev Kumar Tyagi	TEC	dirsd1.tec@gov.in
22	Arvind Tiwary	IoT Forum	arvind_t@sangennovate.com
23	Dr. Vijay Kumar B.P	MSRIT	hod_is@msrit.edu
24	Joydeep Bose	Tejas Networks	joydeepb@india.tejasnetworks.com
25	Govindan	Tejas Networks	govindan@india.tejasnetworks.com
26	Aayushi Sejpal	RJB-CPL	aayushis@rjbx.in
27	Ajay Nayak	RJB-CPL	ajayn@rjbx.in

F. Joint Editorial Team

S. No	Name	Organization
1	M P Singhal	TEC
2	Bipin Pradeep Kumar	Gaia Smart cities
3	Raunaque M Quaiser	STMicroelectronics
4	Rajeev Kumar Tyagi	TEC
5	Ms. Ritu Mohanty	Ratan J Batliboi-Consultants Private Limited
6	Ms. Namrata Singh	TEC
7	Sushil Kumar	TEC

Executive Summary

Urban Design and Design Thinking in ICT for Smart Cities are complex intertwined areas that cannot be addressed through simplistic approaches. This Technical Report seeks to blur the lines between several connected disciplines that most of us are familiar with individually – ICT, Urban Design, Design Thinking, Systems Thinking and Futures Thinking; all in the context of Smart Cities.

Urban Design and Planning, Design Thinking, Systems Thinking and Futures Thinking principles coupled with Digital Communications and Technology adoption is what will separate cities just trying to achieve smartness from cities that are truly smart- cities that can take advantage of the depth of social, economic and natural infrastructure whilst harnessing technology intelligently to enable sustainable growth.

It is now an accepted fact that today's technology is rooted in the blend of design, electronics and computer science. It wasn't so earlier. How a product or service looked or worked, and the ways users interacted with it, were typically an after-thought that focused mostly on cosmetic interventions. Usability and design rarely grabbed anyone's attention until few companies pushed outside the norm. This changed subsequently when those companies eventually became market leaders. Product and technology companies now recognise that their products need to be both visually appealing and deliver great user experiences i.e. thinking about design and applying new approaches to systems from the beginning.

Objectives illustrated in this report:

- Synergizing multiple disciplines merging to deliver great citizen experiences. IoT, ICT or any one technology alone will not make cities truly liveable and smart, neither will using one approach.
- Applying new approaches of thinking - Design, Systems, Futures as it is about inclusivity and Urban Design practices.
- Design Thinking, Systems Thinking, Form & Function, Simplicity, Emotional appeal, Liveability, Socio-cultural and Economic impacts - all have to be considered when it comes to our cities.
- Meshing a design and urbanist's view with a technologist's perspective, aiming to inform city planners and administrators of the broader understanding of smartness, as derived from global and national benchmarks and best practices.
- Considering the intersections between Urban Planning, Design and ICT design, and offering specific Design, Systems & Futures Thinking tools to augment and strengthen the planning process.

The Smart Cities Work Group is one of TEC's 12 M2M Working Groups. Eleven Technical Reports have been released till date and are available on TEC website[1]. These Technical Reports have been mentioned in Annexure-6. ICT deployment in smart cities in India lies within a broader context of institutional, physical, social and environmental factors amidst the complex needs of managing rapid urbanization, while ensuring quality of life and economic opportunities for all citizens.

This Technical Report is in continuation to the "ICT Deployment and Strategies for India's Smart Cities[2]" report wherein the role of ICT in Smart Cities and related use-cases along with future work to be carried out, was described. In its 'Way Forward' section, work on gap analysis, analyzing the Key Performance Indicators, and studying different Smart City designs worldwide that can be taken as sources of information for the design and development of Smart Cities in India were identified.

This Technical report consists of two parts: Part A and Part B

Part A is about the "General Characteristics of Smart City Planning". It builds broad definitions of smartness and smart cities, as defined by global experts, policy makers, and urban theorists. It considers the intersection of technology, urban design and urban planning. It defines multiple ways in which planning can be done – national versus city/state level, greenfield versus brownfield development, hard versus soft infrastructure, and sector based versus geography based plans. It also lays down ideas for including M2M / Internet of Things (IoT), high speed and reliable communication services, analytics and control technologies into city plans, as well as broad-based design ideas and city performance metrics / indicators.

Exploring the practice of urban planning in India, this section highlights the conceptual, methodological and implementation challenges. Some core challenges highlighted are the need to integrate city master plan or development plan with other city development plans for infrastructure, economy, finance, land use, as well as social and cultural infrastructure. It must also consider heritage and ecological aspects and build services as well as opportunities that reflect the demands of its citizens. At the neighborhood scale it must include inclusive participatory planning processes as part of community development across all stakeholders.

Defining the ICT requirements in smart city planning, this section suggests that planners should consider how the new ICT framework can leverage using existing or new physical assets, engage local data ecosystems, define data management strategies, and ensure transparency, security and privacy. Furthermore, dynamic and responsive planning must be integrated for every application within the smart city.

The challenges and requirements may differ from city to city, but the effective use of technological innovations in urban settings with a strong focus on improving living conditions, safeguarding the

[1] *www.tec.gov.in/technical-reports*
[2] http://tec.gov.in/pdf/M2M/ICT%20deployment%20and%20strategies%20for%20%20Smart%20Cities.pdf

sustainability of the natural environment, and engaging with citizens more effectively and actively differentiate Smart Cities from other cities. Smartness is embedded in cities by capturing relevant data, and understanding behavioral and analytical trends. This requires cities to consider integrating data driven planning, big data, real time data, smart data, crowdsourced social data, and data analytics that allow cities to monitor and improve themselves, without compromising the citizens personal and sensitive data. Simulation platforms that integrate mobile laser scanning, 3D modelling, augmented reality, and other tools to create decision support systems make it easy for architects, urban designers, planners, city administrators and citizens to visualize the impact of different initiatives, and thus analyze and select options. Open data architectures, transparency and context sensitive dashboards that capture meaningful indicators are critical in creating effective smartness. Through data analysis we need to translate information into insights and thereafter turn insights into actions. Whilst technology will be an enabler of environmentally and technologically innovative developments and can provide the platform for success, it is what we as citizens do with this platform that will determine the smartness of these cities.

One of the recommendations of Part A is that urban design and planning in India needs to focus on dynamic, integrated, responsive, transparent and secure cities. Dynamic with the use of ICT tools in data collection, analysis, and simulation; Responsive to its citizens with participatory tools, a bottom-up planning approach and capacity building of civic authorities and users; Transparent with the use of real-time data in government institutions as well as transparent to its citizens with open data policies and strategies; its systems integrated using a common data architecture over a comprehensive planning platform.

Part B "Design, Systems, and Futures Thinking for Smart Cities ICT in India" builds on the first part, and details a set of tools that can be used to create effective, dynamic, responsive, integrated, secure, interconnected, desirable, usable, viable designs for smart cities. Through examples and scenarios, this part suggests how Design, Systems, and Futures Thinking tools can be used in the overall planning and design of smart cities. Leveraging these holistic thinking tools, urban local bodies can improve their long-term planning and short-term implementation, allowing for more flexible, agile and robust urban interventions.

Smartness is viewed as the ability of a city to measure and improve its performance, to meet the twin goals of improving livability and livelihood.

Design Thinking offers an easy and intuitive methodology to look at any smart city ICT initiative from the lens of its stakeholders - desirability, technical feasibility, and financial viability. Given that any smart city initiative has multiple stakeholders – primarily the investor seeking returns on investment, the service provider or city administrator seeking improved efficiency, reduced cost, ease of operations and higher order benefits, and citizens seeking ease of usage or improved quality of life. Each initiative needs to be considered from the perspective of every stakeholder; each must gain from the solution being planned.

Systems Thinking recognizes that complex urban problems require interconnected solutions, factoring in constraints or linkages in spatial, physical, technical and digital design. Mapping these factors, planners can model and create infrastructure, communication and data blueprints that interconnect and get information needed for complete functionality, or reduced redundancy, or reduced duplication of hardware or data across city systems.

Futures Thinking uses a set of divergent and convergent thinking, outside-in and inside-out strategies, and maps residual, dominant and emerging trends to sharpen understanding of city functions and/or technologies being considered. These tools allow planners to look beyond the short-term horizon to build solutions that will be resilient and long lasting.

The term “design” in the context of this section implies physical, digital, or interface design of the overall solution, communication or data blueprints, devices and sensors, hardware and software products, and the systems interface through which users interact with the solution. Design for each of these elements needs to be considered both from visual design and functional design perspectives. Visual design includes the look and feel of the product, system or application. Function includes ambient hardiness of products, communication and interlinking of data structures, or the navigation, interaction and experience of the user with the system as well as security, privacy or ethical concerns when designing the system and storing the data.

Four critical and overarching principles of city planning outlined in part B are: -

1. Design solutions to impact urban life
2. Design technology to improve city performance
3. Design systems for mass use in local environments
4. Design solutions that are built to last

Together these two parts, provide a framework for city and urban local body leadership to ensure their plans are suited to their city and its unique challenges, constraints, and strengths, and at the same time leverage typical best-in-class design and technology principles.

PART A

IoT/ ICT Tools for Urban Design and Urban Planning

1 Introduction to General Characteristics of Smart City Planning

The Centre for Cities divides the various definitions of smart cities[3] broadly into three categories:

A. General definitions which focus on digital technologies enabling more resilient, livable, inclusive and sustainable cities;
B. Data-driven definitions that lay the onus of future cities on information and communications technology (ICT); and
C. Citizen focused definitions where technologically connected citizens drive and enable a digital city which adapts itself to real-time data exchange.

A Smart city is considered a new utopia, the city of the future where technology becomes the interface- the arbitrator among citizens, governments and institutions.

Some key verticals targeted in Smart cities are illustrated in Figure 1 below: -

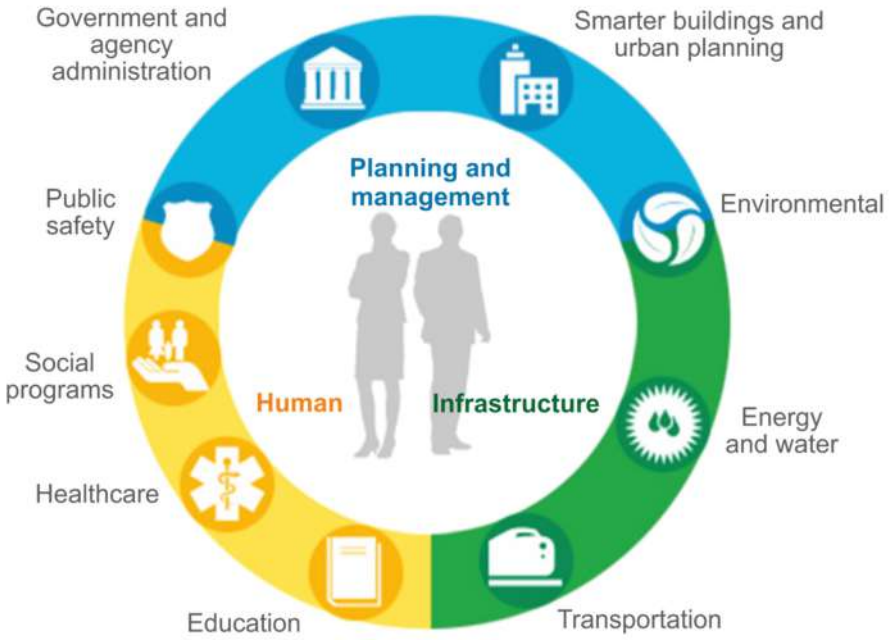


Figure 1: Key verticals targeted in a Smart city

Source: IBM, 'Analyzing the future of cities'; https://www.ibm.com/smarterplanet/us/en/smarter_cities/overview/

Figure 1 also highlights the three crucial aspects of this smart city framework – Planning, People and Infrastructure.

[3] Refer Glossary for detailed clarification on associated terms.

As part of India's Smart City Challenge, the Smart City Mission has identified 24 key features that a city needs to have. These are illustrated in Figure 2 below: -

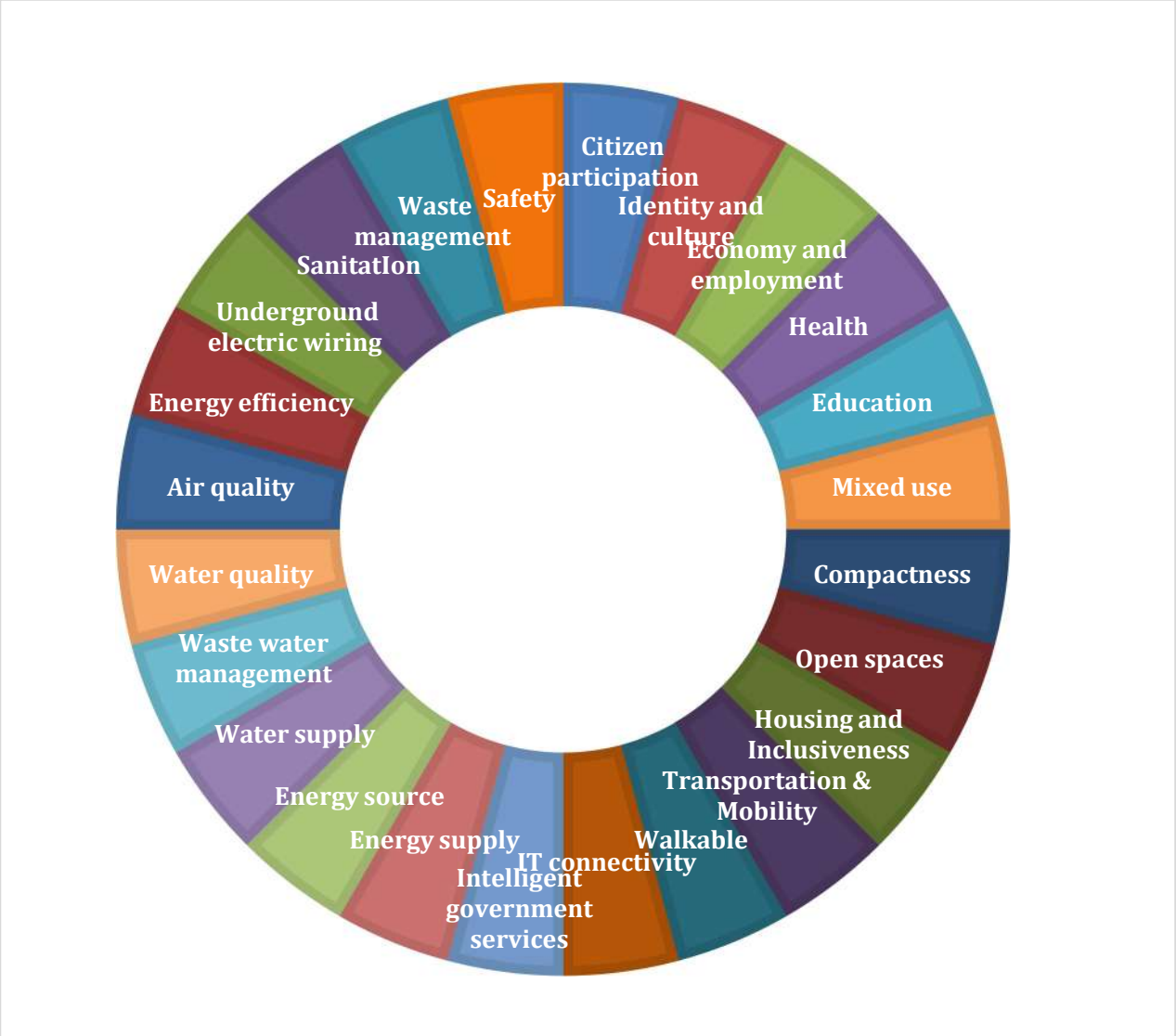


Figure 2: Smart City Mission's 24 features

Source: Adopted from MoHUA, Government of India 'Smart City Proposals' data

In approaching these features of smart cities it's helpful to consider the following five elements–

a. ***Citizens****: Smart Cities are taking different approaches to engaging the people who live, work and innovate within them. Citizens form the cornerstone of Smart Cities.*
b. ***Infrastructure, technology and data****: Infrastructure enables our city systems to operate. For example roads, buildings, electricity and communication networks. Smart Cities are*

exploring how they can future-proof infrastructure to deal with challenges such as climate change etc.

c. ***Innovation and enterprise****: Smart Cities are centers of economic activity. A smart city can be thought of as a smart ecosystem of different organizations, activities and stakeholders who make it smart.*

d. ***Leadership and strategy****: The subject matter of the team and members who lead the smart city efforts is crucial to their development. Effective leadership and inclusive decision-making that empowers city stakeholders is key to the success of smart cities.*

e. ***Measurement and learning****: Smart Cities need to be able to measure the performance, self-learn and improve the ecosystem. We will be exploring how cities are using smart city metrics and indicators and how they measure city performance.*

These five elements have been illustrated in Figure 3 below: -

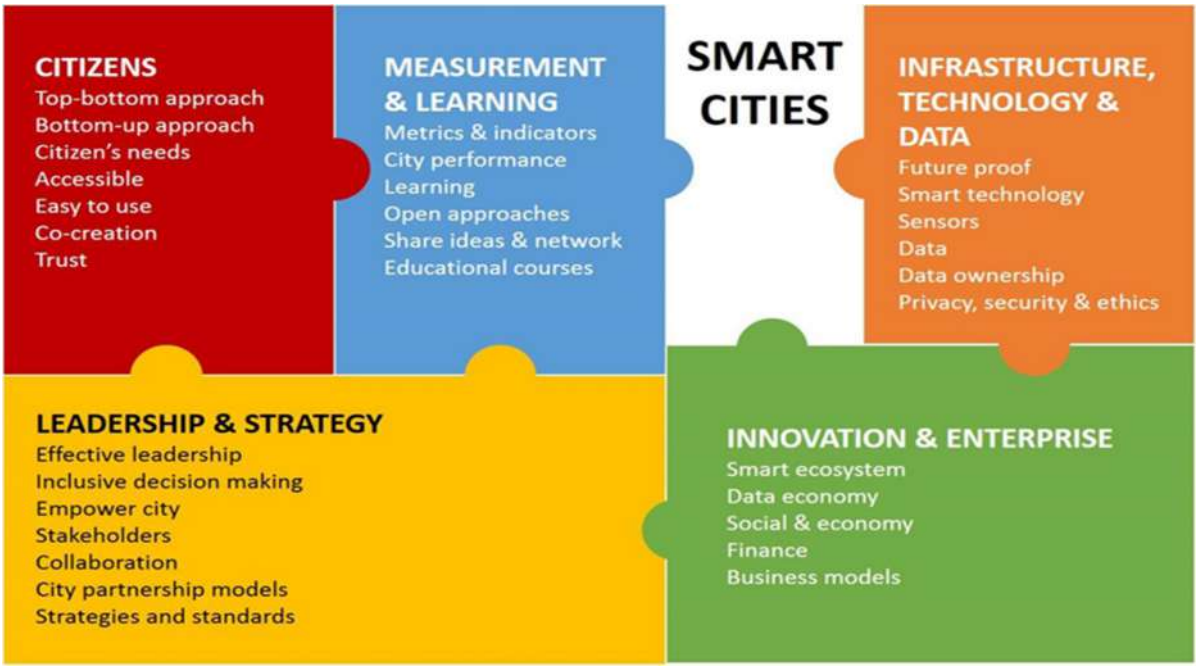


Figure 3: Elements of a Smart City

Source: Lorraine Hudson and Gerd Kortuem, 'Introduction to smart cities', led by The Open University. [http://www.open.edu/openlearn/ocw/pluginfile.php/1058931/mod_resource/content/1/smart_cities.pdf.pdf]

Smart city interventions have emerged in an attempt to address meta-issues such as climate change, urbanization, citizen engagement and resource efficiency etc. This is achieved through the use of sensors, data and advanced computing to help speed up the flow of information, reduce waste and improve the efficiency of resource management.

Applications of ICT in urban planning, design and development, in general, are not new. But the new thrust on ICT in 'smart city' developments place more emphasis on IoT and ICT technologies. **Smart**

cities try to focus on 'smarter use of resources, smarter ways of collecting data and smarter ways to make decisions'[4].

2 Bridging the Gap - Smart City Design and Planning

The discourses that are available in the public domain on smart cities, as well as its applications, are largely led by technologists and administrators with secondary inputs from architects and urban designers. Many applications of smart city technologies rely heavily on ICT. It is believed by architects and urban designers that they do not focus on the place or the physical form of the city, or the socio-cultural and political environment it will inhabit. In the current debate on smart cities the focus on what kind of socio-spatial consequences that it engenders is left out. This section tries to address the large gap in the current mainstream discourse between the physical manifestation of cities of future and a well-defined urban vision for the spatial and typological configurations of the smart city.

2.1 The intersection of ICT, City Design and City Planning

The linkages between urban form and ICT are not direct and depend on multiple factors- local characteristics, priorities and needs of the citizens, global market forces, national and international economic shifts etc. Moreover, the linkages are two-way, in that they are symbiotic in influencing each other. Historically, while the relationship between urban form and ICT are not direct, they are harder to understand and require long term study. The potential of ICT applications in practice cannot be ignored by anyone today. Smart city applications for some sectors such as transportation and water management are well understood and successfully applied. Applications to the practice of urban design and planning are still emerging but offer some promising leads.

To begin with, urban design and planning [5] and the idea of smartness[6] can intersect at three levels as shown in Figure 4.

First is the use of smart technology as an aid to urban design and planning practice. For instance, the access to information made available by Google Earth has already changed the approach to spatial design. Combined with tools like Google Street view, it allows planners and urban designers to easily move across scales. This information can help calibrate urban spaces and their attributes by

[4] Saunders & Baeck, Rethinking Smart Cities from the Ground Up, 2015. [https://ofti.org/wp-content/uploads/2015/06/rethinking_smart_cities_from_the_ground_up_2015.pdf]

[5] Note: While Urban Design and Urban Planning are two distinct fields of theory and practice, they have been loosely and interchangeably used throughout this Technical Report to generally indicate any administrative, government or private initiatives undertaken relating to physical city form and space.

[6] The mention of smart city technologies, ICT, and generally technology, throughout this Technical report, indicate IoT, ubiquitous sensing technologies, wireless networks and bid data analytics on one hand, and increasing use of smart phones, growing preference for online transaction, low cost hardware and peer-to-peer technologies on the other.

understanding the footfalls, preference patterns, user reviews, calculating permeability of large territories, hydrological patterns, population shifts, density and even simulate financial analysis.

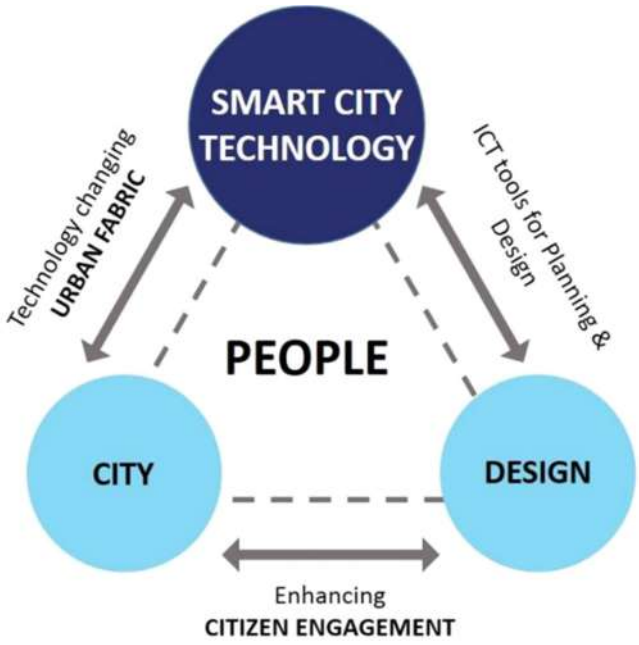


Figure 4: Intersections of Technology, Design and Planning
Source: RJB-CPL

The second prong of smartness would involve creating designs for smart urban spaces. The versatility and adaptability of spaces to varied, multi-disciplinary demands of a smart global society will be the need of the future. It is essential to think about how changes in technology will influence not just the use of space but also the typologies of space in the city. A few questions that crop up:

- Will the advent of online shopping render traditional shopping districts redundant?
- Will large integrated data centers and control rooms become the new centers of government?
- Will the applications of ICT change the economics of urban agglomerations?

Through Urban Design we can adapt the form of urban public spaces to cater to a networked society, create dynamic meeting spaces and flexible, multi-use spaces in the public realm.

Thirdly, the possibilities created by the pervasiveness of interactive technology, allows citizen participation in space making that can be unprecedented[7].

[7]It can be argued that the ICT application for citizen participation is an overlapping feature of general ICT applications in urban design and planning practice. However, for the purpose of added emphasis on a citizen centric approach it has been included as a separate feature of the framework used here.

2.2 Benefits of IoT and ICT in Urban Design and Planning

ICT advantages within Urban Design, Urban Planning and management processes are especially clear today, as maps, data and assessment models are increasingly becoming a common heritage: the integration of sensors, web and wiki based technologies[8] with GIS applications is a very fruitful way to improve the chances of constructive interaction between citizens, policy makers and the skills at stake within the urban planning processes. Cloud technologies, popular among professional and consumers alike, allow regular updates directly from the source through a steady integration of decentralized databases. Geo-referenced systems are central to decision-making processes at the local and regional level, facilitating decisions of institutional and entrepreneurial actors, for example by sharing land knowledge and encouraging fast tracking of administrative procedures. Shared databases can encourage public-private partnerships and project financing by making data, information and feasibility studies available to technical offices or by ensuring multi-utilities contributions. Involvement of local partners interacting with international channels through an increasingly shared regulatory and planning processes are enhanced with ICT.

Urban Design and Urban Planning practices can benefit from ICT tools used for constant and varied data collection, data analysis, mapping and simulation. With smart city technologies, it is also possible to enhance the power and scope of tools that are already used. Figure 5 shows a central smart planning protocol for ICT applications that can be used across scales, sectors and user groups etc.

[8] https://whatis.techtarget.com/definition/wiki

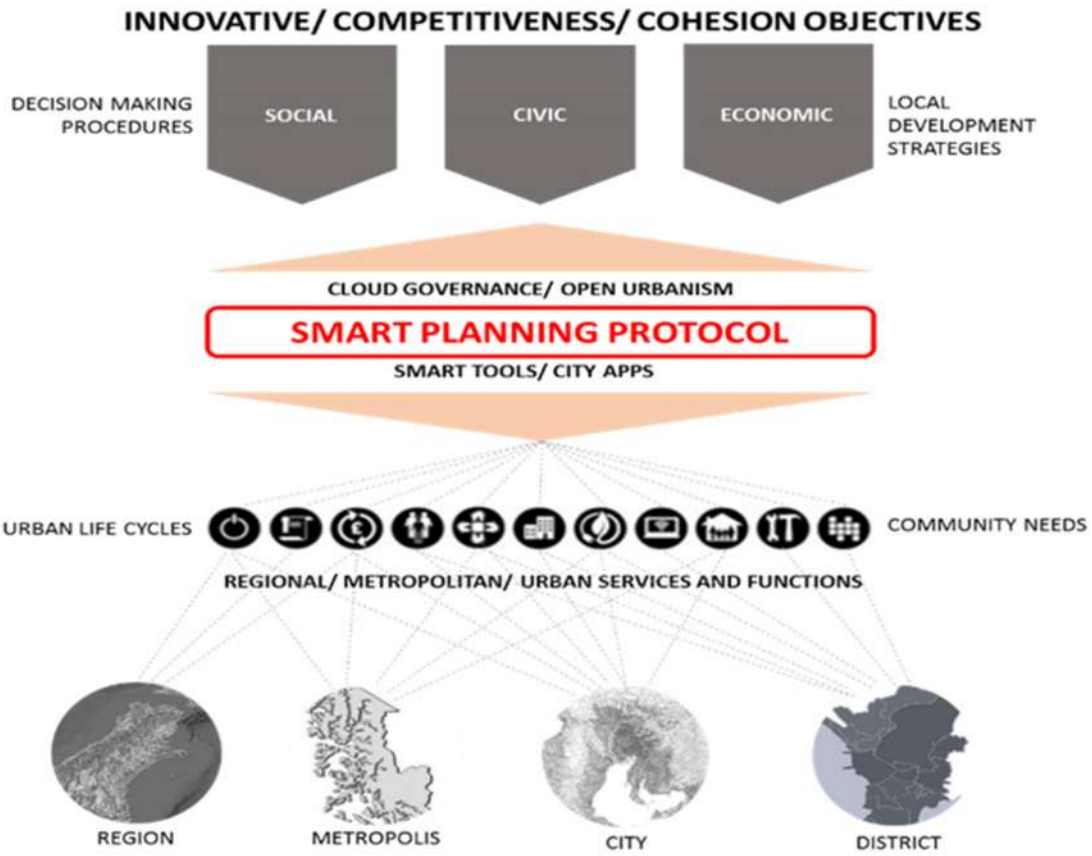


Figure 5: Smart Planning Protocol

Source: M. Carta, Smart Planning Lab, 2014. [https://issuu.com/iaacbits/docs/maurizio_carta]

In using technology as a tool for Urban Design and Urban Planning, the goal is not to automate the process or minimize the role of planners and designers, but to aid the process of decision making. Urban planning supported by data on city's developments, movements and its people can generate plans based on a thorough understanding of cities and rational decision making. ICT provides an opportunity to achieve goals in design and planning that simply may not have been possible before.

2.3 Considerations while using IoT for Urban Design and Urban Planning

In the context of IoT, the applications of technologies that make passive objects dynamic, reactive and automatic in terms of sensing and response can be innumerable. Figure 6 provides a high-level overview of the IoT framework. IoT provides networking to connect people, things and applications, which enable remote control, management, as well as interactive integrated services. Thus, more 'things' can be monitored and controlled, more complex tasks can be accomplished in lesser time and decisions made can be more accurate.

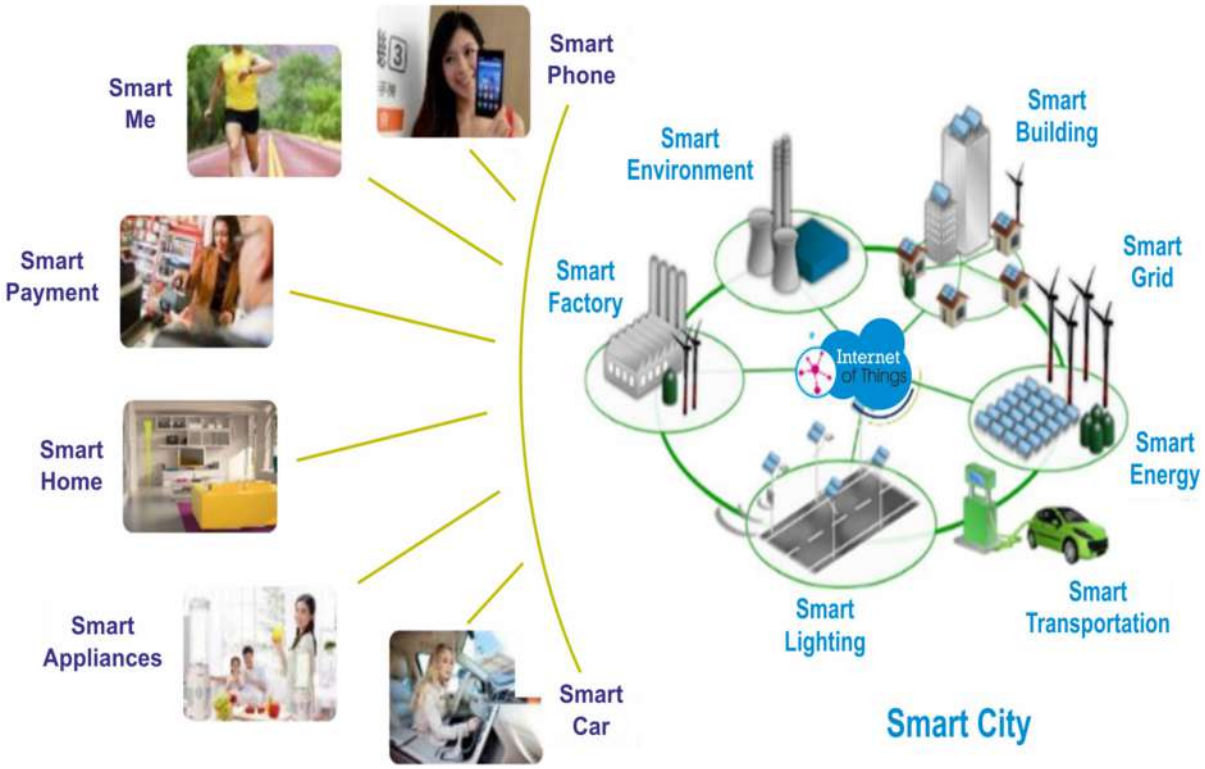


Figure 6: The Internet of Things (IoT) Ecosystem

Source: [http://tec.gov.in/pdf/M2M/M2M_IoT%20Enablement%20in%20Smart%20Homes.pdf]

Eleven Technical Reports have been released by TEC[9], which offer detailed studies of IoT in the different city related verticals. IoT's effect on Urban Design and Urban Planning is expected to revolutionize and change the way all businesses, governments, and citizens interact with the physical world. This level of disruption will have a significant impact on the world in improving the quality of life of every individual.

However, city management by integrating IoT into city systems require a large number of considerations like leveraging existing physical assets, engaging local data eco-systems, clear data management strategies, transparency, security and privacy concerns. The impact of applications of IoT on Urban Design concepts like Placemaking, etc., need closer examination and studies.

2.4 Technology related principles in Urban Design

Smart city literature is ripe with various definitions, but the critical answers to '**What makes a city smart?'** and **'When does it become a smart city?'** are yet to conclusively emerge. These are particularly important to urban form of both Greenfield and Brownfield cities since a smart city is an urbanization process and not a product. It is created and doesn't simply emerge.

[9] TEC Technical Reports are available on http://www.tec.gov.in/technical-reports/

There are several principles that revolve around technology and Urban Design. Some of the important ones include:

- **Consider urban life** before urban place; consider urban place before technology.
- **Urban communities:** Consultations on plans for new developments should fully exploit the capabilities of social media, virtual worlds and other technologies to ensure that communities affected by them are given the widest, most immersive opportunity possible to contribute to their design.
- **Transport:** Transport plans supporting new developments should demonstrate that they have not only provided for traditional transport demand but also that which might be created by online business models and other social technologies
- **Identify "smart machine" functions** that provide speedier and more accurate results within and across city agencies, and establish infrastructure and processes for data collection, integration, interpretation and analysis, etc.
- **Identify complementary information functions** and reorganize city agencies to harness automation, e.g. incorporating data analytics in planning support systems and evolving planning processes that inform, collaborate and co-create with the community
- **Create innovation-fostering agencies** that understand technologies, organization and processes of and across agencies, to form partnerships and initiate projects that support city economic, environmental and social objectives
- **Anticipate and address possible challenges in collaboration**, whether arising between partners or from technology gaps
- **Incorporate multiple, multi-scale feedback** loops to assess the effectiveness of initiatives using metrics, and apply feedback inputs to refine cross-agency processes and long-term strategies
- **Avoid lock-in** through the use of open data and open-source platforms instead of proprietary data formats and through the structuring of partnerships where not a single technology provider or technology dominates
- **Establish clear objectives, and assess ROI (return-on-investment)** from both a financial and non-financial perspective, to evaluate "smart" initiatives and to justify investments
- **Sequence development and investment** to carefully plan the implementation of prerequisite backbone infrastructure, or the use of specific technologies

The complete list of Principles is available at Annexure 1, adapted from: Robinson, R. (N. A.). *Smart City Design Principles*. Retrieved September 21, 2016, from *The Urban Technologist*[10]

[10]https://theurbantechnologist.com/smarter-city-design-principles/

2.5 What makes a city smart?

There have been many smart cities that have been built from scratch (Greenfield). The better-known examples include - Songdo International business district (IBD) in South Korea, Masdar city in Abu Dhabi and Gujarat International Finance Tech-City (GIFT) city in Gujarat.[11]City residents will not live in a city purely due to its technological capabilities but primarily weigh in what it has to offer economically, culturally, socially and environmentally.

More commonly, there are many smart initiatives for existing (Brownfield) cities globally. Annexure 5 presents a view of a few smart cities and smart initiatives from around the world.

To illustrate a point, it would be useful to take an example of IBM's Smart City implementation in Rio, where the entire city has been covered in a dense network of sensors and cameras making possible centralized monitoring and control of its vital functions. This raises the important question of when does a city become a 'Smart City'? Sadoway and Shekar (2014) ask in their paper, 'what makes a city-region that heavily employs any given technology necessarily any smarter than a 'low-tech' city, or even a strategically conceived 'slow city''. There are neither definite nor universally agreed upon parameters, standards or testing tools.

ITU (International Telecommunication union) and UNECE (United Nations Economic Commission for Europe) along with other UN (United Nations) bodies created U4SSC (United for Smart Sustainable Cities). U4SSC has already released Key Performance Indicators (KPIs) for the Smart sustainable cities to establish the criteria to evaluate the ICT´s contributions in making cities smarter and more sustainable[12].

Ministry of Housing & Urban Affairs (MoHUA), Government of India has also developed a set of 'Livability Standards in Cities'[13] to generate a Livability Index with 79 indicators to rate cities. These 79 Livability standards indicators have been grouped into 15 categories from the 24 features contained in the Smart City Proposals (SCPs). It is intended that these 79 indicators will contribute to achievement of UN SDGs (Sustainable Development Goals). To finally compute the Index, different weights are assigned to the 4 pillars of comprehensive development and the City's Livability Index obtained. The illustration in figure 7 below depicts this whole process in a graphical manner.

[11] For a more detailed analysis of stupefying smart city see: The stupefying smart city by London School of Economics
[12] https://www.itu.int/en/ITU-T/ssc/united/Pages/default.aspx
[13] http://smartcities.gov.in/upload/uploadfiles/files/LiveabilityStandards.pdf

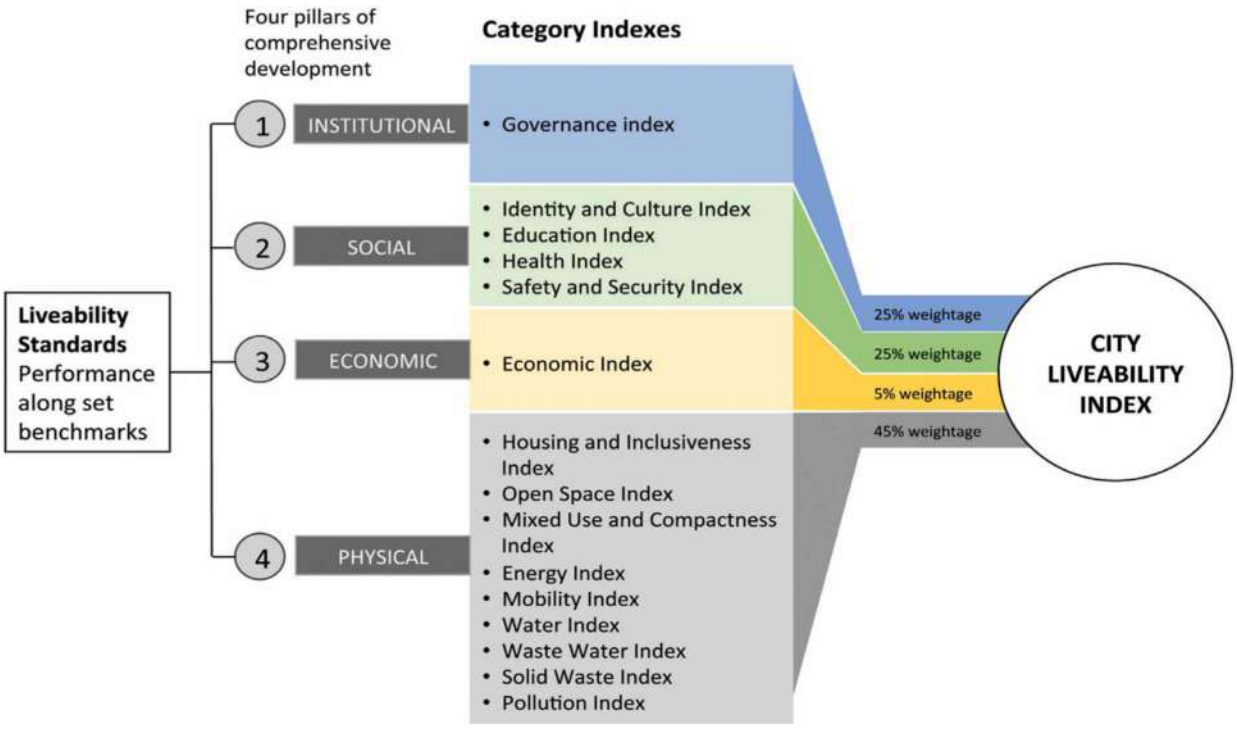


Figure 7: Livability Index

Source: [http://smartcities.gov.in/upload/uploadfiles/files/LiveabilityStandards.pdf]

However, these indicators are in early stage for use by city administrations and there is a dearth of material for Urban Planning and indicators for Urban Design.

3 Urban Planning in India

The constitution of India requires spatial plans for urban areas to be prepared at city, metropolitan and district level[14]. At the city level, master plans[15] are prepared by the respective urban local bodies (ULB). Urban planning in India is primarily focused on detailed land use zoning. Master plans cover a time horizon of 20 years. The process of master plan preparation begins with the projection of population, estimation of the average household size and income levels to determine the demand for residential space. Based on these projections, new plans are proposed.

Development requirements for transportation, conservation of natural resources and the protection of built heritage are treated as residual. So, while spatial plans like area based plans, master plans and regional plans are created for the city and its surroundings at large, typically not integrated with the other city development plans, like physical infrastructure, social infrastructure, economic and financial planning.

[14] Note: Urban planning practices and systems differ across states, and even across cities within states.
[15] http://www.itpi.org.in/pdfs/07_01.pdf

Due to the changes in the economy and subsequent changes in land use, cities are further witnessing significant informalities in housing and livelihoods.

4 What kind of Smart City do we want?

Figure 8: The kind of Smart city

Source: RJB-CPL

A strong thrust on smart city applications has the potential to facilitate the ultimate goal of better infrastructure facilities and improving quality of life in our cities. But, as Dr. Rick Searle points out, **'before investing millions or even billions, cities need to have an idea of what kind of future they want to have and not be swayed by the latest technological trends'**. Figure 8 depicts the kind of eco-system a Smart City should have for proper implementation and functioning.

As detailed in the section above, the current Urban Design and Planning mechanisms in India have not proven to be so effective in incorporating all the urban complexities of Indian cities. This has arisen due to insufficient and not so accurate data collection methods, little connection between socio-economic and spatial processes and less dynamic nature of master plans.

In the Indian context, the opportunity that smart city technologies offer can be tremendous. For instance, where the dearth of data is a crucial hindrance, smart city technologies will facilitate the collection and collation of complex data snapshots. Quantitative data can be collected through sensors, cameras and other monitoring technologies and qualitative, user-oriented data collection can be enabled through user feedback and crowdsourcing on digital platforms. The availability of real-time data will enable a more dynamic and responsive process of planning. Where there is a gap in policy, strategy and planning and an ambiguous overlap of multiple planning authorities, ICT can enable integrated planning systems to work across administrative bodies.

4.1 Data-driven Urban Design and Urban Planning

Though the application of ICT tools in urban planning is not new, smart city technologies expand the scope of urban planning, specifically with respect to data collection. **Cities can become 'smarter' as planning processes become more intelligent with the improvement in quality of data snapshots, understanding of behavioral models and relevant analytics**. Geertman, Jr., Goodspeed, & Stillwell (2015)[16] write that 'Opportunities for urban planning relevant spatial analyses have increased substantially with the advent of urban sensing, ubiquitous computing and the gradual standardization of embedded location information within administrative datasets about urban activities.'

Typically, the quality and consistency of data, the errors and contestation within it have significant human and developmental consequences. At the heart of the smart city initiative lies data, that once collected, analyzed and turned into actionable insights can enable city managers, planners and citizens, to make informed decisions. City's administration, its planners and designers can harness the full potential of technologies by employing them to understand the processes of urbanization in India and the spatial chaos that is noted about its cities. By improving the functioning of the city not only in terms of management and provision of services but also in designing and planning it, technology can improve a city's capacity to become 'smarter' in enabling its everyday planning process to be more intelligent.

4.1.1 Big Data

Big data is an all-encompassing term for any collection of data that is very large or complex and therefore difficult to analyse using conventional data processing applications. Big data refers to the ongoing accumulation of massive, often complex and always changing data sets i.e. machine generated data from sensors or smart phones or data from social media sites. Big data's value is that it can be analyzed and processed to provide insights for better decision making.

4.1.2 Real-time data and short-term planning

Urban and regional planning focus on planning horizons that relate to years – short term being 5 years and long term being 20 to 50 years. Smart cities allow us to shift our focus to how cities function in the short term. Batty (2013)[17] states, 'This is city planning in a new guise that thinks of city being plannable, in some sense, over minutes and days, rather than years, decades.' Big data streamed in real time at the resolution of seconds, can pertain to every type of time horizon if collected for long enough. Big data can allow us to see changes in population that were once sampled every 10 years.

4.1.3 Data from Crowd Sourcing

It is often forgotten, as Anthony Townsend (2013) also argues in 'Smart Cities: Big Data, Civic Hackers, and the Quest for A New Utopia'[18], that cities already have a city wide sensor network, in the form of increasingly popular Smartphones.

[16] https://www.springer.com/in/book/9783319183671
[17] Batty, M. (2013). Big data, smart cities and city planning. *Dialogues in Human Geography*, *3*(3), 274-279.
[18] https://www.amazon.in/Smart-Cities-Civic-Hackers-Utopia/dp/0393349780

Common sensors in Smart phones include accelerometer, ambient light sensor, GPS, proximity sensor, gyroscope, pressure sensor. Where citizen's smart phones can be collaboratively used for such sensing, city administration do not necessarily need to replicate and recreate new sensor network.

4.2 Urban Simulation

Simulations allow planners to anticipate and predict outcomes of various interventions. The advancement in technology and the increase in our ability to collate large quantities of data (that enhance the predictive capacities of statistical models) has increased the computational power and analytical capabilities (that allows planners to calculate the relationship between multiple factors). As a result of computer based visualization techniques, various platforms for urban simulation have proliferated, including both comprehensive systems and system specific prediction tools[19].

4.3 Making Sense of Data

Data integration aside, another principal constraint to big data applications is the access to skilled data scientists and data itself. This is compounded by the problem of acute shortage of quality trained planning professionals in the Indian context. Further, most big data set are currently controlled by corporations; many may be reluctant to provide access to others, especially if the information is sensitive in a competitive market. Though only a recent trend, several datasets in possession of the government are being released as part of open data initiatives. These can be seen at Government of India's open data portal.[20]

In the context of data, it will be useful for cities to safe guard and protect citizen centric data. The EU (European Union) has recently passed the General Data Protection Regulation (GDPR)[21] that can be used as a guiding principle. In India, the Sri Krishna Commission has submitted a report on Protecting Privacy and Empowering India[22], that has implications on data security and privacy. Larger guidelines from the government of India are expected in the near future.

4.4 Sustainable Urban Planning

Figure 9 below is a representation of Circles of Sustainability. A circle of sustainability is a method to understand and assess sustainability for cities and urban settlements, and for managing projects directed towards socially sustainable problems.

[19] More examples of data driven simulation techniques are available at http://datasmart.ash.harvard.edu/news/article/simcities-designing-smart-cities-through-data-driven-simulation-893

[20] http://opendata.gov.in

[21] https://eugdpr.org

[22] http://pibphoto.nic.in/documents/Others/2018727xcxzcx151.pdf

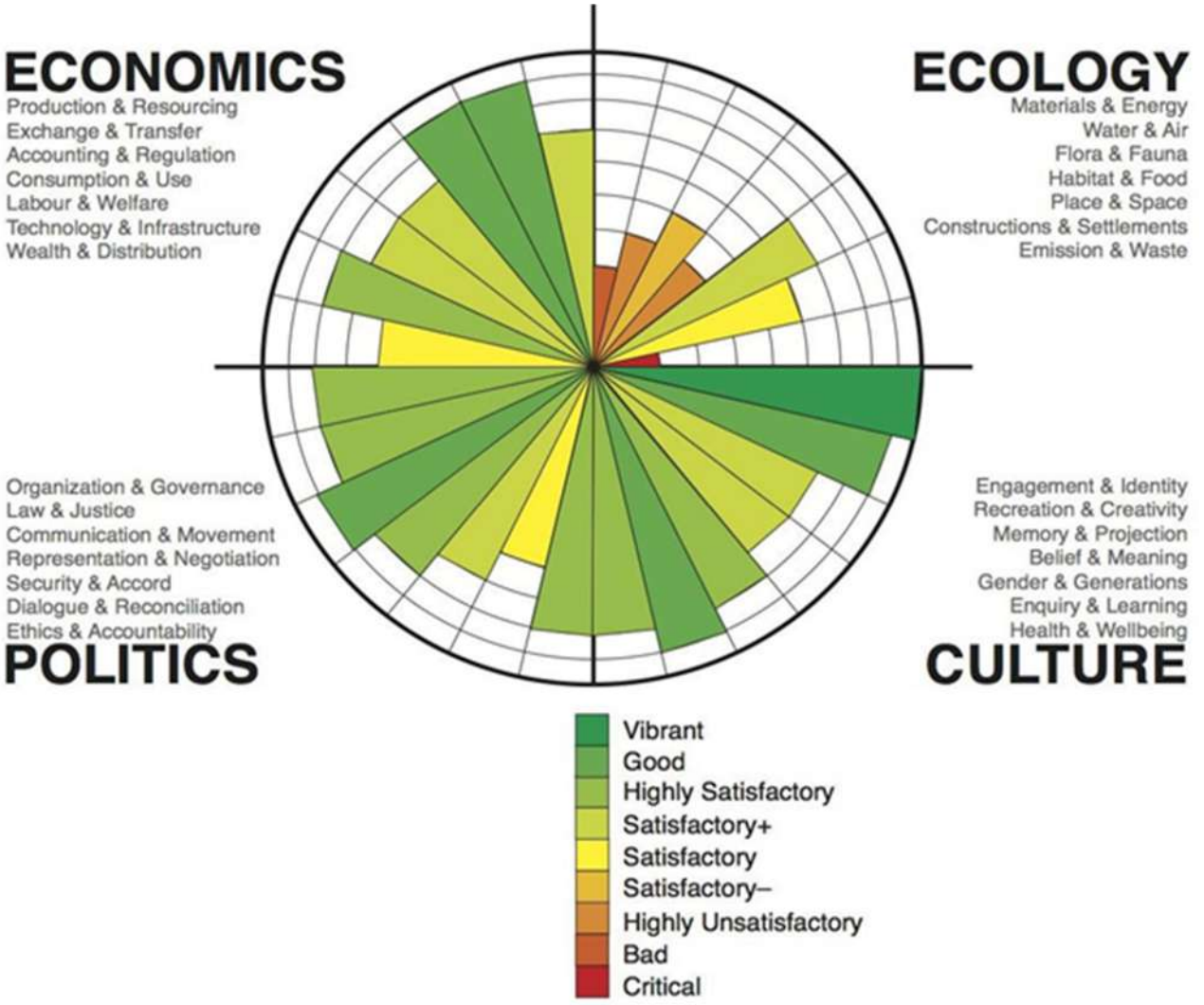


Figure 9: Use of data through citizen participation to qualify Sustainable habitats

Source: https://commons.wikimedia.org/wiki/File:Circles_of_Sustainability_image_(assessment_-_Melbourne_2011).jpg

The above figure describes a tool to quantify sustainable habitats and citizen participation. The concept of sustainability, central to smart cities, is not new to the paradigm of urban design and planning. New urbanism, smart growth, and the ecological city are three sustainable urban development approaches that also posit sustainability as their central concept.

4.5 Smart Cities: Top-down and Bottom-up

The Smart city paradigm stresses on the importance of Smart Citizens. There are multiple interpretations of it. Sadoway and Shekar (2014)[23]define smart citizenship as, 'a call for engaged, active and critically reflective civic-cyber debates and deeper discourses among a diversity of citizens and not only the visions of digitally dominant 'thought' or 'business leaders''. They stress that open access, open source software and net neutrality are all building blocks of ICT infrastructures and platforms for smart citizens. **The concept of smart citizenship need not be limited to only engineers, coders and civic activists but also include civic hacktivists, local associations and community groups.**

4.6 Tools for participation

There are multiple terms for public participation in urban design and planning, such as collaborative, communicative, deliberative and community planning which are shown in Figure 10. Whatever the approach, a broad understanding of participatory processes need to be encouraged at the outset- one that is not limited to information gathering or dissemination regarding the government's work, but also includes a dialogue with public authorities, decision making, and assessment of the final outcomes.

[23] "(Re)prioritizing Citizens in Smart Cities Governance: Examples of Smart Citizenship from Urban India" https://www.researchgate.net/publication/324953632_Reprioritizing_Citizens_in_Smart_Cities_Governance_Examples_of_Smart_Citizenship_from_Urban_India

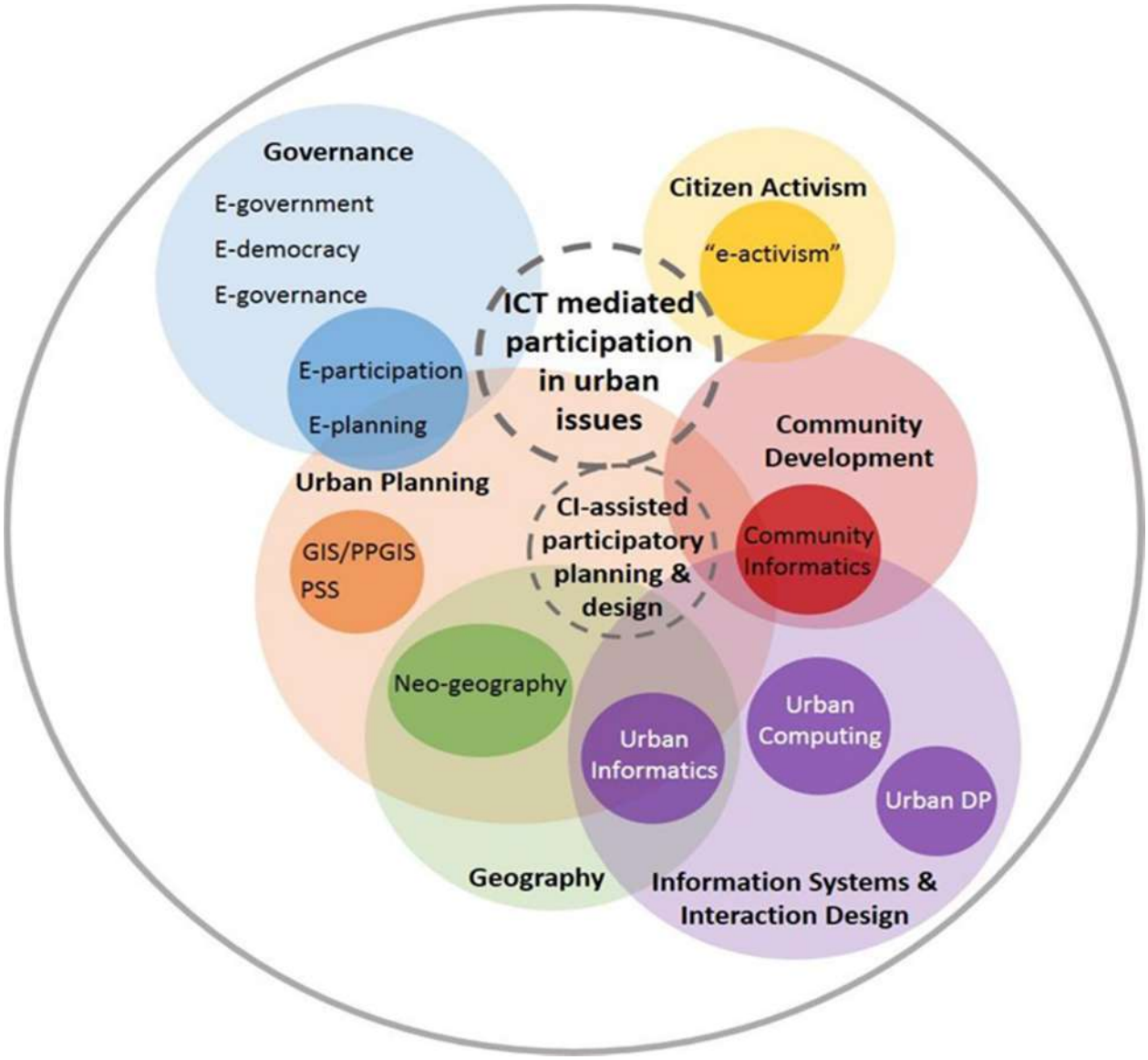


Figure 10: ICT mediated participation

Source: Saad-Sulonen, J. C., & Horelli, L. (2010). The value of Community Informatics to participatory urban design and planning: a case-study in Helsinki. The Journal of Community Informatics[24]

The use of ICT in participatory processes is not new. The current thrust in Smart cities is based on the availability of IoT and ICT, the increasing preference for online transactions, combined with the emergence of low-cost hardware and other emerging technologies. The current need of the hour is to develop new applications based on these.

With regards to ICT-based interventions in governance and planning, the concept of e-governance, and the use of collaborative tools to engage citizens in urban planning and participatory budgeting have

[24] https://www.semanticscholar.org/paper/The-value-of-Community-Informatics-to-participatory-Saad-Sulonen-Horelli/5b96f849352ff1d3566c3d1804ef2a7e9a3a5dbe

been around for a long time. However, the trend of smart cities has demonstrated that new technology can be used to promote citizen engagement in a meaningful manner. Various methods, like social media, feedback systems, etc. can be utilised to collaborate with citizens on issues of planning, design, budgeting and policy.

With the employment of ICT and IoT technologies, it opens up new opportunities in the areas of citizen engagement. These include the following items[25]:-

1. Collaborative Economy: In cities with limited space and resources, technology can connect distributed groups of people through the power of the internet and other digital platforms, to better ensure the use of goods, skills and space.

2. Crowdsourcing Data: City governments can crowd source data from social media sites and sensors in mobile phones, while citizens can use low cost sensors to measure and create crowdsourced maps of their environments.

3. Collective Intelligence: Decision making and problem solving are usually left to experts, yet citizens know a huge amount about their cities. New digital tools make it easier for people to get involved in policymaking, planning and budgeting, and this could help cities make smarter and more democratic decisions.

4. Crowdfunding: People can connect with each other online to collaboratively fund community projects and city governments can use crowdfunding to make spending decisions that more accurately reflect the needs and wishes of citizens.

4.7 Competency building

The use of smartphones is central to a range of smart city applications, particularly as citizens receive real-time updates about information that is relevant to them like information about bus delays, traffic and even smog, and allows city dwellers to change their behaviors and make sustainable choices.

It is widely believed that the new digital tools offer a chance to engage a wider group of people, ensuring all citizen voices are heard. However, in the Indian context, the effectiveness of such initiatives is severely constrained by the lack of the readiness of the public to engage in it, the chasm of the digital divide as well as the low spread of smart phones. The designers and planners must find a way to make the software accessible and usable to even a non-technical audience, and to allow citizens to become active generators of their own urban visions.

[25]Source: Saunders, T., & Baeck, P. (2015). Rethinking Smart Cities from the Ground Up. London: Nesta

4.8 Emerging Issues

The issues of ethics, citizen rights and privacy[26] that have been raised with increased surveillance, technical lock-ins and increasing control with service providers, are well documented. In addition, the reinforced marginalization of excluded groups that may come about as many groups fall through the cracks of the digital divide are widely recognised. Of the many, some flaws that are commonly identified are: the excessive focus on technology rather than urban challenges, emphasis on marketing and promotion at the expense of actual implementation, less exposure on the use cases implemented elsewhere by other city administrations / Governments who are trying to improve their cities, and little to no role of citizen engagement.

Based on the analysis of approximately 100 definitions of smart cities, a CSTEP report (2015)[27] identified that a majority of them posit ICT/IoT technology, economy and environment as the primary aspect of any smart city. This model of smart cities assumes that there is a common goal for the city which can be optimized to increase efficiency in different sectors such as transport, health care, etc., so as to benefit the city as a whole. What remains missing, however, in the smart cities discourse is a technically sound, integrated system and framework based on which the city operates. But the more serious concern is that equity fails to be mentioned anywhere. As the same report states– 'this partially indicates a lack of conscious effort to leverage the capabilities of smart attributes to include the marginalized and disadvantaged within a city's development plans'. Further, many urban researchers have clearly identified the role of large influential and commercial market players in shaping the smart cities discourse, as well as the excessive utopian, techno-deterministic claims about ICT uptake and its uses in cities. They advise municipal bodies to be cautious in their approach towards smart city initiatives.

It cannot be stressed enough that stakeholder engagement is crucial. This, if not carefully executed can have splintering effects on the social cohesion of society, as social groups with limited access to digital resources may find themselves completely isolated. Through well thought out Urban Design and Planning, one needs to shift the focus on solutions that involve the public, both in shaping technologies and in implementing them; solutions that are cheaper and modular so that they can be scaled up and those that are based on evidence instead of hype. Any smart city in India need not re-engineer entire city, or look for the best possible technological solution. But instead it needs to reprioritize citizens and local needs, by seeking more democratic and equitable approaches that prioritize local civic knowledge along with addressing political accountability and civic decision-making processes**.**

To begin with, before mapping out a strategy for the development of a smart city, it is important to see what is already in place and how it can be improved. So that the focus is on what is missing rather than the technology itself. Smart cities not only require digital and technological changes but also

[26] Privacy, security and ethics are challenges that any smart city intervention should take notice of. Questions like: Who is monitoring and controlling all the devices? How secure are these? How to ensure data of all the citizens are secure? Who owns the data and devices? Is the access equal for all citizens?)

[27] Bhattachary. S., Rathi. S.(2015). "*Reconceptualising Smart Cities: A Reference Framework for India."*, (CSTEP-Report-2015-03).

institutional and physical changes. Physical design and planning together with a broad range of social and economic policies can underpin the 'smart' dimension of any smart city. Any Smart city venture needs to address issues of coordination among different levels of administration, and address many moral and ethical issues, such as digital divide, transparency, security and privacy in general and lack of an integrated systems of governance, co-ordination among departments, low levels of digital literacy, lack of service coverage particular to Indian cities among many other issues. That being said, the benefits of technology need to be recognized and realized.

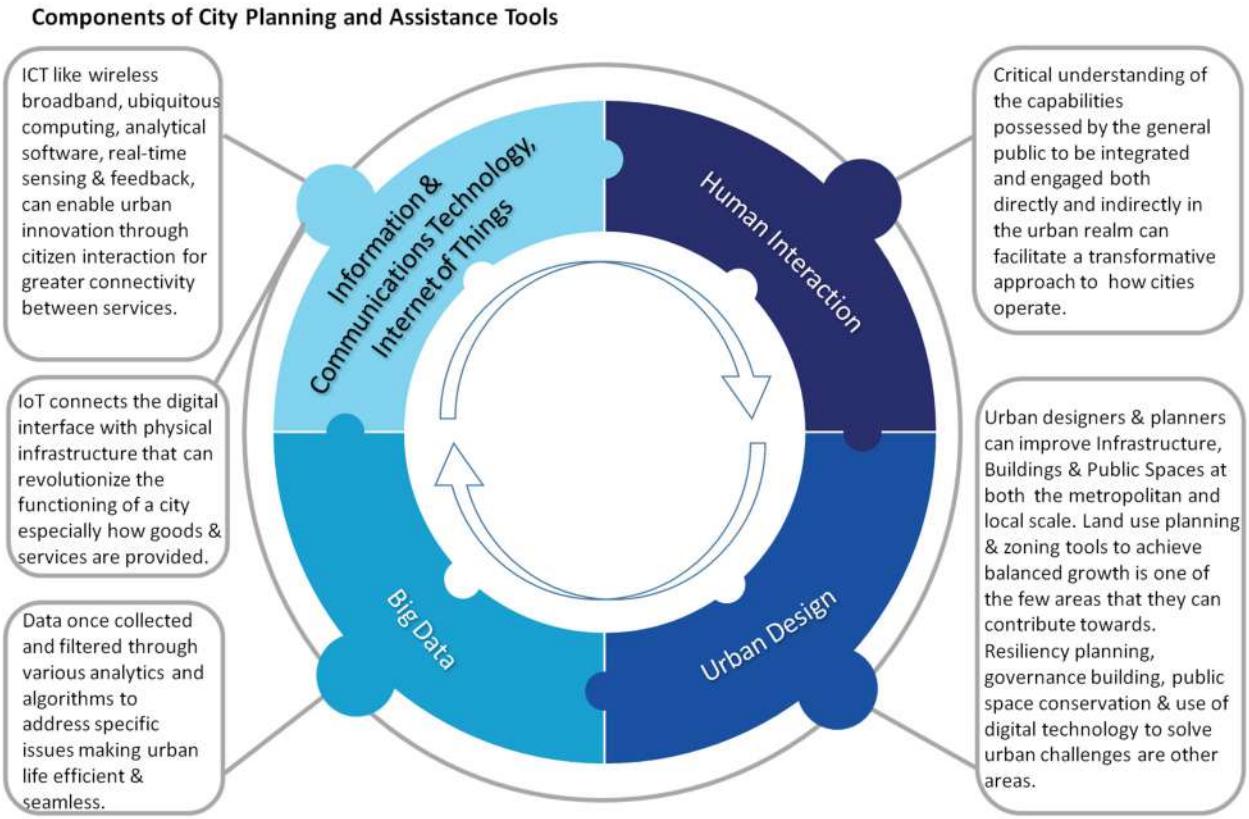


Figure 11: Components of city planning and assistance tools

Source: RJB-CPL

As the Director, SPA (School of Planning and Architecture), Delhi[28] aptly summarizes: *What India today needs is not 'smartness' from the IT sector alone, for it can do little by itself. We need a range of town planning, engineering, technology, material science, architecture and civic design disciplines which need to be amalgamated into a cogent, comprehensive and connected Smart City Plan, which can be implemented in a time bound manner. We need this basic infrastructure first. IT alone cannot be a solution as is being made out to be in some quarters. It can only be a support system for smart city planning and management and not the driver.'*

[28] https://indianexpress.com/article/business/business-others/smart-cities-go-beyond-just-using-tech-tools/

In this respect policy also needs to keep up with technology, and the changes that it brings along. Much of the popular debate in India on smart cities by urban designers is critical of the many techno-utopian images that it has spawned, of the private enclaves that it may create, and its use of mathematical and rationalistic outlook of the city and its problems. Critical of how, if at all, is whether the rhetoric will result in solutions for real problems cities face like those of environment, housing and unemployment.

Technological innovation in India needs to be aligned with social innovation. 'Social innovation means implementing new ideas including technology, design, products, services and models in order to meet social needs'[29]. It will not function unless people themselves see the value generated, appreciate the purpose, accept, and interact with the new technology-based systems.

The focus of smart cities needs to remain on sustainable and equitable use of a city's resources- natural, human and financial. Whether that is achieved with or without the use of technology is immaterial. However true that may be, the more and more clear we get about the use of technology and galvanize towards a meaning of what constitutes 'smart', especially in the Indian context, we have much to gain from the 'Smart Cities' in India.

5 Recommendations

Amidst the many features of smart cities, an attempt has been made to focus on ICT and IoT aspects relevant to the field of Urban Design and Urban Planning, particularly those aspects of the discourse that can conclusively shape future developments. Within these, the focus here has been on general characteristics that can support Urban Design and Urban Planning practice over the tools themselves.

1. ICT and IoT in Urban Design and Urban Planning in India needs to focus on characteristics like dynamic, responsive, transparent, integrated and secure cities:

- **Dynamic** with the use of ICT and IoT tools in data collection, analysis, and simulation.
- **Responsive** to its citizens with participatory tools, a bottom-up planning approach and capacity building of civic authorities and users.
- **Transparent** with use of real-time data in government institutions and transparent to its citizens with open data policies and strategies; and its systems.
- **Integrated** with a common data architecture used over a comprehensive planning platform.
- **Secure** both the physical and digital infrastructure of the city.

2. Urban Design and Urban Planning principles for any city, especially a smart city, need to be adopted in its context and no exhaustive list can be prepared for this. The relationship between ICT / IoT and Urban Design & Urban Planning is still in the definition stage and its applications are still at a very nascent

[29]Bholey, Mihir. "India's Urban Challenges and Smart Cities: A Contemporary Study." *Scholedge International Journal of Business Policy & Governance ISSN 2394-3351* 3.3 (2016): 17-38 - https://thescholedge.org/index.php/sijbpg/article/view/286

stage. However, with thorough discussion and collaboration, keeping in mind the final outcomes, ICT-based interventions can be systematically used for the larger benefit of the citizens.

3. It must be mentioned that the implications of using ICT and IoT in the fields of Urban Planning, Urban Design and City Architecture are not extensively understood by the practitioners themselves. One of the recommendations is to tackle this gap by highlighting many important questions, perspectives and considerations regarding technology applications. In this sense, it is pertinent to critically examine the current trends and present alternative perspectives by beginning with the following:

- What design and planning practices make a city smart? When does a city become a smart city?
- Does short term city management make long term planning redundant?
- As urban spaces are designed and planned to use big data analytics, question is, what is an effective method of data collection in the Indian context?
- In the context of urban planning and design in a smart city, what are the various top-down and bottom-up approaches? How can we improve the capacity of urban local bodies and its decisions to make sense of the data that has been gathered and analyzed?
- But more importantly, how can smart cities be more dynamic, integrated, responsive, resilient, robust and transparent?

4. With regards to the Smart Cities Mission, at the time of preparing this Technical Report, proposals from all 100 cities have been accepted. The policy document as well as the smart cities proposal format and proposals themselves, reinforce many of the best practices that are advocated here. However, the implementations of the solutions in the proposals are critical in determining their successes.

5. Analyzing the proposals of the winning 90 cities, it indicates that roughly only forty-six percent of all the components are ICT based. This indicates that a significant part of smart city components being proposed are non-ICT based. While technology is the focus of many smart cities, it is important not to lose focus of the pre-identified vision and objectives as well as the urban problems to which technological solutions are being applied. All in all, a smart city vision must be followed by its objectives, followed by its features, and lastly followed by its technology components.

6. In using technology as a tool for Urban Design and Urban Planning, the goal is not to automate the process or minimize the role of planners and designers, but to aid the process of decision making. There are three obvious directions towards which smart city initiatives are moving. The first is the use of technology to improve tools used in practice; the second is towards design that responds to the changes in social and cultural fabric of the city; and third the use of technology in promoting citizen participation

7. New emerging ‘smart’ technologies that enable real time sensing and feedback loops - wireless broadband, ubiquitous computing and powerful analytical softwares offer countless possibilities for day-to-day city management as well as city planning and design. However, ICT based components – such as command and control centers based on a communications network bringing in data from devices, chipsets and sensors over cloud platforms appear to have become the core focus of smart city

proposals. While these contribute to building smarter cities, an entirely ICT based focus means that the vision for cities remains incomplete. Without creating much ado of some of the pitfalls of an ICT focus on smart cities, key learnings based on the literature reviewed in this document of best practices and guiding principles for Urban Design and Urban Planning practice are:

5.1 Considerations for smart city plans

- **Focus:** It is important to focus on urban problems rather than the technology itself.
- **Vision:** Any Smart City plans need to first identify a vision in the short term and the long term before a smart city initiative can be implemented. By extension, to ensure that focus remains on long term planning goals rather than short term city management measures.
- **Strategy:** Any smart city strategy needs to consider its long term as well as short term effects on urban form and socio-cultural environment of the city.
- **Implementation:** It is important to implement the strategy efficiently with the best balance between sustainability, profitability and usability.

5.2 Considerations for smart city institutions

- **Culture:** City administrators not only build technological capacity but also focus on changing the culture and staff among decision-making bodies. Smart cities not only require digital and technological changes but institutional and physical changes also.
- **Indian Context:** Particular to the Indian context, any Smart city venture needs to address issues of political coordination among different levels of administration, and address many issues such as lack of an integrated system of governance, co-ordination among departments, low levels of digital literacy, lack of service coverage specific to Indian cities among many other issues.

5.3 Considerations to improve citizen participation

- **People-centric:** For a city to reflect the aspirations of its citizens, it needs to prioritize a design lead approach that is people-centric over a technology lead approach.
- **Top-Down and Bottom-up:** Interventions need to include both top-down and bottom-up approaches.
- **Engagement:** Ensuring meaningful citizen engagement in smart cities is important. The concept of smart citizenship need not be limited to only engineers, coders and civic activists but also include white hat hackers, local associations and community groups. Instead, a smart solution, that may or may not depend on technology and respects local tradition knowledge systems can truly involve users, citizens and city dwellers in the process of city building.
- **Rights and Privacy:** ICT-based interventions need to ensure that for citizens all technology-based platforms are accessible and do not violate citizen rights and privacy.

- **Reducing digital divide:** Reducing India's digital divide might be challenging to answer in a single line, given the extreme economic dichotomy. Consider providing specific digital skills that incentivize the citizens in attaining a better livelihood.

5.4 Considerations for technology-based solutions

- **Review interventions:** Many IoT applications are at their nascent stage, and the science is exploratory. Thus any application launched by the Smart City requires regular view of the evidence on which interventions are based.
- **Planning and designing with data:** This can enable city's governments, its planners and designers to harness the full potential of technologies by employing them to understand the processes of urbanization in India and the spatial chaos that is noted about its cities
- **Explore alternatives:** Cities can consider leveraging existing resources to collect data. For example: there are many alternative and supplementary data collection techniques such as sensing pilots that are based on modular platforms and open specifications as opposed to a capital-intensive sensor-based networks. For the same data collection, cities could also rely on smartphone-based sensor-networks, and data crowdsourced from social media platforms.
- **Extended considerations:** Integrating IoT into city frameworks and systems require a large number of considerations such as leveraging existing physical assets, engaging local data eco-systems, clear data management strategies, transparency and security and privacy concerns.

PART B

Design, Systems & Futures Thinking in IoT/ ICT for Smart Cities

6 Introduction to Design, Systems and Futures Thinking

6.1 Designing "smartness" in Smart Cities

The definition of "smartness" in Smart Cities remains a subject of intense debate amid theorists, practitioners, regulators and citizens alike. At one level, the Ministry of Housing & Urban Affairs, Government of India encompasses its Smart Cities vision to include the basic provision of services in the city, such as clean water, clean environment, energy and infrastructure, for all citizens. Just the provision of basic amenities can significantly improve the quality of life of citizens, and thus make it "smarter". At another level, from the perspective of the need of cities to improve efficiency, productivity, speed and quality of service delivery or introduce new types of interconnected services, the use of ICT technologies becomes imperative. This has been illustrated in Figure 12.

Figure 12: Smart City: a dynamic, evolving, citizen centric entity.

Source: Gaia Smart Cities

The virtuous cycle of measuring, tracking, and managing services and performance can help cities improve and become "smarter".

In this part, it is posited that making a city smart involves two basic tenets. First, smartness means monitoring and improving the performance of a city and its service delivery processes and outcomes. Second, the performance of the city, in turn, must drive its overall citizen centric vision of improving the quality of life of citizens by improving standards of public services and creating economic opportunities for them.

Given this larger purpose, ICT led initiatives cannot be planned in isolation. They must integrate with the broader urban and infrastructure design framework. Most critically, they must also consider multiple issues such as economics, return on investment, lifecycle costs, environment, regulation, incentives, jobs

creation, jobs displacement, stakeholder needs, future trends, ease of usage, ease of adoption, communication, awareness generation, benefits definition, visual interfaces, visual experience, ambient hardiness and much more to ensure an impactful solution.

Technology can make city systems resilient, enable remote measurement and monitoring of city services, allow cross functional city system interaction, and create new closed loops to improve the system and monetize services. These solutions could be sector specific – for example transportation, traffic and roads, waste management, energy, water, environment, e-governance, citizen engagement. These solutions could be function specific – such as distribution, marketing, billing and payments for a specific sector. In each sector, function and solution is underpinned by ICT design to collect and analyze information, control processes and enable faster, better decision making.

Furthermore, this section reinforces and builds on Part A and creates a set of tools to approach ICT based planning and design of smart cities.

Key questions and tenets laid out in Part A include:

- What design and planning frameworks make a city smart?
- Does short term city management make long term planning redundant?
- How can we improve the capacity of urban local bodies and its decisions?
- How can data be better collected in the Indian environment?
- How can ICT and design improve performance, impact sociocultural fabric of city and engage citizens?

The purpose of this part – Part B of this Technical Report is to describe Design, Systems & Futures Thinking approaches when planning, designing and implementing ICT for smart cities. This has critical implications for two sets of stakeholders:

- Firstly, it offers a holistic approach to regulators and city administrators when crafting city vision, preparing detailed ICT enabled plans, and defining procurement processes, regulatory and financial incentives.
- Secondly, it offers a new approach for ICT providers to look beyond technical impact of their solution and consider how it integrates with and impacts the overall ecosystem of people, processes, infrastructure and data.

Given the complexity of the challenge and many interdependent systems, processes and people requirements of delivering public services, systems thinking tools can enable integrative thinking. However, it is more critical to use design thinking principles and human centered approach for ICT for smart cities, to identify real needs for the people and connect them with financial and technical feasibility to ensure long term viable solutions. Much of the current discourse on smart cities focuses on finance or technology as means and ends in themselves. This can lead to fallacious thinking and drive regulators, city administrators, and service providers to create solutions that are technically fascinating and funded through complex financial transactions but fail to touch the lives of citizens.

6.2 Definitions

Design Thinking principles require that ICT ideas, products and solutions must be rooted in the real, on ground realities of Indian cities with varied environmental conditions that affect the lives of citizens from varying walks of life, with varying levels of familiarity with the use of technology, and with varying levels of expectations of how ICT enabled services can transform their lives.

System Thinking approaches provide a deeper understanding of the enmeshed reality of how decisions are made and implemented in Indian cities. It also addresses which systems, processes and people a solution touches, influences, disrupts or displaces for effectiveness. It therefore, finds ways to counter any opposition that arises. Systems thinking allows looking at problems and solutions from all perspectives to identify the "easy wins" to choose early solutions and the path to implementation and deployment. The process of zooming out from the immediate task of designing a specific city service and its associated technologies, also allows planners to look at the macro picture, identify patterns, consider emerging trends, and determine optimal or critical path solutions.

Futures Thinking layers typical strategic planning methods with a structured approach to look at weak signals which may help in identifying emerging trends. Planners designing smart cities ICT are always making decisions on technology or systems structuring or types of solutions that users may continue to prefer over the coming decade. Futures Thinking allows them to future gaze, to categorize and thus understand the trends and practices that may phase out and give way to newer technologies or trends.

Design, Systems and Futures Thinking work complementarily bringing empathy and user centricity into planning and adding depth through understanding the multi-variate ecosystems to create and implement plans that will deliver sustained impact.

7 Frameworks

7.1 Design Thinking Principles

Design Thinking is a methodology – a way of building solutions that centers on the principle of human centered design. While creative teams, whether innovators or designers have been using these techniques for a very long time, the concept started getting popular as a broader management principle over the past decade.

Smart city solutions are "multilateral" by nature – they have multiple facets, requiring multiple people, processes, places or assets to be interlinked. At the same time, while the smart city agenda is being driven by the government, the government and the city administration will require funding for these projects. Hence the question of monetization is crucial to ensure that projects transition from plan to reality.

Even with the broad set of ICT options available today, and not even considering technologies such as fog computing, cognitive analytics, deep learning, artificial intelligence and others, that are yet to emerge as mainstream, it is feasible to put together robust solutions for Indian cities. But it needs to be done in a manner that is strong enough to withstand the exigencies of Indian conditions, is financially viable, environmentally sustainable and usable in the long term. Generating multiple revenue streams that together cover the costs for a project becomes even more crucial.

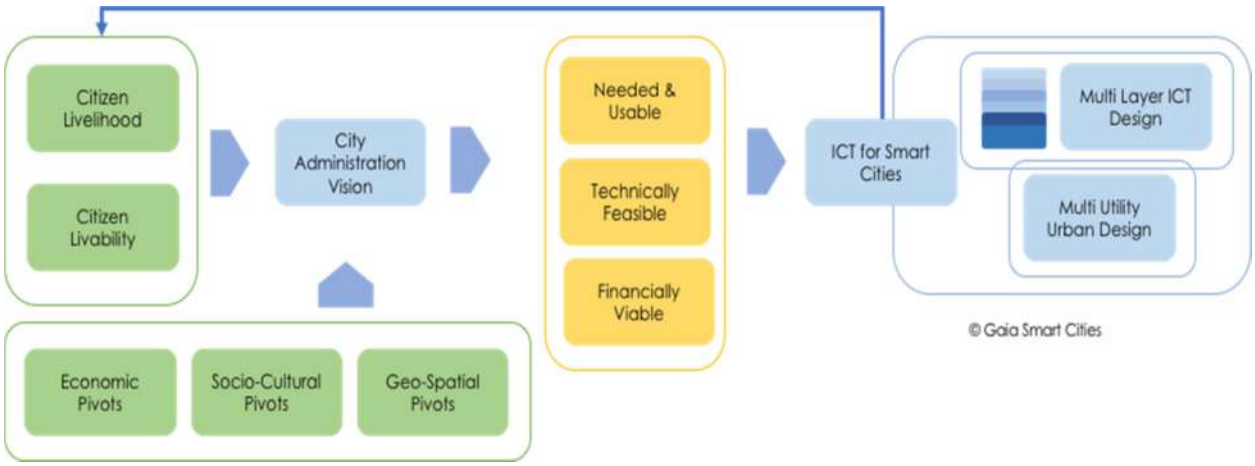


Figure 13: Design Thinking Approach for Smart Cities ICT

Source: Gaia Smart Cities

Elements of Design Thinking approach for Smart Cities:

1. Engaging with and mapping citizens and different kind of users is critical. This must be done before the planning process, to capture real needs and usage patterns, and thus design solutions that work for the people. There must be a follow-through after the planning and implementation phase. Many new solutions will require citizens and users to change their behaviors. Thus, awareness generation, training and behavior change is an important part of delivering a solution.
2. Design Thinking consists of generating a broad set of ideas or solution options, keeping in mind a set of consumers – core users (the key champions), lead and lag users (early adopters and those who resist adoption), and extreme users (who use a service under special circumstances)- and ideas that would meet their current needs as well as emerging and latent undiscovered needs. This human centric approach allows planners to identify solutions that are desirable to people, and hence will get adopted.
3. This broadening of scenarios is followed by a conscious narrowing down, to select options that are technically feasible and financially lucrative. It is crucial to design solutions that can be deployed at price points that match demand, and to consider business model innovations to

enable multiple revenue or monetization streams in scenarios where a single revenue stream does not generate sufficient return on investment.

4. Rapid prototyping of new solutions is needed. Implementation needs to be planned to allow for innovation and experimentation, so that solutions can be tested and improved in field conditions before being scaled. Solutions taken as-is from other countries or other cities may not suit the needs of a specific city.

These 4 steps are condensed and illustrated in Figure 13.

7.2 Systems Thinking Principles

Systems Thinking is a toolkit that offers a way to consider all the interdependencies and impact of a complex process, such as ICT for Smart Cities, to identify interlinkages and pivots, and thus craft a better solution.

Considering a solution in isolation – when planning, designing, procuring, and implementing not only can lead to cost overruns, data and systems duplication, opaque city infrastructures, gaps in the overall solutions, but also in many cases a sub-optimal solution that involves taxpayers and investors' money but does not lead to the desired outcomes and efficiencies.

In contrast, when a solution is placed in its context, it can help to create a System Map as shown in Figure 14. This map, in turn, enables regulators and city administrators to visualize its principal drivers, understand the interconnections, pivots and impacts, and thus craft a more robust solution. This qualitative approach of identifying multiple drivers and sensing their importance gives a broad picture. Figure 14 shows when the city is broadly considering ICT for making it smart, what various factors that impact it are in yellow, the connections and impacting factors between these are shown by the arrows, what the outcomes could be, is in green and what actual applications are in blue.
The ICT design of a smart city is influenced by the available financial, regulatory and innovation constraints and must integrate with legacy systems, processes and data architectures of city. What becomes obvious on mapping the factors, is the role of talent, skills and sharpness of available advisors and providers, their awareness of newest trends, and the availability of lifelong learning platforms. This is not a trivial driver that can be presumed as given.

Role of the Smart city administration and the Regulator is critical, especially as the project moves to detailed planning, project structuring, and implementation. At every step, conscious choices need to be made given resource and time constraints. Active engagement is crucial to ensure optimal allocation, spending, and impact.

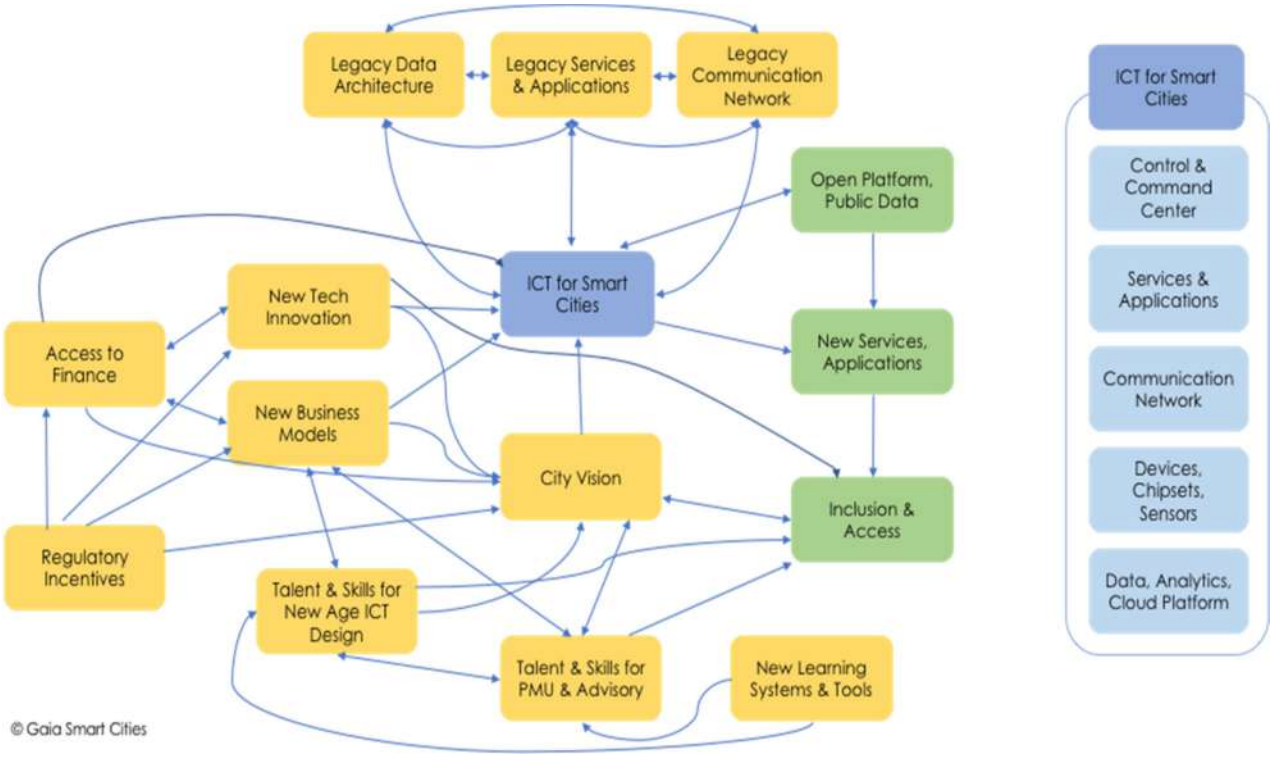


Figure 14: Systems Map for ICT for Smart Cities

Source: Gaia Smart Cities

7.3 Futures Thinking Principles

Futures Thinking offers a methodology to consider trends, technologies, user behaviors, and evolving user needs that may shape the future, and thus allows planners and designers to future-proof their solutions.

Over the past several years, given the failures of some firms leading to collapse of the global economy, there is a new focus today on the ability to read weak signals. Experts are concerned that people frame complex and ambiguous problems through their perception biases, through filtering information, distorting inferences and bolstering information that matches their initial perceptions[30].

Researchers from Mack Institute of Technological Innovation at University of Pennsylvania suggest that weak signals can be captured by studying the ecosystem broadly and leveraging multiple ways of capturing information by tapping local intelligence, global experts, consumers, competitors, and leveraging intuition. Mapping this information against multiple scenarios can offer a way to interpret trends that may matter in the future.

[30]Paul J.S. Schoemaker & George S. Day, "How to Make Sense of Weak Signals", MIT Sloan Management Review, Spring 2009 - https://sloanreview.mit.edu/article/how-to-make-sense-of-weak-signals/

7.4 Distinguishing between Design and Design Thinking

It is important at this stage to distinguish between “design”, the way something looks and works, and “design thinking”, a framework for creating better and holistic design that puts users at the center of the design process. An illustration of this is shown in Figure 15.

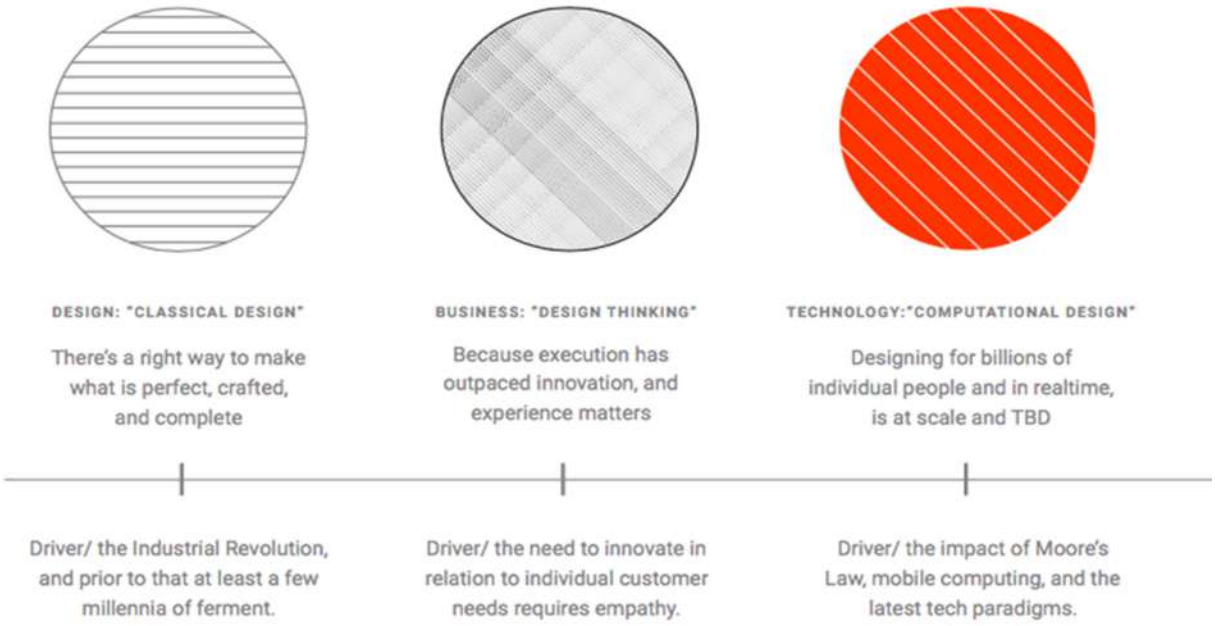


Figure 15: Three Phases of Design Development.

Source: Design in Tech Report 2017 [https://designintech.report/2017/03/11/design-in-tech-report-2017/]

Design itself consists of two parts – visual design and functional design as illustrated in Figure 16. In the context of smart cities, design has physical and digital components, each of which has visual and functional design elements.

Figure 16: Elements of Design for Smart City ICT

Source: Gaia Smart Cities

Physical ICT consists of products – devices, sensors, communication gateways, servers and more. Design governs how components are architected together in a usable solution. Visual design defines how a product, or a system looks, whereas functional design is concerned with how the component or aggregated solution works and its robustness in harsh ambient conditions and rough usage by millions of users.

Digital ICT consists of software, systems, and interfaces. Design must consider the visual design of interfaces as well as the functionality, experience and interaction design of the multiple elements of the system. Experience and interaction depend on the navigation structures of a site and functionality for users. It is important to consider the idea of discoverability while designing digital solutions. Whether we are looking at a feature for a specific user group within a solution, or a citizen centric application that must be "found" easily before it is used, designing for discoverability is critical. When these digital solutions store data and critical information of citizens and government departments, designing digital security and privacy becomes critical as well.

8 The Challenge of Building "Smartness" in Smart Cities

The Ministry of Housing & Urban Affairs, Government of India has identified about 100 cities for its Smart Cities challenge. As these cities move from crafting strategic plans to detailed planning, blueprint creation, vendor selection, and implementation of Pan City and Area Based Development initiatives, the focus shifts to visible outcomes.

Most of these are brownfield cities, with existing systems and processes. They have unique economic potential, cultural or heritage strengths and demographics strengths and constraints. Each city is not an island, rather the epicenter of its urban-rural spread that must consider the hinterland that surrounds it and gives it additional advantages or constraints. Hence ICT designs must necessarily fit into existing systems and infrastructures, while reimagining it in parts or re-visualizing it anew but with appreciation of the complicated network of system, process or people interdependencies.

9 Design Thinking Approach for Smart Cities ICT Design

9.1 Multiple Stakeholders of a City

Each smart city has multiple stakeholders, which can be bucketed into the three key categories – Government, Service Providers and Citizens. A simple relationship between the three is shown in Figure 17. In the case of ICT/ IoT for Smart Cities, these stakeholders would specifically include:

1. Government:

These are government officials at all levels – central, state, municipal, urban local body. Each of these government bodies will have regulatory frameworks, financial expectations and systems architectures that would influence how a city can implement the ICT blueprint underpinning its smart city initiatives.

2. Service Providers:

These could be classified into the following sub categories.

A. Investors:

Institutional or sovereign funds that look at smart cities from the perspective of investments. The Indian Finance Minister had stated in a dialogue in June 2016 that India needs to spend $1.5 trillion over the next ten years to overcome its infrastructure gap[31]. Investors will need adequate return on investment, which in turn implies that cities must define plans for infrastructure development that can be monetized over a medium-term horizon, thus creating incentives for these investors to participate.

B. Industry and Service Providers:

Service providers oftentimes provide goods and services as well as financing to cities. In the case of ICT design for smart services, these providers could enable any layer of technology – from network to communications to data architecture to applications. Cities have limited funds for implementing all the projects they envision. Hence, they encourage service providers to double up as investors, bringing in technical knowhow and ideas, technology products and services, as well as financing to implement these projects.

[31] Press Trust of India, "India needs $1.5 Trillion for Infrastructure, The Economic Times, June 26, 2016
Source: https://economictimes.indiatimes.com/news/economy/infrastructure/india-needs-1-5-trillion-for-infrastructure-arun-jaitley/articleshow/52922015.cms

3. Citizens:

While the goal of smart city initiatives is to improve the efficiency of a city, and thus improve the quality of life of citizens, they remain the most forgotten set of stakeholders. Citizen centric view is essential to the eventual success of any smart city ICT project. Bringing in human centered design to ensure ease of usage is critical. For online services, intuitive digital interface design is essential.

City administrators must ensure that the interests of all the stakeholders, especially the financial incentive to build, operate, and manage the solution in the longer term, are aligned for a sustainable outcome.

City administration the world over is concerned that private enterprise led technology is exacerbating the inequality in communities[32] in direct contrast of the desire of cities to create more social inclusion. However, the long-term sustenance of optimal solutions deployment and operations will require city administrators to consider and approve new types of business models, and multiple revenue streams that allow private players and innovators to thrive in the ecosystem.

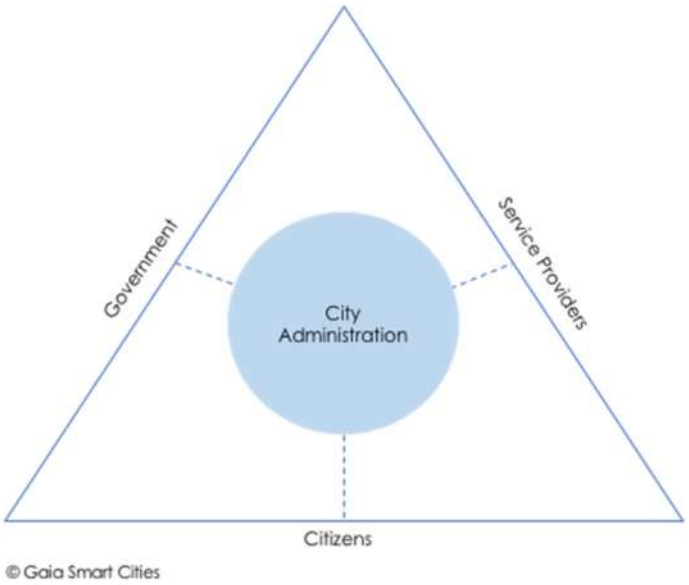


Figure 17: Stakeholders of a City

Source: Gaia Smart Cities

The city administration for the smart city projects need to ensure that the needs of each stakeholder are addressed through planned initiatives.

Smart city ICT projects also need to enable multiple partnerships between different stakeholders to create a robust ecosystem. This is shown in the Figure 18.

[32] Eric Brynjolfson, Andrew McAfee, and Michael Spense, *Foreign Affairs,* "New World Order: Labor, Capital and Ideas in the Power Law Economy", July/August 2014 - https://www.foreignaffairs.com/articles/united-states/2014-06-04/new-world-order

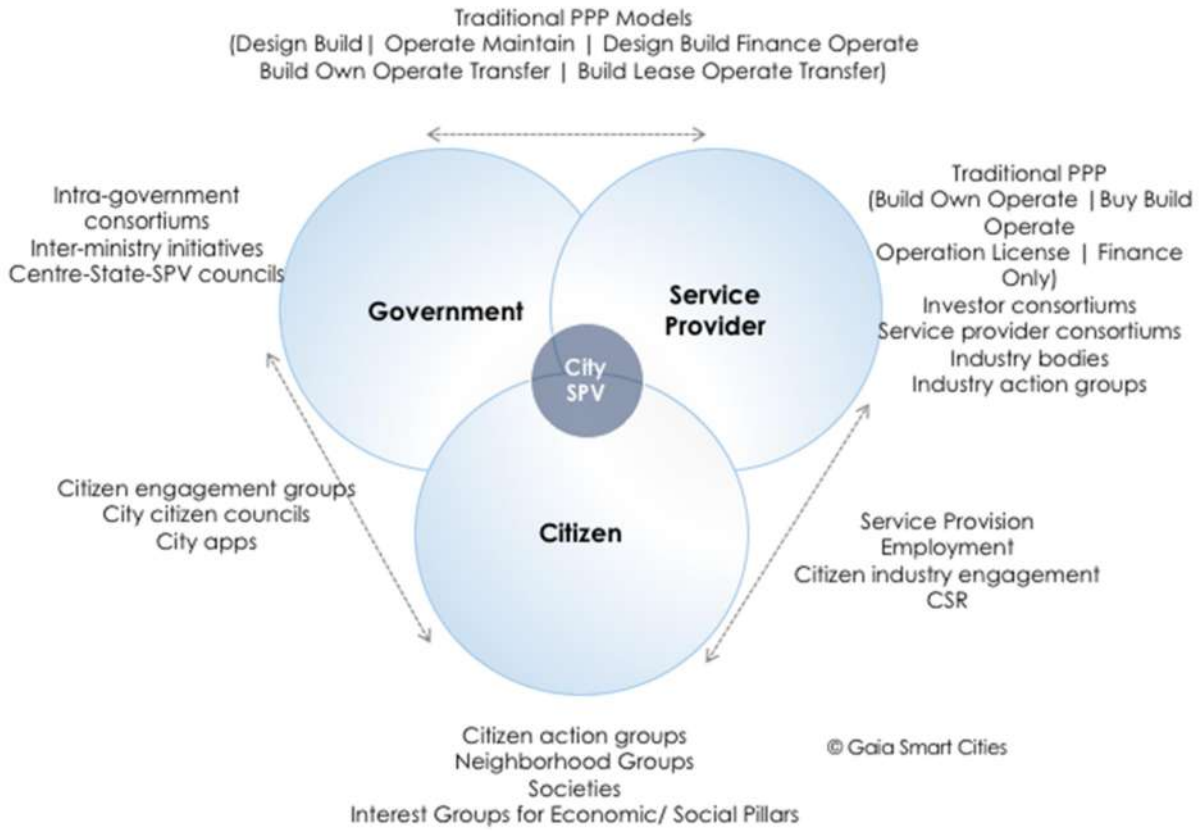


Figure 18: Multiple partnerships for a city

Source: Gaia Smart Cities

ICT can be a huge enabler to track and incentivize partnerships or create information parity that allows different stakeholders to transparently come together for the common good and individual return on investment.

Ultimately, smart city ICT projects must create win-win situations for every stakeholder.

9.2 Lifecycle Impact of Smart City ICT Design

The design of each smart city project needs to be evaluated on multiple parameters to ensure comprehensive benefits during its entire lifecycle.

This lifecycle impact is assessed along multiple parameters as shown in the Figure 19.

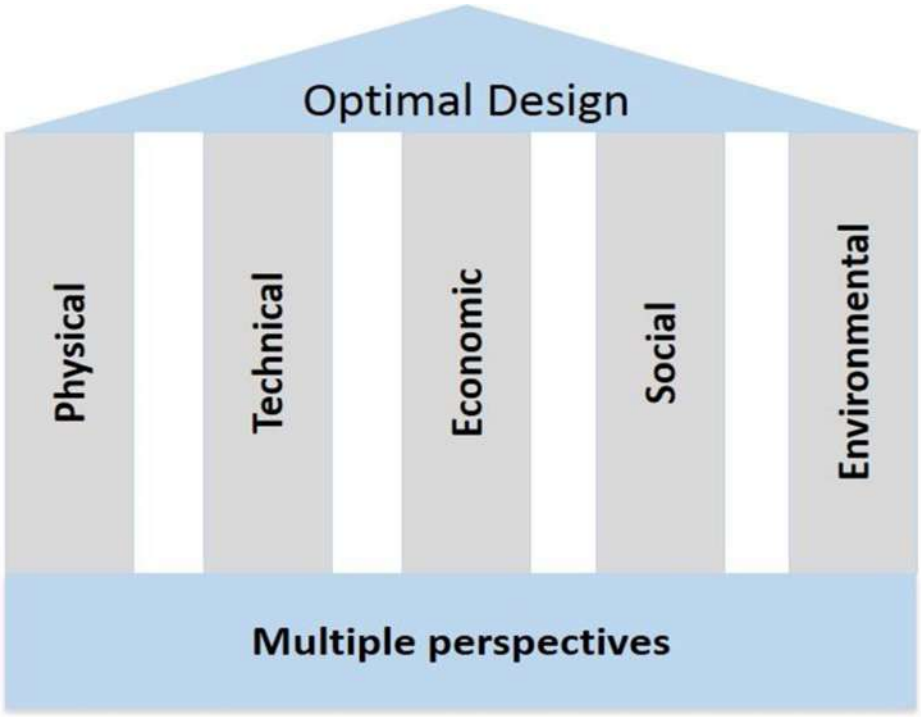


Figure 19: Parameters for smart city design

Source: Adopted from MoHUA, Government of India city proposals

Consider, for example, the implementation of a city waste management system. The optimal design would consider each parameter and ensure real benefits accrue.

- **Physical:**
  The physical ICT design of the smart waste management system considers how existing waste management infrastructure can be made smarter. Internet of things (IoT) devices can monitor waste levels in commercial bins. Vehicle telematics and on-board devices can map the movement and effectiveness of garbage trucks along their daily beat. The physical design of the devices themselves is critical. They need to be able to withstand rough conditions, extremes of weather from heat and cold to humidity, and be easy to install and maintain.

- **Technical:**
  The technical ICT design considers how the information on waste collection and disposal is available to city and urban local body officials, as well as creates open source interfaces for citizens and third-party private sector providers to engage with.

- **Economic:**
  The economic incentives for smart city ICT design can be built at multiple levels, and benefits can be stitched together for every stakeholder.

For example, correlating ICT based tracking of service levels, with staff performance can create incentives for them to improve their performance and increase efficiency. Linking real time information on volume and type of waste collection can create incentives for waste to value creators to integrate with the system. The degree of granularity of information on electronic waste collection and segregation will enhance the value. For example, a typical old electronic device can be of value to entrepreneurs looking for old parts or looking to strip the electronics to its constituent plastic or metallic elements for material recycling.

- **Social:**
  Optimal smart city ICT design can create social benefits for the city. For example, making location-based waste collection data available to citizens can allow citizen action groups, education action groups and others to engage with the city and their local areas to provide feedback and create awareness campaigns.

- **Environmental:**
  The environmental impact of smart city ICT design can only be seen in the longer term, but intelligent design can anticipate it in advance. Procuring waste management trucks with lower emissions parameters or building waste to energy plants that require higher capital expenditure but have lower operational emissions are choices that cities need to make.

9.3 Desirability, Feasibility and Viability of Smart City ICT

Each city must choose from a dashboard of multiple possibilities to identify the specific projects it will implement.

Macro level scenario planning has already been done by the cities selected through the Smart Cities Challenge[33]. But as cities define the details of their chosen plan, or other cities work towards revised plans, they need to consider the three important aspects of design thinking. This is articulated in the Figure 20.

[33] http://smartcities.gov.in/content/city_challenge.php

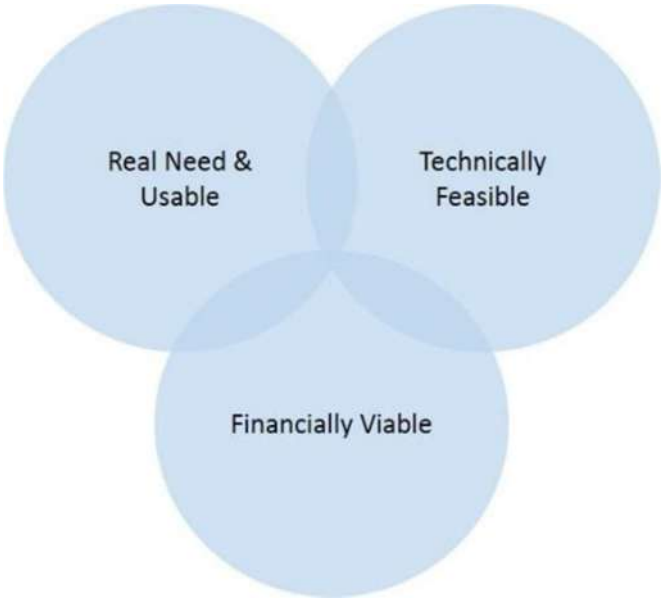


Figure 20: Design Thinking Principles

Source: Gaia Smart cities

This strategic planning process needs to review the city project and its ICT framework from the following perspectives:

- Would it serve a real need for any one or several of the stakeholders of a city? Would it be easy to use and adopt?
- Would it be technically feasible, within budgeted cost and timeframe as envisioned?
- Would it create real returns or monetization potential for one or more of the stakeholders?

The plans defined by cities are dependent on two key pivots:

i. Pan city initiatives consider basic city functions that can influence the lives of all citizens. These include transport, waste, water, sanitation, energy, connectivity, governance, health or education.
ii. Area Based Development plans consider retrofitting, redeveloping or building a Greenfield area within the city.

These plans rely on harnessing the unique advantages of a city in terms of its geography, heritage, economic and natural strengths.

These questions must be addressed in further detail at the detailed planning and implementation stage.

9.4 Understanding Users and their needs for Smart Cities ICT Design

Both cities' administrators and ICT service providers often begin from the lens of what technology can do and what it will cost. But getting users' perspective is crucial to understand how users will interact and engage with the services, what behaviors would they need to modify, and how to make the

interface intuitive and easy to adopt. In the case of cities, users include citizens and the staff providing the services.

ICT Design needs to consider three separate groups of users.

- **Mainstream users:**
  This is the largest bucket of users of any product, service or system. They value efficiency.

- **Lead users:**
  These might be the early adopters, or people who use a product, service or system more than others and they can help identify user needs or solution improvements.

- **Extreme users:**
  These might be specific groups such as the elderly or special needs individuals, who may have different requirements and will need a special solution.

  For example, City Safety & Surveillance systems could include CCTV cameras, safety hotlines and apps, incident management center, citizen incident reporting dashboard and more. The mainstream users of this solution would be citizens and city police. Lead users will be on-ground security personnel. If they use the system daily, it is important that the system design is intuitive and suited to their specific requirements. Extreme users could be national level officials, and the system needs to be integrated into larger systems for their usage.

Needs can be classified as:

- **Primary & Secondary Needs:**
  User needs must be mapped and bifurcated into critical and essential needs that must be met, and the next layer needs that are good to have but can be prioritized further. Projects can be phased accordingly.

- **Latent Needs:**
  Each set of users may have current or emerging needs that may not have been identified and solved for. Identifying and articulating these unspoken requirements will make design more robust.

  One latent need for Security & Surveillance systems could include mapping city visitors' data, customs and immigration data, and city security trends to understand linkages that can inform future processes for both departments.

9.5 Understanding Users through Building Personas and their Daily Journeys

After defining user categories, planners and administrators must understand their needs. Building detailed user personas bring alive their behavioral drivers, motivations, aspirations, and deterrents when adopting a design or service. Collating the learning from multiple personas and journey maps creates a robust and holistic solution that delivers better interfaces and better experience.

Since city services are built for citizens, it is important to understand how and why they will use and interact with a solution, how it will enhance their lives, how can it be perceived as a threat, and, more so, what will stop them from using a solution.

For example, by looking at Smart Mobility solutions from the perspective of just two user personas – a young man and a middle-aged woman, as illustrated in Figure 21, we can define a certain set of needs for citizens, which will translate into ICT requirements for the city solution.

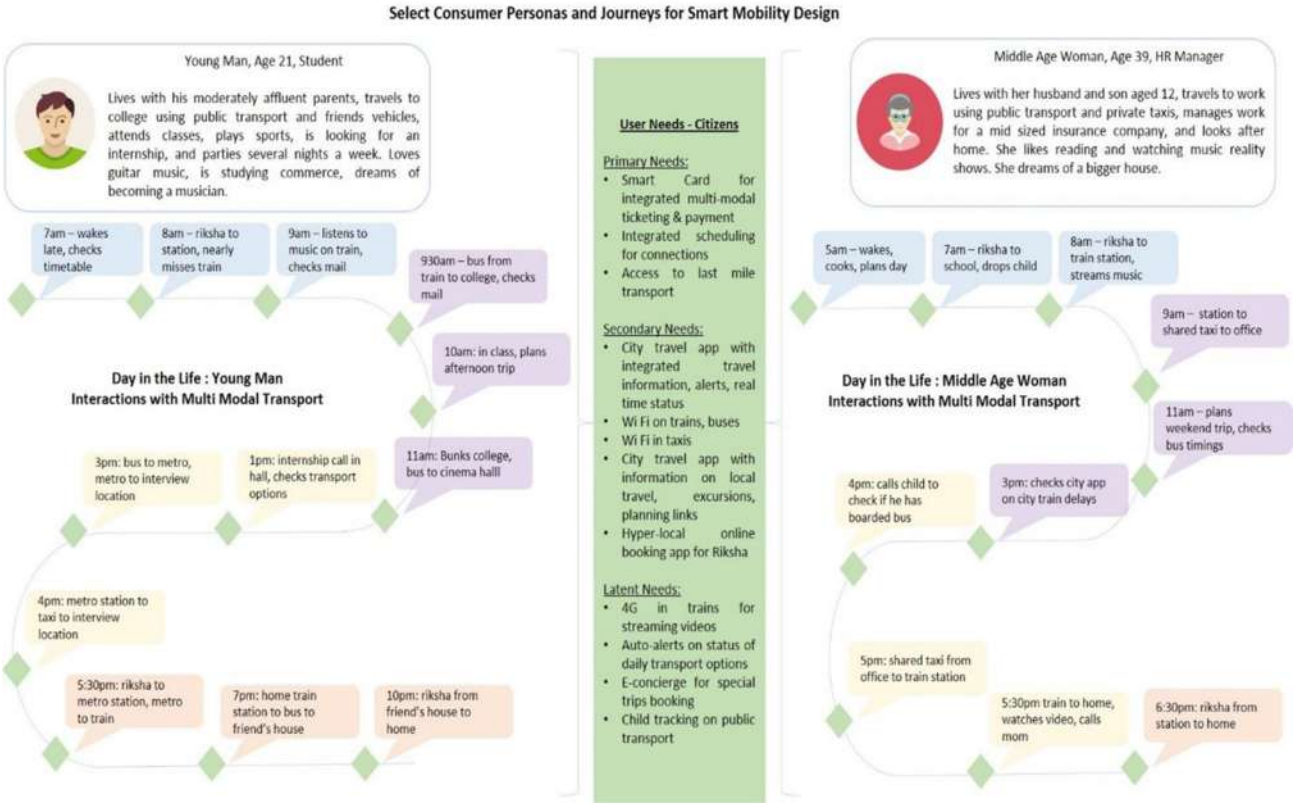


Figure 21: User Personas and Journey Mapping to define need states

Source: Gaia Smart Cities

Capturing needs and personas for multiple types of users, across stakeholder categories, allows planners to understand the complementary and conflicting needs, and prioritize them based on technical, financial, social, environmental, or ease of adoption constraints.

This also gives planners a way to understand needs and interactions at every touchpoint. It gives planners a method to understand when and how users engage with a solution, which existing or new systems, processes or assets would need to converge to create a seamless and feasible solution, and thus arrive at the final requirements for the solution. Typically, when solution requirements are defined without understanding consumers, it leads to the creation of a system that does not match the exact needs and usage patterns of people.

10 Systems Thinking approach for Smart City ICT Design

Real world problems are complex and intertwined. Many competing factors influence every system. Simplistic solutions underestimate the nature and level of challenge and lead to solutions that may fall significantly short of being impactful.

Systems Thinking assumes that a complex set of parameters govern outcomes in any one area. It provides a big picture and identifies all the primary and underlying factors that influence a solution, to map the entire system. This map gives planners, levers of change that can lead to transformation.
In an uncertain and complicated system, Systems Thinking allows planners to synthesize understanding, adopt expansive world views, and consider probabilistic influences and outcomes.[34]

Using this principle for ICT design for smart cities will allow planners to map out dependencies, determine the flow of information and communication, leverage the power of shared knowledge, and in the long run reduce costs. It will also allow planners to map the exigencies and points of failure or data constriction. More importantly, it allows planners to visualize how the ICT system fits within its ecosystem and the various non-ICT factors that need to be considered to deliver an effective smart city solution.

[34] University of Pennsylvania Scholarly Commons, John Pourdehnad, Erica R.Wexler, Dennis V. Wilson, "Systems & Design Thinking: A Conceptual Framework for their Integration", Jul 1st 2011 - http://journals.isss.org/index.php/proceedings55th/article/viewFile/1650/592

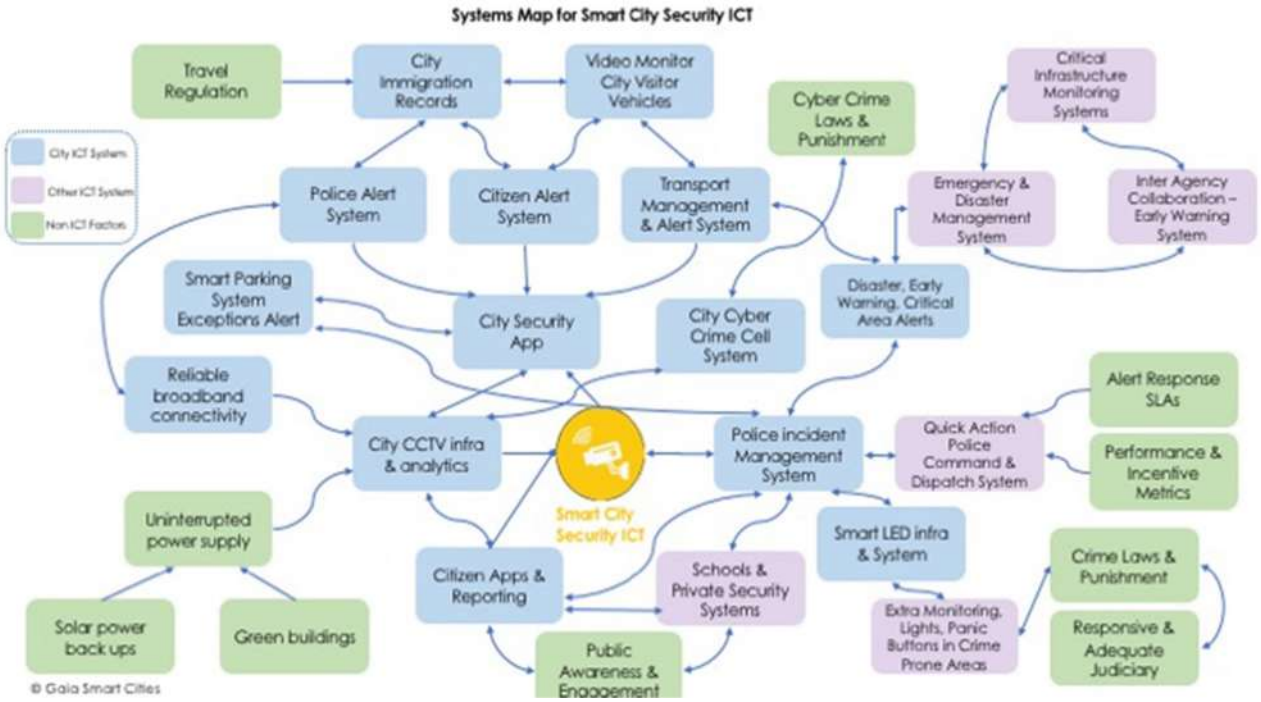


Figure 22: Systems Map for Smart City Security ICT

Source: Gaia Smart cities

The Figure 22 looks at the ICT systems and non-ICT factors that must be considered when designing Smart Security Systems for early warnings and deterrence of crime, and rapid response and resolution.

The next step is to understand which critical factors have greater effect on outcomes and manage them. Building the system will require cooperation and data sharing between multiple authorities and systems, such as police systems, national and state level early warning systems, traffic management systems, smart parking systems, critical area and crime prone area monitoring and alert systems, and several others. This robust system, thus, requires as much creativity in designing a robust data architecture, as it needs in inter departmental and citizen cooperation, capacity building and awareness.

Leveraging Systems Thinking at the start of any project ensures that administrators and planners can include broad based thinking and consider the multiple interlinked factors that govern the ultimate usability and impact of the smart city solution.

11 Futures Thinking & Trend Spotting

Timelines matter when designing resilient and robust smart cities. Today, products and technologies become obsolete within a few years, driven by rapid innovation at decreasing costs and, in turn, fuel consumerism.

While the lifecycle of products may be a few years, city infrastructure both physical and digital, need to last for at least ten to fifteen years to ensure return on investment on initial capital expenditures. Global studies reveal that new Greenfield cities may take as much as twenty plus years to take shape and emerge as viable livable places that attract suitable investors, industries and residents. Brownfield cities may certainly take a decade or more to mold and change public behavior, and inculcate, rejuvenate and sustain economic and sociocultural vibrancy.

Given these long-time horizons, it is imperative that Design and Systems Thinking approaches for smart cities are rooted in the present, learn from the errors of the past but also straddle the future.

11.1 Futures Thinking Tools

The Institute for the Future[35] has created a set of tools to look at the future through a structured way; of looking at multiple scenarios, considering broad factors determined in the systems maps, learning to identify weak signals that may be the markers for emerging trends, and creating a vision that is at once inclusive and inspiring.[36] This is illustrated in Figure 23.

Four methods have been outlined to approach Futures Thinking:

1. Look back at past drivers of user needs and behaviors, and solution successes and failures to look at the future
2. Look at signals at the fringe that may be markers of future trends
3. Look at the needs for extreme users to forecast how needs for mainstream users may evolve
4. Look at news, innovation, media and sociocultural trends to identify areas where future opportunities may emerge

[35] http://www.iftf.org/our-work/people-technology/technology-horizons/open-cities/

[36] Anna Roumiantseva, The Fourth Way: Design Thinking Meets Future Thinking, October 19 2016 [https://medium.com/@anna.roumiantseva/the-fourth-way-design-thinking-meets-futures-thinking-85793ae3aa1e] (accessed: Sept 2018)

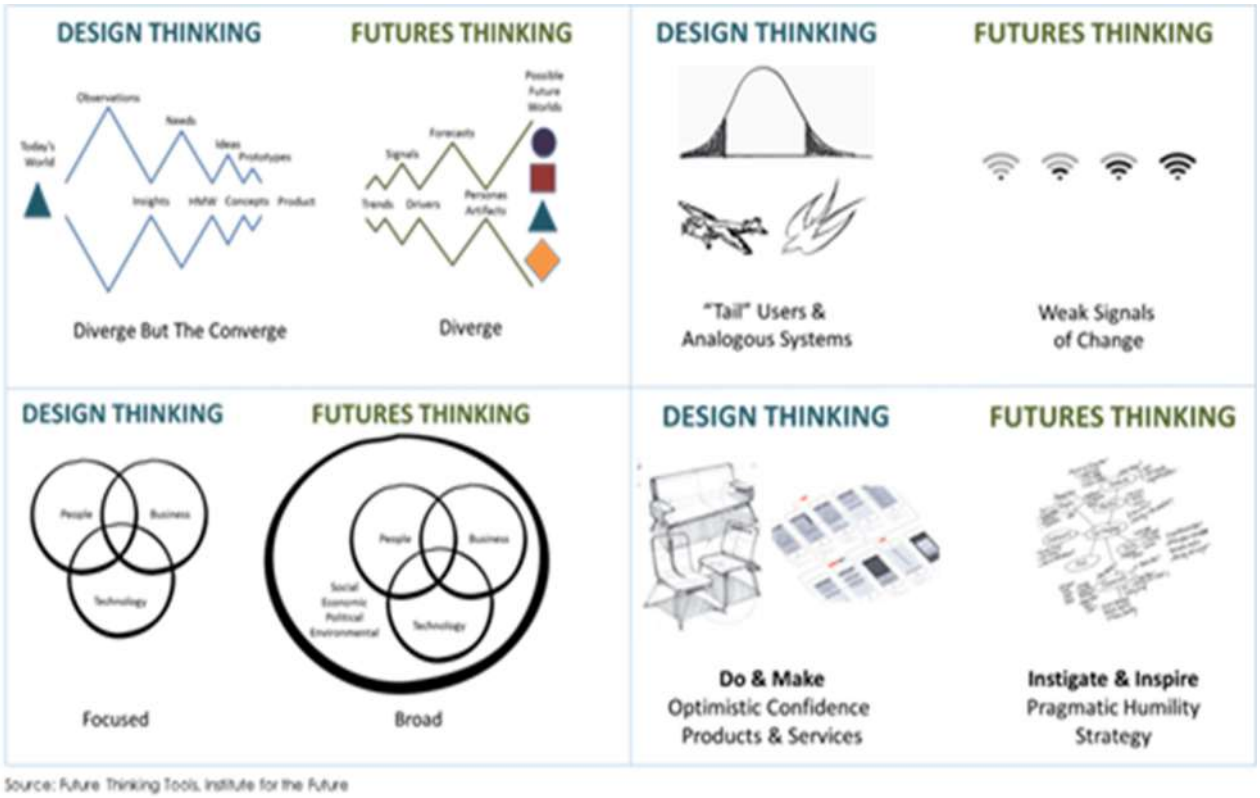


Figure 23: Futures Thinking Tools

Source: Future Thinking Tools, Institute for the Future

These tools are inspired by the changing economic and lifestyle vision of cities and citizens, which must in turn shape the future behaviors of cities, and aspirations, skillsets and mindsets of mainstream citizens to catalyze the future city.

This vision of the technologically savvy, open, and inclusive city, which creates opportunities for people to participate, and transform themselves is further outlined in Figure 24.

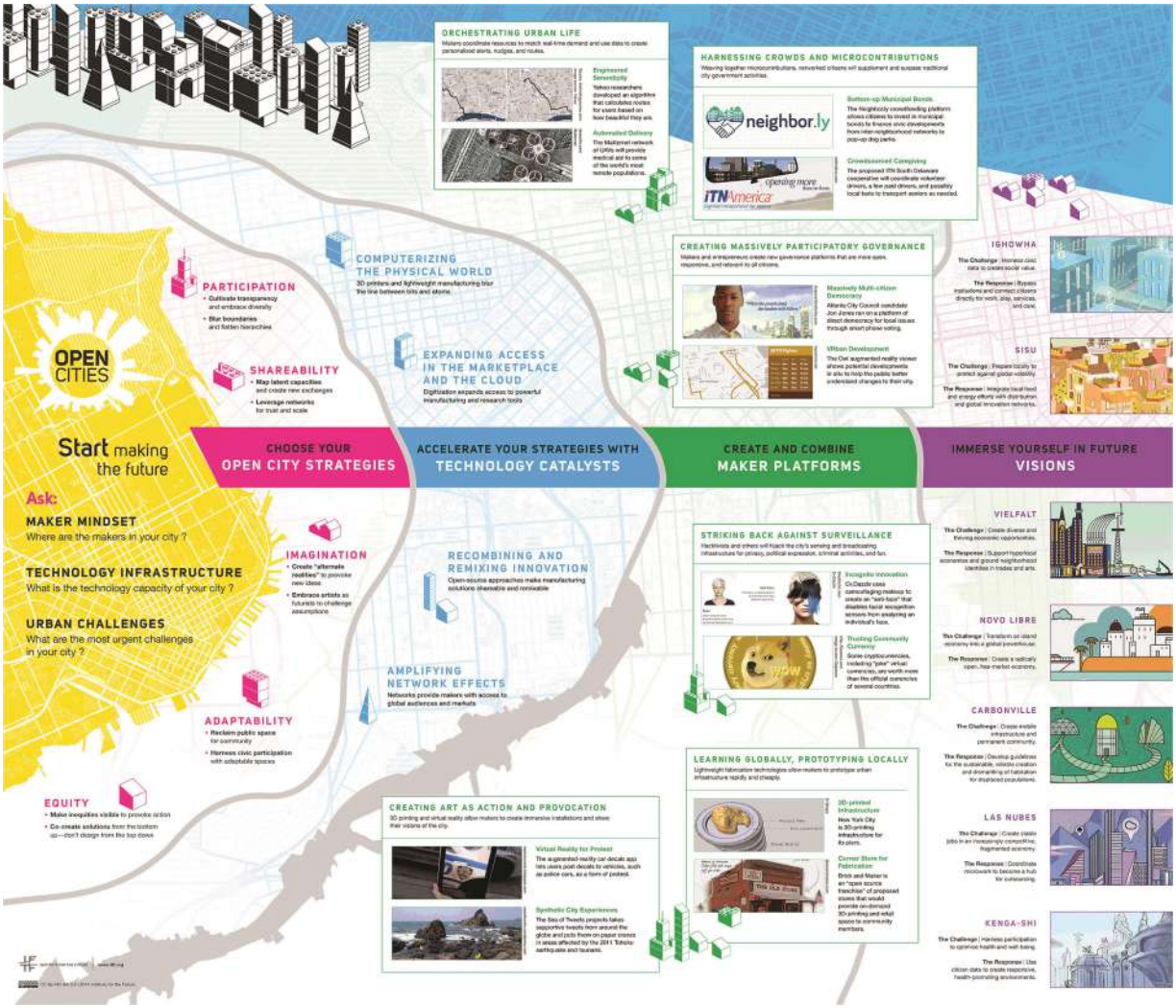


Figure 24: Open Cities Map

Source: Institute for the Future [http://www.iftf.org/our-work/people-technology/technology-horizons/open-cities/]

11.2 Strategic Planning using Outside-In and Inside-Out Approach

Traditional Futures Thinking methodologies resemble traditional strategic planning models that relied on outside-in approach of looking at the ecosystem and the landscape in which the city resides, to determine its strategy and vision.

However, each city is unique – not just in terms of geographic assets, commercial and economic strengths, culture and heritage, but also in terms of the mindsets of its people and the kind of life they value. It is critical then to layer the outside-in approach with an inside-out approach to create the unique vision of the city and then translate it into ICT design, infrastructure and urban design.

Figure 25 defines a model for smart city ICT design from the outside-in and inside-out perspectives.

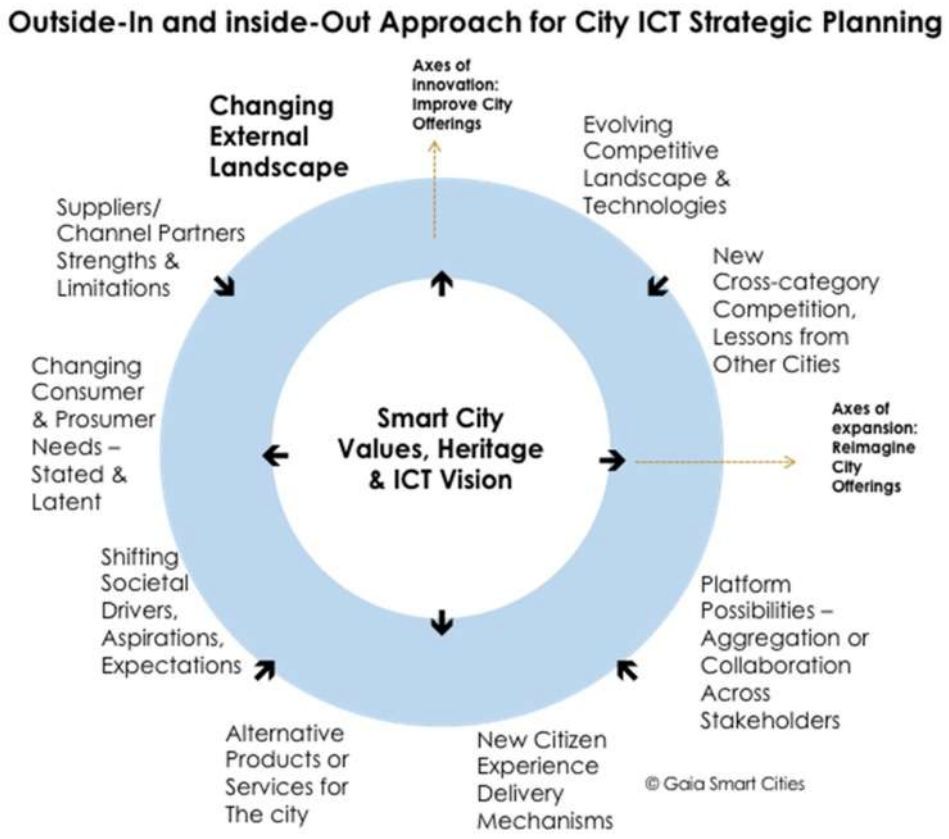


Figure 25: Outside-in and Inside-out Model

Source: Gaia Smart Cities

Using this framework for Smart Cities ICT design, planners and city administrators would look at technology and non-technology led factors that govern the cities ecosystem, as well as the smartness the city envisions for itself, based on its unique advantages. This includes:

Outside-In Approach

- Existing and legacy technology and data architecture of the city and its multiple functions
- Potential for collaboration across city entities to create common data and communication architectures to ensure seamless interoperability and efficiency
- Shifting and evolving needs of consumers, and prosumers - people who are both service providers as well as consumers – and the level of technology, real-time information and management they require within the city services
- Evolving aspirations of citizens, and how they perceive themselves – e.g. makers and innovators etc.
- Strengths and weaknesses of available set of ICT suppliers and vendors
- New global and national trends in creating experiences for the citizen in delivering basic amenities, social services, livelihood and training opportunities, measuring service performance or impact, et al.

- Alternatives such as citizen or private sector or partnership based service delivery models to augment the services provided by city authorities e.g. advertisers, security products companies, e-wallet firms, citizen action groups etc., could come together to build a smart parking solution

Inside-out Approach

- Unique culture, history, and heritage of the city and how that influences its vision and the emergent ICT strategy
- Existing strengths of a city
- Unique skills and values of citizens

11.3 Trends Mapping – Residual, Dominant and Emerging Patterns

Learning from the past and the present enables planners to look at:

- Older technologies, methods of thinking, and opportunities at the last stages of usefulness
- Current best practices, popular thinking and dominant technologies
- New, disruptive technologies and their potential impact in the future

Figure 26 defines the trends in city development and urbanization at a top-down strategic level.

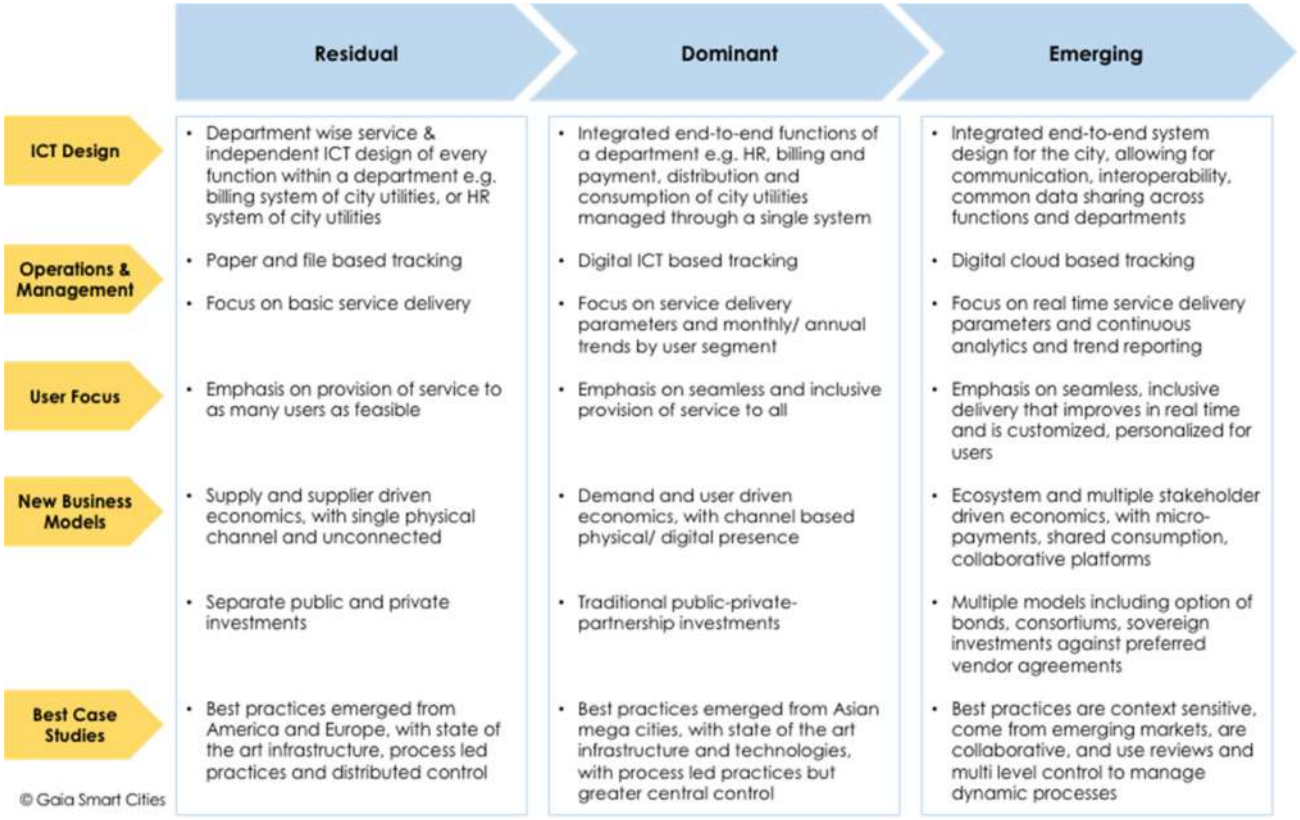


Figure 26: Mapping macro trends in smart city development

Source: Gaia Smart Cities

Going further, these trends can be mapped for every area of smart city development – from how a specific city function is delivered, to the specific emerging technologies, best practices, management or monetization methods that influence the function and the hardware, software, analytics and user interfaces needed to deliver it.

Figure 27 shows the trends as an example, applied to the delivery of public utilities such as water, gas or energy.

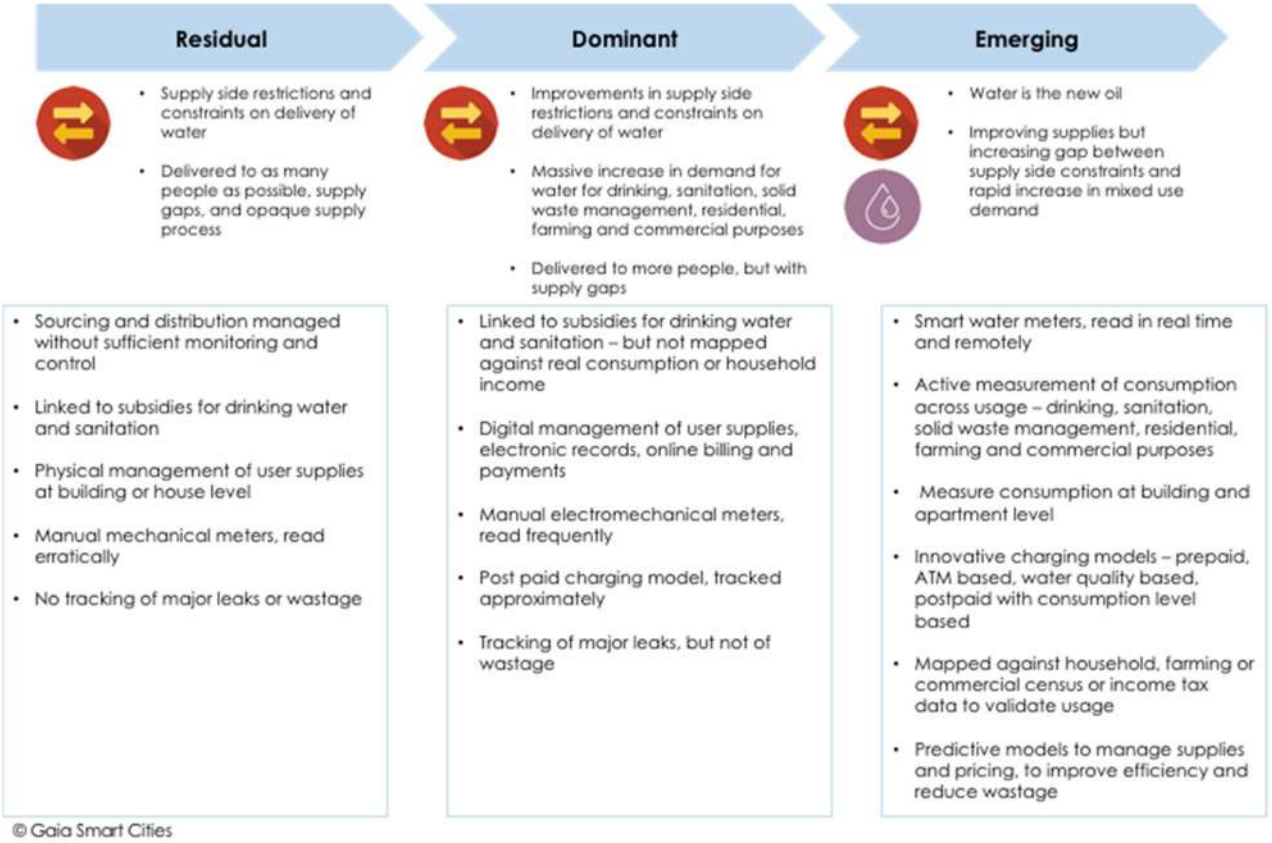


Figure 27: Trends in Public Water Metering and Management System

Source: Gaia Smart Cities

Real time metering & remote measurement using ICT and IoT are changing the way city administrators can deliver and manage water supplies. Pre-fabrication is giving way to 3D printing of equipment and even entire buildings. Moreover, given wastage, misuse of water, and inefficient storage and usage practices in residential, farm, and commercial segments, it is becoming critical to accurately measure consumption at every level and to charge accordingly.

11.4 Finding suitable models of best practices or emerging practices

Cities will need to identify models from around the world that may suit their unique circumstances, strengths and constraints.

Cities of mature economically developed markets operate under a systematic, process oriented approach and their models may not be best suited for Indian cities. Their systems may be designed to operate at higher price points, or for lower population and usage density. Furthermore, the ICT component of many of these mature cities may already be at the peak of its lifecycle, and they may

themselves be looking to upgrade. Hence, their technology blueprint should not be the model to emulate for Indian cities.

Indian cities will need to create their own best practices, and carefully choose from current and future practices from around the world in parts to find what suits their conditions.

12 Interface Design

Users experience complex ICT systems through its digital interfaces. The navigation structure and interactions define the experiences. Moving users along the journey of trial, adoption, usage, championship requires that the system improve their quality of life.

Whether ICT interface design relies on Design Thinking to map and build visual interaction journeys for each user group, or moves further to Computational Design to create personalized journeys, pages and feeds for each individual registered user, it is important to apply design thinking principles.

During the detailed design phase, user interaction journeys can be mapped to see how each key user needs to interact with different types of system interfaces, and thus create specific experiences for each set of users – whether it is the service administrator or the citizen as illustrated in Figure 28.

Creating personalized interfaces and dashboards and targeted navigation structure for each key user type allows them to manage their tasks, improve efficiencies, reduce interaction with distracting screens, and improve overall system experience.

Interfaces may need to be designed for large sets of users, and may need complex algorithms to ensure they can track and store unique user preferences and offer personalized information going forward. This computational design framework will require special technical experience and visual design skills.

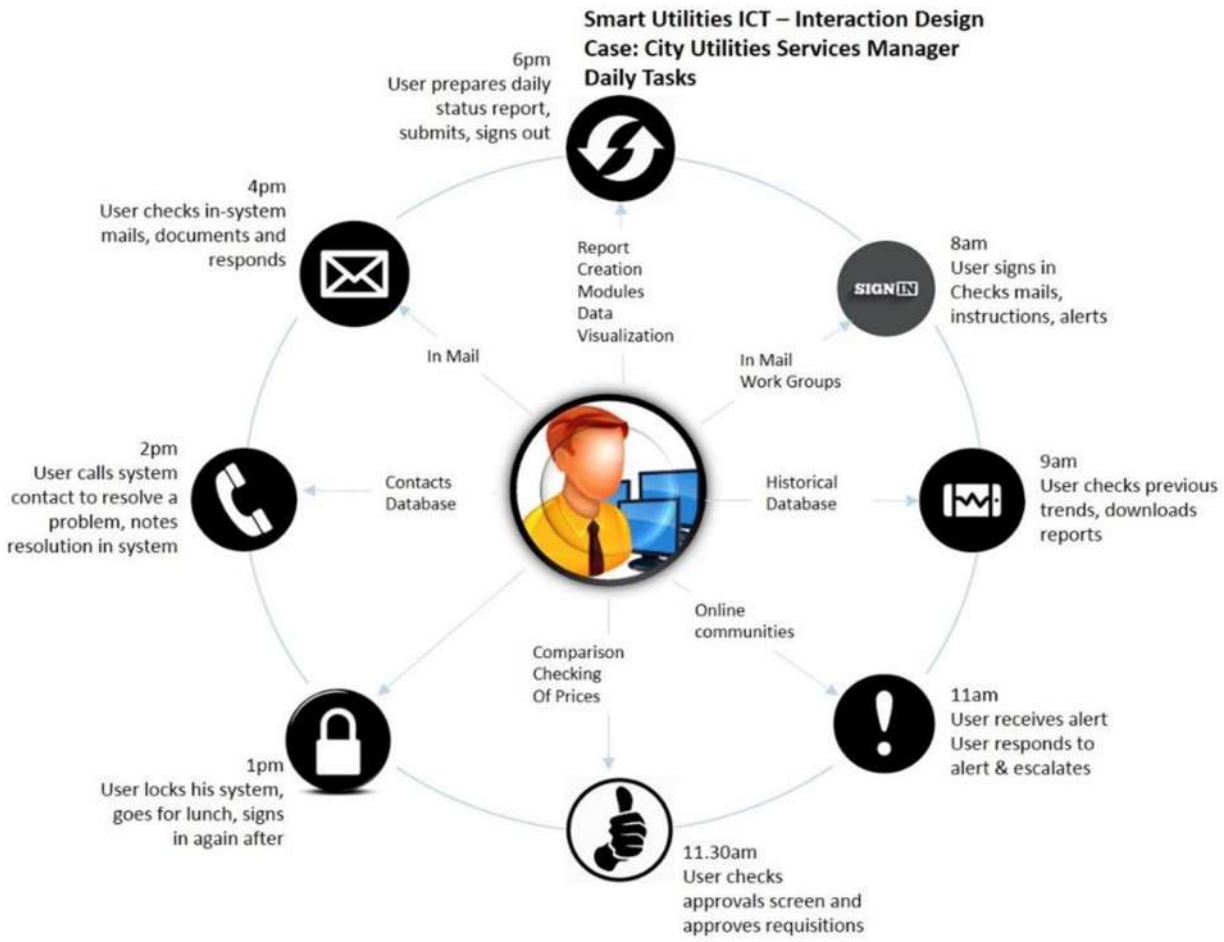


Figure 28: User Tasks and Interaction Journey

Source: Gaia Smart Cities

13 Integrating Design, Systems & Futures Thinking Approaches for Smart Cities ICT

In the complex ecosystem of smart city solutions usage and management, it is critical to approach the challenge in a holistic manner, and consider multiple influencing factors and ensure benefits for multiple stakeholders.

Design, Systems, and Futures Thinking are essentially complementary approaches. Used together, they allow solutions to be thorough and long lasting. Moreover, most of the tools and approaches delineated in this report ask the planners and city administrators to look beyond just technology, at the complex mesh of regulatory, institutional, governance, economic, and social factors influencing the solution.

Cities should consider, analyze and select scenarios and ICT options based on desirability, feasibility, and viability to ensure impact on the two penultimate goals of each city – quality of life and livelihood improvements for citizens.

14 Current Smart Cities Plans in India - Opportunities & Gaps for using Design, Systems & Futures Thinking in ICT

The expectation from smart city challenges[37], as defined by the Ministry of Housing &Urban Affairs, Government of India requires holistic thinking. Unique city strengths and weaknesses were considered to define Smart City Plan and included urban planning, smart solutions and financial details. Citizen engagement criteria ensured that resident aspirations were considered.

Looking at the successful plans submitted by cities, it becomes clear that these plans are thorough but high level. The next stages include detailed project planning and feasibility assessment, solution structuring, specifications definition, and project management of implementation.

Planners and city administrators need to be mindful of six key pitfalls going forward. These are:

- Gaps between plan and implementation
- Gaps in translating integrated plans into silo-based procurement
- Gaps between stated and actual governance frameworks
- Gaps between short term versus long term objectives
- Gap between deployment and usage or usefulness
- Gap between data transparency and cyber security & privacy

14.1 Managing the gap between planning & implementation

The smart city challenge plans are the first steps. These are highly top-level plans providing a strategic overview of scenarios and options dashboards.

As cities move to the next steps of creating project management units, detailing specific parts of the plan, opening some parts for tendering, solution definition and implementation, cities need to be mindful of the many ways in which plans may fail. Points of failure may include:

- Lack of multi-party collaboration upfront to create integration and synthesis
- Lack of detailed level design, systems and futures thinking approach in each specific solution
- Tender documents that are not based on holistic and long-term thinking
- Lack of ability to create unique, multi-party investment and monetization options

14.2 Managing integrated plans and avoiding silo-based procurement

Rules and policies governing procurement follow set patterns. While procurement metrics are moving from lowest cost to cost plus quality based selection, it is not enough. The way an integrated project is conceived and then partitioned for easier procurement, deployment and management determines the manner of writing tender documents.

[37] http://smartcities.gov.in/content/innerpage/challenges.php

- Tender documents should be thorough and precise in detailing solution requirements. However, the solution being sought may not be accurate. This is an important point. In innovation and technology, precision without accuracy leads to massive failures because the system is designed with immense amount of details for an inappropriate solution.

For example, tenders being released by cities for smart poles may ask for solar panels, LED lights, Wi Fi or Li Fi, and even smart charging stations. Whether poles are installed in the center of the road or along the sidewalks, including smart charging stations might be an impractical task as it may be infeasible for vehicles to stop for charging without completely disrupting traffic. Such a solution might be easy to deploy, appear desirable at first glance, and be easy to monetize, but fails in usability criteria.

- Often, tender submissions are done through consortiums where lead bidders, trained in the existing system of cost-based-thinking, may choose partners and solutions based on lower costs, and not focus on real impact delivery.

Some tenders ask some or all sub-contractors to be declared and impose joint liabilities for each party. However, that alone does not ensure that the optimal technical solution will be chosen and deployed. Planners and decision makers will need to themselves understand the changing technology paradigms and make informed decisions when choosing between disparate options. The details of solutions should not be left to the master system integrator.

14.3 Managing short term versus long term objectives

Successful rejuvenation of cities - whether the redevelopment of Paris and London in the nineteenth century, New York in the twentieth century, or Pittsburgh in the twenty first century – requires long term approach and sustained effort that remains constant even through political or administrative changes.

Barcelona, a poster child for smart cities in the past decade, has struggled with vision continuity through changes in city administration and political shifts.

As the government and smart city planners and administrators look at implementation of plans, they will need to consider the long term in a variety of ways.

- Use Futures Thinking tools to consider future scenarios and emerging user trends and technologies
- Incentivize planners to plan for the long term, rather than focusing on short term performance, competition, or promotion
- Ensure continuity of plans and implementation despite political or administrative changes

14.4 Managing usability, adoption and usage

User centricity is a key element of design thinking, and cities need to consider users from a few different perspectives.

There may be practical considerations to ensure usability of a solution. These may include:

- Physical design, hardiness, national and international accreditation of a solution
- Digital design, optimal navigation, interaction and experience of a solution
- Ability of citizens to use a solution.

Cities also need to consider adoption and usage of a solution. New solutions may require citizens or service providers to change behaviors.

For example, garbage segregation at source is a feature in several smart city plans. This needs multiple changes. Citizens, household members and staff, housing society staff must understand the goals and ensure segregation happens. Local shopkeepers must stock different kinds of garbage bags and housing societies must install different types of bins. Waste management staff must segregate collection, and in turn create new beat plans, staff, equipment, monitoring systems to ensure segregated collection. New entrepreneurs must use segregated waste for reuse or recycling or upcycling, thus converting waste to value and benefiting the entire chain.

Understanding and managing the entire chain is crucial. In Indian cities, waste collection is a problem but waste disposal is an even bigger problem. Solving piecemeal will not lead to long term impact, and building efficiency in one single part of the system will create bottlenecks and have ongoing negative impact on other parts of the system.

Smart city ICT design plans thus need to consider:

- Creating awareness and advocacy for smart city initiatives amid citizens
- Creating awareness and training for smart cities initiatives amid administrators and service providers at all levels
- Inviting 3rd party providers e.g. fin-tech companies, tech startups, citizen action groups, CSR funds, etc. to participate
- Use of ICT to spread awareness
- Use of ICT to drive and monitor behavior change
- Consider the entire end-to-end value chain and find ways of impacting every part of the process

14.5 Managing Cyber Security & Privacy

Smart Cities will see a proliferation of data from internet of things sensors, digital systems, and user generated reports. At the core of smart city efforts lie the concepts of interoperability of data leading to data sharing and transparency. Secure by design principle where the hardware and software has been design from the foundation to be secured, is the basic tenet. Hence it is critical to build rules for data privacy and embed stringent tools to ensure data security at every level in the multi-tiered information architecture of cities.

These include:

- Physical safety, security, access controls, and privacy at data centers and disaster recovery centers
- Policies, frameworks, and processes to ensure access control and safety measures
- Digital safety, encryption, firewalls, intrusion detection, privacy filters, and data management at every level in city ICT architecture, including:
    - Sensors and edge devices
    - Sensor networks and connectivity modules
    - Network design and connectivity
    - Databases, Servers, and Cloud Hosting Platforms
    - Middleware and Applications
    - Interface Devices and Dashboards

15 Leveraging Design, Systems and Futures Thinking Tools for India's Smart Cities

Transforming India's cities is a massive problem requiring multifaceted solutions.

At one level, development needs to be broad based to decrease the pressure on few mega cities, and economic opportunities need to be created to meet the aspirations of individuals in cities and their surroundings.

At another level, existing legacy systems, rudimentary technologies, older thinking for management and planning, deep distrust of sharing and platform based open solutions, lack of enough opportunities for nimble new-tech firms to participate, and many other tangible deterrents hold back progress.

Given the nature and magnitude of the challenge, using point solutions will lead to another exercise in expenditure of public funds and deployment of solutions that may meet technical and planning requirements, but fail to solve the underlying core problem of livability and livelihood. It is critical, therefore, for planners, city administrators and advisors to weigh the penultimate goal of smart cities projects and create metrics to ensure all plans are evaluated and implemented against these objectives.

Use of Design, Systems, and Futures Thinking gives planners simple, intuitive and easy to use tools to ensure that outcome based urban and ICT plans are developed and implemented. Figure 29 shows that Design Thinking approach is used for User centered design, Systems Thinking can be used for obtaining and setting Performance Metrics, how both can be applied to benefit mass usage and eventually how Futures Thinking approaches build solutions that last longer.

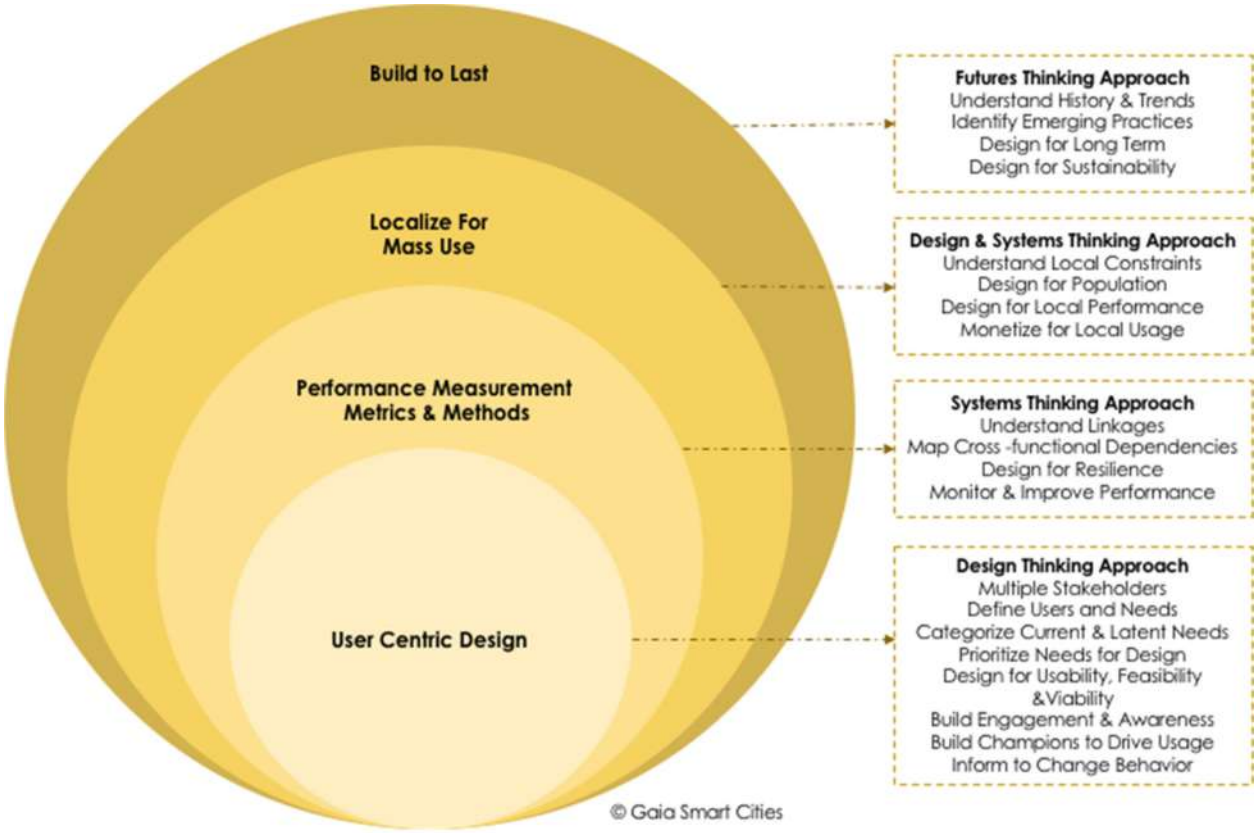


Figure 29: Leveraging Design, Systems and Futures Thinking Tools for Smart Cities

Source: Gaia Smart Cities

Cities that create smart city solutions using supplier-centred design are often surprised when their products or services are not popular among both, government departments or citizens. They have often failed to seek out and understand the real needs of their users. Increasingly, design processes that place the citizen at the centre are recognised as being critical to the creation of successful smart solution.

Cities must ensure that they move towards open, integrated, end to end lifecycle based, dynamic, citizen centric, locally financially viable, and locally optimized solutions as illustrated in Figure 30.

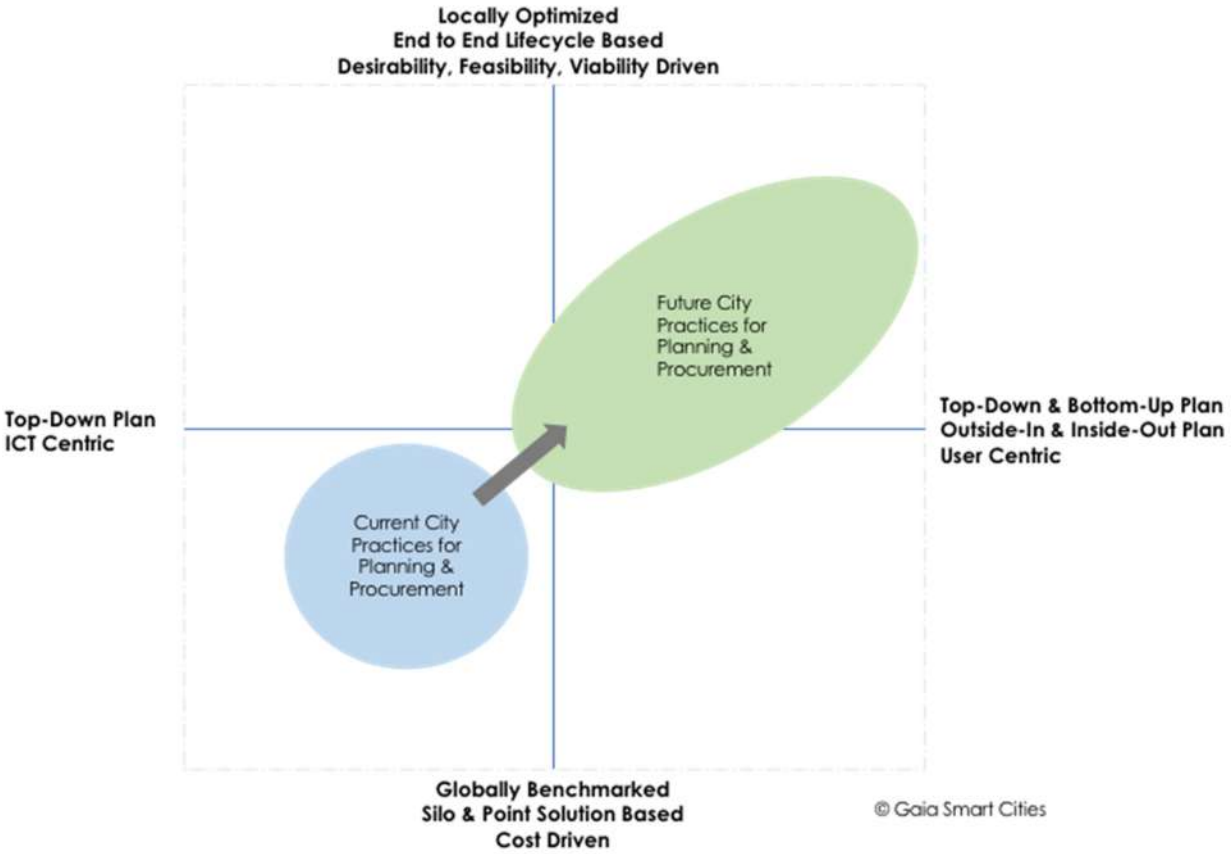


Figure 30: Changing the planning process for cities

Source: Gaia Smart Cities

16 Conclusion and Recommendations

More mature societies and cities, in Japan[38] as an example, have articulated that in an information society – termed Society 4.0, the cross-sectional sharing of knowledge and information was not enough, and cooperation was difficult. The next step in their evolution, termed Society 5.0 is achieving a high degree of convergence between cyberspace (virtual space) and physical space (real space).

Society 5.0 enables the provision of only those products and services that are needed by the people that require them at the time they are needed, thereby optimizing the entire social and organizational system. It is a society centred on each and every citizen, where new value created through innovation will eliminate regional, age, gender, and language gaps and enable the provision of products and services finely tailored to diverse individual and latent needs. In this way, it will be possible to achieve a society that can promote economic development and find solutions to social problems. Design, Systems and Futures Thinking echo similar principles.

Achieving Society 5.0 with these attributes would enable not just every city, but India as a whole to realize economic development while solving key social problems. It would also contribute in meeting the Sustainable Development Goals (SDGs) established by the United Nations[39].

This conclusion attempts to summarize and recommend an overarching framework or a toolkit for planners, administrators, experts, and leaders in cities and urban local bodies to ask the right questions, design and implement the right solutions, and measure the right outcomes. Using the frameworks and tools described in this technical report, city administration can impact the performance of the city and lives and livelihoods of its citizens.

1. An important item in the Toolkit is a list of crucial questions city decision makers are supposed to ask while designing and implementing their smart cities plans. These include:

1. What are the dreams and aspirations of the city?
2. What are the unique advantages and disadvantages of the city?
3. Which services and functions are needed by citizens and stakeholders?
4. How will stakeholder needs be categorized and prioritized?
5. What defines smartness in city solutions?
6. Which parameters determine city performance?
7. How will smartness be calibrated and monitored?
8. How can solutions be designed to meet real needs?
9. How can designs ensure usability and adoption?
10. What behavioural change and awareness is needed to improve adoption?
11. Which physical, environmental, social or behavioural constraints must be considered?
12. How will financial and budgetary constraints be met?

[38] http://www8.cao.go.jp/cstp/english/society5_0/index.html
[39] https://www.itu.int/en/sustainable-world/Pages/default.aspx

13. How will solutions be monetized?
14. How can micropayments accrue to make a solution viable?
15. Which systems, functions or services influence the design or usage a solution?
16. How can the new system integrate with legacy systems?
17. Which systems and databases must be interlinked?
18. How will data be collected and stored?
19. How will data be communicated?
20. What is the optimal governance mechanism for city planning?
21. How will true technocrats and experts be included in planning and implementation?
22. How must solutions be aggregated, bundled or unbundled for better procurement?
23. How will innovative products or solutions be sourced?
24. What is the infrastructure, economic, social, environmental outcomes of a solution?
25. How will impact assessment be conducted and quantified?

2. The aim of asking the above questions is to assist decision makers and make them aware of four critical and overarching principles of city planning.

A. Design solutions to impact urban life:

ICT led planning and solution design falls within and must integrate with the overall city development plan. The city plan, in turn, must create a vision that integrates the place and technology through comprehensive planning of physical and digital infrastructure. This vision depends on the heritage, geography, economy and aspirations of the city. However, the plan at its very core must consider people – citizens, service providers, investors. City planning must ensure that the solution designed provides real benefits to the people and improves access, efficiency, livelihood, ease of living, sociocultural vibrancy, community vitality, citizen services, and governance.

B. Design technology to improve city performance:

ICT design within the overall smart city design must aid and improve the performance of city functions and provide benefits to every stakeholder. Using design and systems thinking frameworks, planners must focus on accruing multi-parameter benefits including economic, infrastructural, social, cultural, or environmental gains. Using these frameworks, planners must also recognize the interdependencies of functions and systems in a city, which, in turn, create constraints or opportunities for design innovation. Planners must design open, shared, interconnected, transparent, secure, and ethical systems and data structures.

C. Design systems for mass use in local environments:

ICT and non-ICT components of smart cities design in India must be designed to suit the Indian environment. The physical, climatic, and behavioral patterns in India are distinctive. Designs must be built to suit Indian terrain, weather patterns, and usage patterns. Best practices from evolved and mature cities in North America or Europe, or from technologically advanced cities of East Asia may not suit India. Our cities planners must consider a set of global and indigenous

solutions, from established firms and innovators, to craft solutions that suit Indian economy, market, and conditions. Monetization potential per user or per service may be lower in India compared to global markets. Hence, innovative financial and investment mechanisms must be considered. The population of our cities put a lot of pressure on usage, therefore solutions must be designed and personalized for millions of users.

D. Design solutions built to last:

Cities develop, evolve and rejuvenate over long horizons. Future thinking frameworks enable city planners to conceptualize, design and develop solutions that are long lasting and resilient. It is important to engage with citizens and stakeholders to understand their current, latent, and future expectations, desires and motivations. Solutions must meet these combined needs for the next decade or two. Technologies and technical architectures evolve quickly. Yet the urban and ICT design envisioned and implemented must remain useful, relevant, and operational over a long period.

3. Future needs for technology infrastructure such as optical fiber cables (OFC), wireless access networks, Clouds etc. should be anticipated from the existing service providers.

4. It may be ensured that information can be made openly available without additional expenditure. Whether or not information is actually available will be dependent on privacy, regulatory, commercial and legal agreement, but it should not be additionally subject to unreasonable expenditure.

5. Technology for Smart cities – both legacy and new requirements should be standards compliant and conform for interoperability in general. Standards released by various National / International bodies such as ITU, ETSI, 3GPP, OneM2M, IEEE, NIST, BIS, TEC etc. may be followed to ensure interoperability.

6. Property development proposals and urban infrastructure plans should indicate how they will attract business and residential users by providing sustainable solutions for heat and power such as combined heat and power (CHP), smart metering, local energy grids and solar energy

7. Residential spaces should include avenues for environmental monitoring, interactive portals, and connectivity to enable remote support, telehealth systems and home working.

8. A bottom-up approach when pursued with a top-down approach yields benefits such as better allocation and usage of local resource, as well as delivery of services with improved efficiency. Design and provide a technology platform that enables more peer 2 peer self-organizing & evolving communities to enable this. In addition, design protocols and methods to incentivise those contributing to the development of society while punishing and charging those misusing common goods and creating externalizations.

9. It is required to design and provide horizontal services that IoT applications across different city segments and verticals commonly need[40]. Verticals can be considered to be the different departments, segments can be considered areas like Data Management, Security, etc.

10. During the various stages involved in the Smart City roll out, beginning with the solution specification right up to the project implementation phases, administrators and planners can prepare themselves with the following set of recommendations for the challenges they may encounter:

No	Factor	Challenges	Goals	Recommendations
1	**Prioritization of projects defined in Smart City Plan (SCP)**	Initial grant given by the government to cities may not cover all the projects envisioned	Best and visible outcomes for the city and citizen, given resource constraints	Use Design Thinking lens to map and rank SCP ideas by impact and the lens of desirability, feasibility, viability to select the quick wins and Phase 1 projects
2	**Solution - component wise specifications, including detailed project reports & feasibility studies**	Solutions need to manage complex processes and interdependencies	Optimal and robust solution design that considers real needs and multiple interdependencies	Use Design Thinking and Systems Thinking to ensure the solution is neither over-designed nor overlooks interdependencies on other processes, systems, people, components
3	**Solution - component wise technology options**	Solutions can be based on multiple competing technologies	Optimal and robust solution design that is feasible, works within city budget, and lasts long	Futures Thinking to understand signals and trends; Design Thinking to map solution viability based on infrastructure and operating expenses
4	**Solution – overall blueprint by each large initiative**	Solutions need a complex interplay of components and connect with legacy systems	Seamless, end to end solution connecting processes, systems, data, and dashboards of multiple components	Use Systems Thinking to map various interdependencies and linkages in processes, systems, data & dashboards. Use Design Thinking to identify lead, mainstream, and extreme users to identify use cases and boundary specifications
5	**Solution – citywide ICT blueprint**	Complex individual components have complementary & contradictory requirements, processes, systems, or data structures	Optimal solution with a carefully considered blend, balance, and weightage of individual components	Use Systems Thinking tools to map and visualize the overall solution. Use Design Thinking tools to map and prioritize complementary and contradictory requirements to define the final blueprint specifications.
6	**Solution Budgeting**	Budget is more than hardware and	True cost of long term solution implementation	Use of Design Thinking tools for scenario planning to understand

[40] https://www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Documents/events/2018/RDF/Workshop%20Presentations/Session2/IoT-presentation-Marco-Carugi-final-reduced.pdf

		implementation costs. Long term operations and maintenance cost, hardware lifecycles and other factors may get underestimated.	and operations must be estimated, and structured (through PPP or existing funds)	all possible users, use cases, boundary conditions, points of failure, points of excessive use, and more. These will influence lifetime costs.
7	**Project Structuring – degree of specifications**	Over specifying a solution leads to limited set of vendor options. Under specifying a solution leads to open-ended and incomplete solutions.	Optimally specified solution that leaves room for innovation, without leaving margin for missed functionality.	Use of Futures Thinking to understand emerging technologies options. Use of Design & Systems Thinking to understand as-is constraints and list, prioritize, and balance current, future, and latent needs to optimally "specify" solutions.
8	**Project Structuring – business models**	Cities have resource and budget constraints, and need innovative financing models.	Designing financing structures that are win-win for all stakeholders.	Use Design Thinking & Systems Thinking lens to see the complex motivating factors for each stakeholder, and identifying optimal financial structuring and optimal outcomes for all.
9	**Project Implementation – silo based procurement**	Cities have traditionally procured solutions in silos.	Cities may need to be encouraged to think, plan, and implement holistically, and choose a master system integrator who may do the same.	Use Design Thinking lens to map all stakeholders and their interests to encourage holistic thinking; making thorough integrated plans; and, "nudge" cities towards integrated procurement
10	**Project Implementation –prioritization & sequencing**	Project concessionaire has to balance many sub-projects across initiatives and may not balance quick wins and sustained gains.	Cities need to ensure that project concessionaires plan, structure, and prioritize tasks.	Use Design Thinking & Systems Thinking lens to see project dependencies, pivots for creating huge impact on either infrastructure or lives, and put "people" in the centre of implementation timelines to ensure initiatives that impact lives and livelihoods get implemented, and the larger project timelines are managed for stage wise impact.
11	**Project Implementation - governance**	Project implementation can stall, lag, or fail if not properly governed. Solution can be planned well but implemented such that people don't adopt it, it becomes infeasible, or unviable.	Ensure project desirability, feasibility, viability at every stage of implementation.	Use Design Thinking lens at every stage of project implementation. Check for usability. Check for feasibility of components and overall solution in live environment or if shortcuts/alternatives are taken. Check for viability given budget or time overruns, or reduced impact, or delayed or

				lowered revenue streams, higher ops costs, which influence long term project viability.

Table 1: Recommendations for Smart City Challenges

ANNEXURE 1. Smart City Design Principles

Adapted from Source: Robinson, R. (N. A.). Smart City Design Principles. Retrieved September 21, 2016, from The Urban Technologist[41]

Design principles for any city, especially a smart one, needs to be rooted in its context and no exhaustive list can be prepared. With thorough discussion and collaboration, keeping in mind the final outcomes, technology can be systematically used.

Principle 1: Consider urban life before urban place; consider urban place before technology.

Principle 2: Demonstrate sustainability, scalability and resilience over an extended timeframe.

Principle 3: Demonstrate flexibility over an extended timeframe.

Physical infrastructures and construction

Principle 4: New or renovated buildings should be built to contain sufficient space for current and anticipated future needs for technology infrastructure such as broadband cables; and of materials and structures that do not impede wireless networks. Spaces for the support of fixed cabling and other infrastructures should be easily accessible in order to facilitate future changes in use.

Principle 5: New or renovated buildings should be constructed so as to be as functionally flexible as possible, especially with respect to their access, infrastructure and the configuration of interior space; in order to facilitate future changes in use.

Connectivity and information accessibility

Principle 6: Any development should ensure that wired and wireless connectivity is available across the entire development, and with the capacity to expand to any foreseeable growth.

Principle 7: Ensure that information from its technology systems can be made openly available without additional expenditure. Whether or not information is actually available will be dependent on commercial and legal agreement, but it should not be additionally subject to unreasonable expenditure. And where there is no compelling commercial or legal reason to keep data closed, it should be made open.

Principle 8: The information systems of any new development should conform for interoperability between IT systems in general; and for interoperability in the built environment, physical infrastructures and smart cities specifically.

[41] https://theurbantechnologist.com/smarter-city-design-principles/

Principle 9: New developments should demonstrate that they have considered the commercial viability of providing the digital civic infrastructure services recommended by credible research sources.

Sustainable consumerism

Principle 10: Any data concerning a new development that could be used to reduce energy consumption within that development, or in related areas of a city, should be made open.

Principle 11: Property development proposals should indicate how they will attract business and residential tenants through providing up-to-date sustainable infrastructures for heat and power such as combined heat and power (CHP), smart metering, local energy grids and solar energy.

Urban communities

Principle 12: Consultations on plans for new developments should fully exploit the capabilities of social media, virtual worlds and other technologies to ensure that communities affected by them are given the widest, most immersive opportunity possible to contribute to their design.

Principle 13: Management companies, local authorities and developers should have a genuinely engaging presence in social media so that they are easily approachable.

Principle 14: Local authorities should support awareness and enablement programmes for social media and related technologies, particularly “grass roots” initiatives within local communities.

Principle 15: Urban development and regeneration programmes should support the formation, activity and success of local food initiatives by cooperating with local community and business support programmes for infrastructures they need to succeed and grow.

Principle 16: Residential accommodation should incorporate space for environmental monitoring, interactive portals, and connectivity to enable remote support, telehealth systems and home working.

Economic development and vitality

Principle 17: New developments should demonstrate through the use of the latest urban modelling techniques that they will increase connectivity – particularly by walking and cycling – between important value-creating districts and economic priority zones that are adjacent or near to them.

Principle 18: Developments should offer the opportunity of serendipitous interaction and innovation between stakeholders from different occupations.

Principle 19: Developments should provide, or should be adaptable to provide, facilities to enable the location and success of future ways of working including remote and mobile working, “fab labs” (3D printing facilities), “pop-up” establishments and collaborative working spaces.

Governance

Principle 20: Planning, usage and other policies governing the use of urban space and structures should facilitate innovation and changes of use, including temporary changes of use.

Privacy and public safety

Principle 21: Any information system in a city development should provide a clear policy for the use of personal information. Any use of that information should be with the consent of the individual.

Transport

Principle 22: Transport plans supporting new developments should demonstrate that they have not only provided for traditional transport demand but, also that which might be created by online business models and other social technologies.

Extension

Principle 23: New developments should demonstrate that their design takes account of the latest and best practices and patterns from smarter cities, smart urbanism, digital urbanism and place making.

ANNEXURE 2. Tools useful in Smart Design and Planning

Listed below are a mix of tools providing services across various sectors, useful in Smart Design and Planning.

1. **eGovernance**: It is necessary for government authorities across the spectrum to engage at a personalized level while addressing civic or other public issues. Apps like mapmyindia are being developed to take care of the citizen – government interface. GPS-guided biometric system can be used to track employees and vehicles to maintain civic amenities. Citizens can provide personal feedback and raise concerns on local and neighbourhood issues easily.

2. **India.gov.in:** It is the Indian Government web portal that helps all levels of government deliver services and information, automate internal operations, and improve staff productivity while reducing the costs of governance.

3. **MyGov.in:** it is a citizen engagement platform created by Government of India to promote active participation of Indian citizens in the country's governance and development.

4. **Smart sensors** can revolutionize design and planning in an attempt to ensure smooth functioning of cities. Data collected can be used to monitor parking spaces availability in the city. Monitoring of vibrations and material conditions in buildings and bridges, monitoring of sound levels, monitoring of vehicles and pedestrian levels to optimize driving and walking routes. Smart Lighting uses intelligent and weather adaptive lighting in street lights. Detection of rubbish levels in containers to optimize the trash collection routes, monitoring the quality of tap water in cities, detecting leakages and wastes of factories in rivers and controlling real-time leakages and wastes in the sea are some other applications of sensors.

5. **Spatial tools**, notably Geographic Information System (GIS) for mapping and monitoring urban areas, have become extremely popular. Monitoring the spatial patterns of urban sprawl on a temporal scale can be undertaken using temporal remote sensing data acquired from space borne sensors. These help in inventorying, mapping and monitoring linear and radial growth patterns. In the recent past, the geospatial domain has seen significant developments in modelling urban systems using approaches ranging from operations research to system dynamics and agent-based models. Models of urban systems are essentially built to aid in planning for understanding, evaluating, visualizing and deciding various interventions.

6. **Geospatial processing programs:** Each geoprocessing tool performs a small yet essential operation on geographic data.
   ArcGIS software can be used in calculating optimum paths through a transportation network, predicting the path of wildfire, analyzing and finding patterns in crime locations, predicting which areas are prone to landslides or predicting flooding effects of a storm event.

ERDAS IMAGINE (**E**arth **R**esource **D**evelopment **A**ssessment **S**ystem): This is an image processing software mainly utilized for study and analysis of satellite imagery. It combines various bands of satellite imageries, to perform detailed analysis of various objects and information using the pattern recognition technique such as land use / land cover analysis.

ENVI software combines advanced image processing and proven geospatial technology to help extract meaningful information from all kinds of data and make better decisions.

It can be used to utilize and preserve natural resources to ensure the products, food, and energy we use are available to us now and in the future.

Geospatial image analysis tools are used to predict natural disasters, prepare and manage disaster response efforts.

It can predict climate trends and forecast weather conditions that might exist tomorrow or even decades from now.

It can also be used to monitor pipeline activity and transportation infrastructure, ensure safety and mitigate the risk of injury, and maintain other critical operations.

7. **BIM** (Building Information Modelling) is a process involving the generation and management of digital representations of physical and functional characteristics of places. It is an intelligent 3D model-based process that equips architecture, engineering, and construction professionals with the insight and tools to more efficiently plan, design, construct and manage buildings.

8. **Flow Design** software acts as a wind tunnel simulator, so that one can understand and analyze airflow patterns through and around structures in built-up areas: identify hazards caused by moving air, such as gusts and downdrafts, and those regions that can contain high concentrations of pollutants.

9. **Solar analysis** softwares are used in the plotting of sun path throughout the year for a given area to measure intensity of heat and casting of shadows in a built environment to help architects and planners better design public and private spaces that respond to the micro climate. One example is Solar Friend that helps you analyze your rooftop conditions and determine the best system for solar power generation at any location worldwide. Bosch Solar Friend makes it really easy to estimate the average annual energy yield that can be expected when installing Bosch solar modules on your rooftop.

10. **Smart Energy** is a robust state-of-the-art web based energy analysis and thermal load simulation program tool. It has been specifically designed to meet the needs of HVAC engineers for calculation of hourly loads through simplified tabbed graphical interface.

11. **MyTransport SG Mobile** is a Singapore based app offering a wide range of information for all modes of land transportation, empowering commuters, motorists and cyclists in Singapore to make informed decisions and better plan their journey.

12. **Citizens Connect**: The city of Boston created this to encourage residents to be the "eyes and ears" of their neighborhoods by flagging potholes, graffiti and other nuisances.

13. **Urban Network Analysis**, an open-sourced software inspired by social networks and mathematical network analysis methods, is changing the way we look at urban environments. The tool measures traits such as reach, gravity, closeness, and straightness. The software can express practical features like the volume of traffic along sidewalks and streets or how many amenities and services are close by. Designers can also assign specific characteristics to individual buildings, as well as track urban growth analytics – valuable knowledge for city governments and policy makers.

ANNEXURE 3. Smart Growth principles

Smart Growth as defined by Smart Growth Network[42] is "development that serves the economy, community and the environment". This approach focuses on the connections between the economic, environmental and social aspects of the built environment and offers alternatives for guiding future development in a way that is more sustainable and equitable and is most often characterized by ten principles of growth as mentioned below:

1. Mix land uses
2. Take advantage of compact building design
3. Create housing opportunities and choices for a range of household types, family sizes, and incomes
4. Create walkable neighbourhoods
5. Foster distinctive, attractive communities with a strong sense of place
6. Preserve open space, farmland, natural beauty, historic buildings and critical environmental areas.
7. Reinvest in and strengthen existing communities and achieve more balanced regional development
8. Provide a variety of transportation choices
9. Make development decisions predictable, fair, and cost-effective.
10. Encourage citizens and stakeholder participation in development decisions

Smart Growth principles examine how our communities are designed in relationship to place. With features like forest/farmland preservation, walkable neighborhoods, urban villages and transit oriented development, livable communities may be designed in a way that they are healthy, economically vibrant, socially equitable, and environmentally sustainable.

[42] https://smartgrowth.org/what-is-the-smart-growth-network/

ANNEXURE 4. New Urbanism

New Urbanism[43] promotes creation and restoration of diverse, walkable, compact, vibrant, mixed use communities composed of the same components as conventional development, but assembled in a more integrated fashion, in the form of complete communities. These contain housing, work places, shops, entertainment, schools, parks, and civic facilities essential for daily lives of the residents, all within easy walking distance of each other. New Urbanism promotes the increased use of trains and light rail, instead of more highways and roads. Urban living is rapidly becoming the new hip and modern way to live for people of all ages. Currently, there are over 4,000 New Urbanist projects planned or under construction in the United States alone, half of which are in historic urban centers.

New Urbanism is the most important planning movement of this century, and is about creating a better future for all. It is an international movement to reform the design of the built environment, and is about raising our quality of life and standard of living by creating better places to live. New Urbanism is the revival of our lost art of place-making, and is essentially a re-ordering of the built environment into the form of complete cities, towns, villages, and neighbourhoods. New Urbanism involves fixing and infilling cities, as well as the creation of compact new towns and villages.

Principles of New Urbanism

The principles of New Urbanism can be applied increasingly to projects at the full range of scale from a single building to an entire community.

1. Walkability
    - Most things within a 10-minute walk from home and work
    - Pedestrian friendly street design (buildings close to street; porches, windows & doors; tree-lined streets; on street parking; hidden parking lots; garages in rear lane; narrow, slow speed streets)
    - Pedestrian streets free of cars in special cases
2. Connectivity
    - Interconnected street grid network disperses traffic & eases walking
    - A hierarchy of narrow streets, boulevards, and alleys
    - High quality pedestrian network and public realm makes walking pleasurable
3. Mixed-Use & Diversity
    - A mix of shops, offices, apartments, and homes on site. Mixed-use within neighbourhoods, within blocks, and within buildings
    - Diversity of people - of ages, income levels, cultures, and races
4. Mixed Housing
    - A range of types, sizes and prices in closer proximity
5. Quality Architecture & Urban Design

[43] Source: http://www.newurbanism.org/

- Emphasis on beauty, aesthetics, human comfort, and creating a sense of place; Special placement of civic uses and sites within community. Human scale architecture & beautiful surroundings nourish the human spirit

6. Traditional Neighborhood Structure
   - Discernible center and edge
   - Public space at center
   - Importance of quality public realm; public open space designed as civic art
   - Contains a range of uses and densities within 10-minute walk
   - Transect planning: Highest densities at town center; progressively less dense towards the edge. The Transect is an analytical system that conceptualizes mutually reinforcing elements, creating a series of specific natural habitats and/or urban lifestyle settings. The Transect integrates environmental methodology for habitat assessment with zoning methodology for community design. The professional boundary between the natural and man-made disappears, enabling environmentalists to assess the design of the human habitat and the urbanists to support the viability of nature. This urban-to-rural transect hierarchy has appropriate building and street types for each area along the continuum.
7. Increased Density
   - More buildings, residences, shops, and services closer together for ease of walking, to enable a more efficient use of services and resources, and to create a more convenient, enjoyable place to live.
   - New Urbanism design principles are applied at the full range of densities from small towns, to large cities
8. Smart Transportation
   - A network of high-quality trains connecting cities, towns, and neighbourhoods together
   - Pedestrian-friendly design that encourages a greater use of bicycles, rollerblades, scooters, and walking as daily transportation
9. Sustainability
   - Minimal environmental impact of development and its operations
   - Eco-friendly technologies, respect for ecology and value of natural systems
   - Energy efficiency
   - Less use of non-renewable fuels
   - More local production
   - More walking, less driving
10. Quality of Life
    - Taken together these add up to a high quality of life well worth living, and create places that enrich, uplift, and inspire the human spirit.

ANNEXURE 5. Smart cities and Initiatives around the world

The following table gives examples of multiple smart cities and city initiatives across the world. A caution worth mentioning is that, the following table only provides a general description of each city or initiative and not a detailed analysis of the positive or negative components of each.

SL. No.	LOCATION	DESCRIPTION
Smart Cities		
1	Masdar City, Abu Dhabi, United Arab Emirates	Masdar is a planned city project in Abu Dhabi, in the United Arab Emirates. Its core is being built by Masdar, a subsidiary of Mubadala Development Company, with the majority of seed capital provided by the Government of Abu Dhabi. Designed by the British architectural firm Foster and Partners, the city relies on solar energy and other renewable energy sources. Masdar City is designed to be a hub for clean tech companies. The first tenant is the Masdar Institute of Science and Technology, a university partnership with MIT's Technology and Development Program.
2	Amsterdam Smart City Project, Netherlands	Amsterdam Smart City (ASC) is a unique partnership between companies, governments, knowledge institutions and the people of Amsterdam. It is a frontrunner in the development of Amsterdam as a smart city, where social and technological infrastructures and solutions facilitate and accelerate sustainable economic growth, improving the quality of life in the city for everyone. ASC believes in a habitable city where it is pleasant to both live and work. In six years ASC has grown into a platform with over 100 partners, which are involved in more than 90 innovative projects.
3	Smart City Barcelona, Spain	Smart-city areas include public and social services, environment, mobility, companies and business, research and innovation, communications, infrastructure, tourism, citizen cooperation, and international projects.
4	Smart Cities, China	In an effort to promote urbanization and boost the national economy, the ministry is looking to transform cities combining government investments, modern infrastructure, and information technology to make them more competitive.

5	Songdo, South Korea	Songdo International Business District (Songdo IBD) is a new smart city or "ubiquitous city" built from scratch on 600 hectares (1,500 acres) of reclaimed land along Incheon's waterfront, 65 kilometers southwest of Seoul, South Korea and connected to Incheon International Airport by a 12.3-kilometre reinforced concrete highway bridge, called Incheon Bridge. Along with Yeongjong and Cheongna, it is part of the Incheon Free Economic Zone. Smart apps, video-conferencing facilities in every apartment, daily energy consumption tracking. 40% Green space, water taxi, bicycle hire scheme, LED traffic lights, renewable energy for transportation, solid waste management pipe network, grey water and rain water collected for irrigation and recycled, automated traffic signals through public travel patterns to remove traffic jams.
6	MK: Smart Initiative, Milton Keynes, UK	MK: Smart is a large collaborative initiative, partly funded by HEFCE (the Higher Education Funding Council for England) and led by The Open University, to develop innovative solutions to support economic growth in Milton Keynes. Central to the project is the creation of a state-of-the-art 'MK Data Hub' which will support the acquisition and management of vast amounts of data relevant to city systems from a variety of data sources. These will include data about energy and water consumption, transport data, data acquired through satellite technology, social and economic datasets, and crowdsourced data from social media or specialized apps.
7	Yokohama Smart City, Japan	Smart houses and electric vehicles, Energy management systems by involving members of public and commercial customers, CO2 emission reduction, introducing photovoltaic systems, Smart Homes, electric vehicles, etc.
8	GIFT City, India	Command Centre for city management using the ICT, Utility tunnels, Central solid waste management system and building cooling systems

9	Keihanna Eco-City (Kansai Science Park), Japan	The Keihanna Science City (officially known as the Kansai Science City) is nestled in the green Keihanna hills stretching over Kyoto, Osaka, and Nara prefectures in western Japan. The city, which has been constructed and maintained under the Kansai Science City Construction Act, is one of Japan's national projects – much like the Tsukuba Science City in the east of Japan. With about 130 research facilities, including universities and cultural facilities, the city has accomplished remarkable success in the fields of cultural and scientific research.
10	Singapore	Long-term planning and strategic partnerships with leading universities and corporations, and substantial government investments in both money and manpower have enabled Singapore to transform the city into one of the most innovative, sustainable and tech-savvy cities on the planet. Every 10 years since 1971, Singapore issues a concept plan with a 40-50-year time frame. On the city's streets, a network of sensors, cameras and GPS devices embedded in taxi cabs track traffic, predict future congestion alerting all downtown drivers to alternate routes. Singapore's advanced system on congestion pricing utilises traffic data to adjust prices in real-time and drivers' accounts are automatically deducted as they glide beneath electronic gantries. The city's water management system is among the world's most advanced, and the government is testing a new desalination technology for seawater that would be 50 percent more energy efficient than any current method. A superfast, next-generation broadband network already reaches 95 percent of homes and businesses in Singapore.
11	Dubai	After focusing the initial 10 years on physical infrastructure and its modernisation, Dubai embarked on a smart city programme across three tracks – smart life, smart economy and smart tourism. The six key initiatives included: 1) Open and easy access to data shared among residents and institutions with smart boards for residents to obtain information about the city; 2) A central control centre to monitor and manage traffic throughout the city; 3) 'Smart Electrical Grid' programme to encourage residents to use solar energy and sell the surplus to the Authority; 4) Smart parks and beaches that will provide relevant information such as safety instructions, weather and sea conditions, temperature and more; 5) Police smartphone to enable residents to make reports and enquiries without having

		to travel down to a police station; 6) World's largest 5D control room, which will be the central operation centre to oversee all government projects and monitor real-time situations in the city, including emergencies, road conditions, weather, etc.
12	Birmingham	Birmingham Smart City Programme is led by the Birmingham Smart City Commission, a body created by the city council which includes leading figures from the business, academic and public sector. It is a collective ambition by city stakeholders to deliver real change by developing intelligent and integrated services through the use of digital technologies, data and open collaboration, driven by the citizens and communities that are core to the city's future growth. The roadmap comprises 39 proposed actions like free community Wi-Fi, eHealth services, smart metering etc., to be delivered over the next three years, by identifying funding through European, national and regional programmes.
SMART INITIATIVES		
13	Andorra Living Lab, Andorra	Collaboration between the Andorran government and the MIT Media Lab for developing a living lab to test the use of data for addressing urban design, tourism, and innovation for the country of Andorra. Actua Tech is a partnership between Andorra Telecom and FEDA (National Utility Company).
14	HafenCity Project, Hamburg, Germany	Cooperation agreement between the HafenCity University and the MIT Media Lab to develop smart cities planning in the HafenCity District (Port of Hamburg) and neighbouring districts. Projects include the use of urban data analytics to create interactive city planning tools.
15	Rise Prize, India	Mahindra's one Million Dollars project to fund two Challenges: (1) Affordable, DIY Solar Kit, (2) Driverless Car for Indian conditions.
16	Catapult Driverless Vehicle Project, UK	Intelligent Mobility project using self-driving technologies for people and goods movement.
17	Lee Kuan Yew Centre for Livable Cities, Singapore	The Lee Kuan Yew Centre for Innovative Cities (LKY CIC) at the Singapore University of Technology and Design (SUTD) focuses on the integrated use of technology, design and policy to study solutions for cities. The LKY CIC works with architects, designers, engineers, social scientists, and urban planners to understand the complex and critical issues of urbanisation, and to explore sustainable and innovative urban solutions.

18	Singapore-MIT Alliance for Research and Technology (SMART), Singapore	The Singapore-MIT Alliance for Research and Technology (SMART) is a major research enterprise established by the Massachusetts Institute of Technology (MIT) in partnership with the National Research Foundation of Singapore (NRF) in 2007. Research areas include BioSystems and Micromechanics, Environmental Sensing and Modelling, Infectious Diseases, Future Urban Mobility, and Low Energy Electronic Systems.
19	Kista Science City, Stockholm, Sweden	Kista Science City is a creative melting pot in Stockholm where companies, researchers and students collaborate in order to develop and grow. The foremost sector in Kista is ICT. Kista Science City AB is a wholly-owned subsidiary of the Electrum Foundation and an operative, non-profit organisation. The goal is to make Kista Science City a place where people and business can continue to develop. Strong cooperation between business, academia and the public sector is encouraged in order to ensure continued growth in Kista Science City.
20	Smart City at TAF (Taiwan Air Force), Taipei, Taiwan	Collaboration between the Office of the Premier of Taiwan and the MIT Media Lab to develop Living Lab experiments at the former Taiwan Air Force (TAF) base in central Taipei. Experiments include low-speed, self-driving vehicles as well as urban innovation incubators.
21	Kashiwanoha Campus City, Japan	The first key element of Kashiwanoha Smart City is an environmental approach to town development taking full advantage of the natural environment specific to the site as a regional resource. As a second element, on top of this urban platform, focus is on energy conservation, reduction and storage infrastructure, next-generation traffic systems, and resource recycling systems, networking them to achieve optimal control. Concurrently, the third element is efforts to develop multifarious communities that support the sustainable lifestyles of people who gather at the town.
22	Skolkovo, Russia	The Skolkovo Innovation Center is a high technology business area that is being built at Skolkovo near Moscow, Russia. The site aims to be a highly modern complex created to encourage science and technology companies. The projected infrastructure of Skolkovo will enable the utilities sector, enterprises and households to improve their economic efficiency, reduce the burden on the environment as well as ensure the comfort and safety of the city's residents and guests.
23	Nagama City, Japan	Reduction of ICT cost and enhance network operation and management efficiency

24	Toyota City Low-Carbon Verification Project, Japan	A distinctive feature of the project is that, firstly, it will be focused primarily on local citizens and aim to optimize energy use in daily life and at the community level through initiatives directed at reducing local-household CO2 emissions—trending up in recent years—and eventually expand these to the community level. Secondly, it will promote initiatives to transform areas such as transportation systems and local citizens' lifestyles. In line with these goals, the project will try to optimize both household and on-the-go energy use, and construct a low-carbon public transportation system, thus resulting in optimal energy use in all spheres of daily life. Through these measures, the project targets a reduction in household CO2 emissions—the primary focus—of 20 percent (70 percent or more for smart houses) and a reduction in transportation-sector CO2 emissions of 40 percent.

Table 2: Smart Cities and Smart Initiatives

ANNEXURE 6. Technical Reports released in TEC

1. M2M Enablement in Power Sector
2. M2M Enablement in Intelligent Transport System
3. M2M Enablement in Remote Health Management
4. M2M Enablement in Safety & Surveillance Systems
5. M2M Gateway & Architecture.
6. M2M Number resource requirement and options
7. V2V / V2I Radio Communication and Embedded SIM
8. Spectrum requirements for PLC and Low Power RF Communications.
9. ICT Deployments and strategies for India's smart cities: A curtain raiser
10. M2M/ IoT Enablement in Smart Homes
11. Communication Technologies in M2M/ IoT domain

These Technical Reports (TRs) are available on TEC website (www.tec.gov.in/technical-reports/).

Glossary

1. **Big data:** Big data is an evolving term that describes any voluminous amount of structured, semi structured and unstructured data that has the potential to be mined for information. Big data is often characterized by 4Vs: the extreme Volume of data, Veracity of data, the wide Variety of data types and the Velocity at which the data must be processed.
2. **Brownfield:** Brownfield is a term used in urban planning to describe land previously used for industrial purposes or some commercial uses. Development of brownfield sites also presents an opportunity to reduce the environmental impact on communities, and considerable assessments need to take place in order to evaluate the size of this opportunity.
3. **Citizen engagement:** Citizen engagement can be defined as an individual and collective actions designed to identify and address issues of public concern. It can be defined as citizens working together to make a change or difference in the community.
4. **Citizen Participation:** Citizen Participation is a process which provides individuals an opportunity to influence public decisions and has long been a component of the democratic decision-making process.
5. **Crowd sourcing:** Crowdsourcing is the process of getting work or funding, usually online, from a crowd of people. The word is a combination of the words 'crowd' and 'outsourcing'. The idea is to take work and outsource it to a crowd of workers. The principle of crowdsourcing is that more heads are better than one. By canvassing a large crowd of people for ideas, skills, or participation, the quality of content and idea generation will be superior.
6. **City Development Plan:** A City Development Plan (CDP) is both a perspective and a vision for the future development of a city. It presents the current stage of the city's development – where are we now? It sets out the directions of change – where do we want to go? It identifies the thrust areas — what do we need to address on a priority basis? It also suggests alternative routes, strategies, and interventions for bringing about the change – what interventions do we make in order to attain the vision? It provides a framework and vision within which projects need to be identified and implemented. It establishes a logical and consistent framework for evaluation of investment decisions.
7. **GIS:** A Geographic Information System (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. GIS can show many different kinds of data on one map. This enables people to more easily see, analyse, and understand patterns and relationships.
8. **Greenfield:** Greenfield land is undeveloped land in a city or rural area either used for agriculture, landscape design, or left to evolve naturally.
9. **Information and Communications Technology (ICT):** ICT refers to all the technology used to handle telecommunications, broadcast media, intelligent building management systems, audio visual processing and transmission systems, and network-based control and monitoring functions.
10. **Internet of Things (IoT):** The Internet of things is the internetworking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other

items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. The IoT allows objects to be sensed and/or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. The Technical Report on "Communication Technologies in M2M/IoT Domain" talks in detail about the different connectivity technologies and different use case of IoT.

11. **Inclusive Design:** The British Standards Institute (2005) defines inclusive design as: 'The design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible without the need for special adaptation or specialized design.' Inclusive design does not suggest that it is always possible (or appropriate) to design one product to address the needs of the entire population. Instead, inclusive design guides an appropriate design response to diversity in the population through: developing a family of products and derivatives to provide the best possible coverage of the population, ensuring that each individual product has clear and distinct target users and reducing the level of ability required to use each product, in order to improve the user experience for a broad range of customers, in a variety of situations.
12. **Interventions:** The act or fact of interposing one thing between or among others.
13. **Livable:** Suitable for living in; habitable; comfortable.
14. **Master plans:** The purpose of a Master Plan is to promote growth, guide and regulate present and future development of towns and cities. It is an important instrument for guiding and regulating development of towns and cities over a period of time, and contributes to planned development both conceptually and operationally.
15. **Machine to Machine:** Machine to machine refers to direct communication between devices using any communications channel, including wired and wireless.
16. **New Urbanism:** It is an international movement to reform the design of the built environment, and is about raising our quality of life and standard of living by creating better places to live. New Urbanism is the revival of our lost art of place-making, and is essentially a re-ordering of the built environment into the form of complete cities, towns, villages, and neighbourhoods. New Urbanism involves fixing and infilling cities, as well as the creation of compact new towns and villages.
17. **PSS:** Planning Support Systems (PSS) can be defined as spatial decision support systems consisting of three important components, namely: data, models and geo-visualisation (Klosterman 1999). The techniques reported here have been used to develop a working planning support system based on the internet.
18. **Public realm:** The public realm embraces the external places in our towns and cities that are accessible to all. These are the everyday spaces that we move through and linger within, the places where we live, work and play**.** It can be any publicly owned streets, pathways, right of ways, parks, publicly accessible open spaces and any public and civic building and facilities. The quality of public realm is vital in creating environments that people want to live and work in.
19. **Planning principles:** A planning principle is a statement of a desirable outcome from a chain of reasoning aimed at reaching, or a list of appropriate matters to be considered in making a

planning decision. While planning principles are stated in general terms, they may be applied to particular cases to promote consistency.

20. **Real-time data:** Real-time data refers to data that is presented as it is acquired. There is no delay in the timeliness of the information provided. Real-time data is often used for navigation or tracking.
21. **Resilient:** Able to withstand or recover quickly from difficult conditions.
22. **Regional planning:** Regional planning is a category of planning and development that deals with designing and placing infrastructure and other elements across a large area. Planning zones may include several towns, cities or even parts of different states or regions. The key to regional planning is anticipating the needs of a community or group of communities before those needs arise. Experts in this field might try to predict how and where the population of a region is going to grow over the next decade and recommend the building of roads and other infrastructure to support that growth before it happens.
23. **Resource management:** It is the efficient and effective development of resources when they are needed. Such resources may include financial resources, inventory, human skills, production resources, or information technology (IT).
24. **SDSS:** A Spatial Decision Support System (SDSS) is an interactive, computer-based system designed to assist in decision making while solving a semi-structured spatial problem. It is designed to assist the spatial planner with guidance in making land use decisions. A system, in which models decisions could be used to help identify the most effective decision path.
25. **Sustainability:** Sustain can mean “maintain", "support", or "endure”. Since years sustainability has been used more in the sense of human sustainability on planet Earth and this has resulted in the most widely quoted definition of sustainability as a part of the concept sustainable development. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
26. **Smart city:** There are various definitions as well as terms associated with Smart cities. These conceptual variants are mutually connected and overlapping depending on the context and definition. Riddled with substantial confusion in definitions and complicated usages, a variety of the labels associated with smart cities can be categorized into three dimensions: technology, people, and community. If technology is taken into consideration; Smart city could be also named as Digital City, Intelligent city, Ubiquitous city, Wired city, Hybrid city and Information city. In terms of people, it could be named as Creative city, Humane city, Learning city and Knowledge city. Whereas taking community as a larger dimension, it could also be named as a Smart Community.
27. **Smartphone:** A mobile phone that performs many of the functions of a computer, typically having a touchscreen interface, Internet access, and an operating system capable of running downloaded apps.
28. **Service delivery:** It is used to describe the distribution of basic resources citizens depend on like water, electricity, sanitation infrastructure, land, and housing.
29. **Technology:** Technology is the collection of techniques, skills, methods and processes used in the production of goods or services or in the accomplishment of objectives, such as scientific

investigation. Technology can be the knowledge of techniques, processes, and the like, or it can be embedded in machines which can be operated without detailed knowledge of their workings.

30. **Urbanization:** The gradual increase in the proportion of people living in urban area. Urbanization creates enormous social, economic and environmental changes, which provide an opportunity for sustainability with the potential to use resources more efficiently, to create more sustainable land use and to protect the biodiversity of natural ecosystems.
31. **Urban Planning/ City Planning:** Urban Planning is about balancing social, economic, and environmental concerns to create sustainable urban places that are culturally rich, environmentally responsible, socially diverse and economically sound.
32. **Urban Design:** Urban Design focuses on a holistic design of the urban environment through the shaping of space, built form and landscape and the many strands of place-making that contribute to identity amenity, livability and beauty.
33. **Weak Signals:** Weak signals seemingly random or disconnected piece of information that at first appears to be background noise but can be recognized as a part of significant pattern by viewing it through a different frame or connecting it with other piece of information.
34. **Zoning:** Zoning describes the control by an authority which designates legal areas in a municipality to permit and prohibit land uses.

References

- Adler, L. (2016, August 29). SimCities: Designing Smart Cities through Data-Driven Simulation. Retrieved October 20, 2016, from *Data-Smart City Solutions: http://datasmart.ash.harvard.edu/news/article/simcities-designing-smart-cities-through-data-driven-simulation-893*
- Anna Roumiantseva, The Fourth Way: Design Thinking Meets Future Thinking, October 19 2016
- Anderson C. (2008). "The end of theory: will the data deluge make the scientific method obsolete?" Wired Magazine, July 16. Retrieved July 30, 2013 from: http://www.wired.com/science/discoveries/ magazine/16-07/pb_theory
- Angelidou, M. (2014). Smart city policies: A spatial approach, Cities 41: S3–S11.
- Arup. (2011). Designing with data: Shaping our future cities. London: RIBA.
- Batty, M. (2013). Big data, smart cities and city planning. *Dialogues in Human Geography*, *3*(3), 274-279.
- Buck, N. T., & While, A. (2015). Competitive urbanism and the limits to smart city innovation: The UK Future Cities initiative. *Urban Studies*, 0042098015597162.
- Campagna, M., Floris, R., Massa, P., Girsheva, A., & Ivanov, K. (2015). The role of social media geographic information (SMGI) in spatial planning. In *Planning Support Systems and Smart Cities* (pp.41-60). Springer International Publishing.
- Ching, T. Y., & Ferreira Jr, J. (2015). Smart cities: Concepts, perceptions and lessons for planners. In *Planning Support Systems and Smart Cities* (pp. 145-168). Springer International Publishing.
- Cohen, B. (2012, September 19). What exactly is a smart city? Retrieved on December 2, 2016, from: https://www.fastcoexist.com/1680538/what-exactly-is-a-smart-city
- Bhattachary. S., Rathi. S.(2015). "*Reconceptualising Smart Cities: A Reference Framework for India."*, (CSTEP-Report-2015-03).
- Dwivedi, M., A. U. (2015). New Horizons in Planning Smart Cities using LiDAR Technology. *International Journal of Applied Remote Sensing and GIS (IJARSGIS)* , 40-50.
- Eric Brynjolfson, Andrew McAfee, and Michael Spense, *Foreign Affairs,* "New World Order: Labor, Capital and Ideas in the Power Law Economy", July/August 2014
- Geertman, S., Ferreira, J., Goodspeed, R., & Stillwell, J. C. H. (Eds.). (2015). *Planning Support Systems and Smart Cities*. Springer.
- Habitat III. (2015). *Habitat III issue papers 21- Smart Cities*. New York: United Nations Habitat. Retrieved October 16, 2016, from http://unhabitat.org/wp-content/uploads/2015/04/Habitat-III-Issue-Paper-21_Smart-Cities-2.0.pdf
- Imrie, R., & Hall, P. (2003). *Inclusive design: designing and developing accessible environments*. Taylor & Francis.
- India Bureau, Business Insider, "Indian IT Sector Finding It Hard to Retain Employees", Mar 7, 2017
- Khansari, N., Mostashari, A., &Mansouri, M. (2014). Impacting sustainable behaviour and planning in smart city. *International Journal of Sustainable Land Use and Urban Planning (IJSLUP)*, *1*(2).
- Khansari, N., Mostashari, A., (2013). Impacting Sustainbale behaviour and planning in cities. *International journal of Sustainable Land Use and Urban planning* , 46-61.
- Kumar, A., & Sarkar, P. K. (2017). Making Delhi a Smart City: Economic Buoyancy with Spatial Justice. In *Smart Economy in Smart Cities* (pp. 495-549). Springer Singapore.
- Carta, M. (2014). Smart planning and intelligent cities: A new Cambrian explosion. In Smart Rules for Smart Cities (pp. 123-132). Springer International Publishing.
- Maringanti, A. (2016, June 29). Avoiding the zombie city algorithm. Retrieved October 16, 2016, from *Live Mint: http://www.livemint.com/Specials/8Pu1lCFeS5bIExZWpPQ8oI/Avoiding-the-zombie-city-algorithm.html'*
- Maringanti, A., & Mukhopadhyay, P. (2015). Data, Urbanisation and the City. *Economic and Political Weekly*, Vol 22.
- Paul J.S. Schoemaker& George S. Day, "How to Make Sense of Weak Signals", MIT Sloan Management Review, Spring 2009
- Pethe, A., Nallathiga, R., Gandhi, S., &Tandel, V. (2014). Re-thinking urban planning in India: learning from the wedge between the de jure and de facto development in Mumbai. *Cities*, *39*, 120-132.

- Press Trust of India, "India needs $1.5 Trillion for Infrastructure: Arun Jaitley", *The Economic Times, June 26, 2016*
- Ramanatham, S. (2016, June 29). Getting smart needs a capacity that can't be built overnight. Retrieved October 16, 2016, from *Live Mint: http://www.livemint.com/Specials/ca02Ff1WrJOPIhg3ONwsUJ/Getting-to-smart-needs-capacity-that-cant-be-built-overnigh.html*
- Rao, P. S. N. (2014, August 9). Smart cities go beyond just using tech tools. Retrieved October 16, 2016, from *The Indian Express: http://indianexpress.com/article/business/business-others/smart-cities-go-beyond-just-using-tech-tools/*
- Robinson, R. (N. A.). *Smart City Design Principles*. Retrieved September 21, 2016, from *The Urban Technologist: https://theurbantechnologist.com/smarter-city-design-principles/*
- Roy, A. (2009). Why India cannot plan its cities: Informality, Insurgence and the Idiom of Urbanization. *Planning theory*, 76-87.
- Samarajiva, R., Lokanathan, S., Madhawa, K., Kreindler, G., &Maldeniya, D. (2015). Big Data to Improve Urban Planning. *Economic & Political Weekly*, *50*(22), 43.
- Samarajiva, R., Lokanathan, S., (2015). Big Data to Improve Urban Planning. *Economic & Political Weekly, Vol l no 22.*
- Saad-Sulonen, J. C., &Horelli, L. (2010). The value of Community Informatics to participatory urban design and planning: a case-study in Helsinki. *The Journal of Community Informatics*, *6*(2).
- Sadoway, D., &Shekhar, S. (2014). (Re) Prioritizing Citizens in Smart Cities Governance: Examples of Smart Citizenship from Urban India. *The Journal of Community Informatics*, *10*(3).
- Saunders, T., &Baeck, P. (2015). Rethinking Smart Cities from the Ground Up. *London: Nesta*.
- Searle R. (2014) City as Superintelligence. Retrieved September 21, 2016, from *IEET.org: http://ieet.org/index.php/IEET/more/searle20140907*
- Sheikh, S., & Banda, S. (2015). Surveying Slums. *Economic & Political Weekly*, *50*(22), 73.
- Staff Writers, "Monetizing the Smart City", *Connected World, Jun 6, 2016, accessed on Mar 10, 2017*
- Townsend, A. M. (2013). *Smart cities: Big data, civic hackers, and the quest for a new utopia*. WW Norton & Company.
- University of Pennsylvania Scholarly Commons, John Pourdehnad, Erica R. Wexler, Dennis V. Wilson, "Systems & Design Thinking: A Conceptual Framework for their Integration", Jul 1st 2011
- Eric Brynjolfson, Andrew McAfee, and Michael Spense, Foreign Affairs, "New World Order: Labor, Capital and Ideas in the Power Law Economy", July/August 2014
- Senior Professor and Head, Centre for Future Cities, SPA-New Delhi. 2014. "Smart cities go beyond just using tech tools." The Indian Express: Business,9 August, 2014, accessed October 16, 2018 https://indianexpress.com/article/business/business-others/smart-cities-go-beyond-just-using-tech-tools/

ISO 9001:2008

TELECOMMUNICATION ENGINEERING CENTRE
DEPARTMENT OF TELECOMMUNICATIONS
MINISTRY OF COMMUNICATIONS
GOVERNMENT OF INDIA