



UNIVERSITY OF CAGLIARI

DIEE - Department of Electrical and Electronic Engineering

Smart Cities



Smart City

- In the early 1990s the term "**Smart City**" was coined to signify how urban development was turning towards technology, innovation and globalization
- The more recent interest in smart cities can be attributed to the strong concern for **sustainability**, and to the rise of new **ICT technologies**
 - Mobile devices (e.g., smart phone, tablet)
 - Internet of Things (IoT)
 - Cloud networking and computing technologies
 - Big Data and Open Data
- Although the growing interest and development of Smart Cities around the globe, there is not a standard and accepted definition of the Smart City

Smart City - Definition

- *"A smart city connects physical, social, business, and ICT infrastructure to uplift the intelligence of the city" [1]*

[1] Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., et al. (2010). Foundations for smarter cities. IBM Journal of Research and Development, 54, 1–16.

- A city may be called 'smart' *"when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory government" [2]*

[2] H. Schaffers, N. Komninos, M. Pallot, B. Trousse, M. Nilsson, and A. Oliveira, "Smart cities and the future internet: Towards cooperation frameworks for open innovation," The Future Internet, Lect. Notes Comput. Sci., vol. 6656, pp. 431–446, 2011.

Smart City - Definition

- The “smart city” defines *“the new urban environment, one that’s designed for performance through ICTs and other forms of physical capital. With the effective management of resources through intelligent management, visionaries hope that cities will drive a higher quality of life for citizens, drive down waste, and improve economic conditions”* [3]

[3] C. L. Stimmel, “Building Smart Cities. Analytics, ICT, and Design Thinking,” CRC Press, Taylor & Francis Group, 2016.

- *“A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects”* - Focus Group on Smart Sustainable Cities, UNECE and ITU, October 2015 [4]

[4] <https://www.itu.int/en/ITU-T/focusgroups/ssc/Pages/default.aspx>

Smart City - Definition

THEN

- The role of cities and regions in ICT-based innovation was mostly focused on deploying broadband network infrastructure

NOW

- The stimulation of ICT-based applications enhancing sustainability and citizens' quality of life is the key priority
- "Smart" solutions are efficient and feasible solutions for economic growth of the city and society
- The smartness of a city describes its ability to bring together all its resources, to effectively achieve specific goals

Smart City - Motivations

- The **increment of urban population** is growing constantly, and constantly quicker
 - In 1960, the population living in cities was around 1 billion
 - In 1986, it doubled, and in 2005 was 3.2 billions
- The percentage of population living in urban environments **cross the 50%** in 2007
- Following this pattern, our planet will see **in 2030 5 billion urban people**
- In Europe, the **urbanization trend** is very important
 - The European population (in the EU 27 countries) grew by 100 million, from 400 to 500 million, between 1960 until 2009
 - More than 75% of the global population lives in towns, using 80% of resources and contributing 85% to the European GDP (Gross Domestic Product)

Smart City - Motivations

- This unprecedented **speed in urbanization** in conjunction with the current **economic crisis** has become an overwhelming **issue** for city governance and politics cities
- Cities and towns are suffering to provide **basic urban services**, and the increasingly consumption by humans has amplified **scarcity of environment and natural resources** in the earth
- The future of our towns is dependent to the way we will manage to work out the **economical, social, and environmental** developments in synergy
- In Europe, it was proposed in 2010 the strategy called “**Europe 2020**” aimed to revive the economy and to develop a smart, sustainable and inclusive growth
<https://ec.europa.eu/eurostat/web/europe-2020-indicators>

Smart City - Motivations

Europe 2020: Main actions

- **Smart growth**, developing an economy based on knowledge and innovation
 - Between now (2010) and 2020, an estimated 16 million more jobs will need a high level of qualification, while the low-skilled asset demand is expected to fall by 12 million
 - The improvement of the initial training is paramount as well as the means to acquire and develop new skills during a career
- **Sustainable growth**, which promotes a better efficiency energetics as well as a greener and more competitive economy
- **Inclusive growth**, which supports high employment rate and a strong social and territorial cohesion. Inclusive growth is economic growth distributed fairly across society and creates opportunities for all

Smart City - Motivations

Europe 2020: Targets for 2020

- **Employment:** 75% of the population between 20 and 64 years should be employed
- **Poverty:** reduce the poverty rate of 25%, which means 20 million people out of poverty
- **Education:** reduce to less than 10% the population between 18 and 24 years leaving school without a diploma; raise to at least 40% the population between 30 and 34 year with a higher degree
- **Research & Development:** 3% of European GDP invested in R&D, combining private and public sectors, which is a point higher than the current rate (compared to 2.6% of GDP invested in R&D in the USA and 3.4% in Japan)
- **Climate change & energy:** objective "20/20/20" climate change: a 20% reduction of greenhouse gas emissions compared to 1990 levels; raising 20% the energy efficiency; reach 20% of energy production through renewable sources

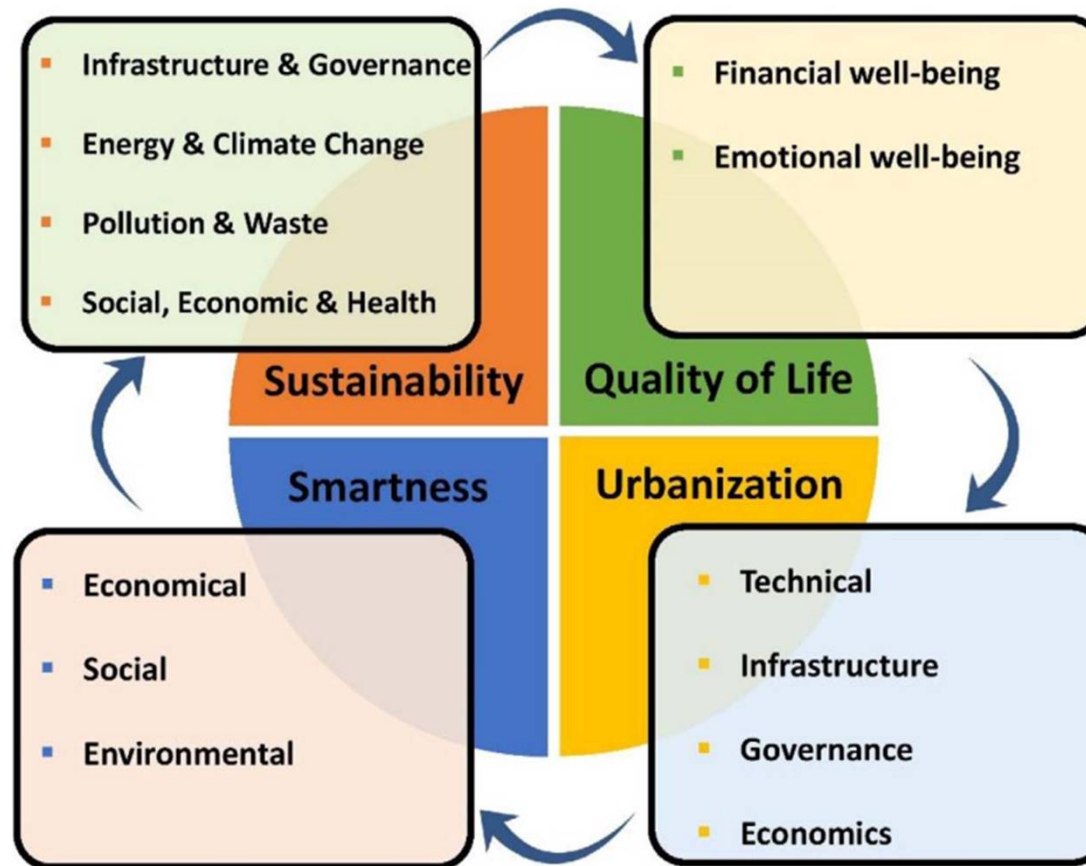
Smart City - Motivations

- Following the Europe 2020 strategy, the European economy will have the chance of improving its **competitiveness**, creating **wealth** and **jobs**
- All these improvements will bring the opportunity to develop a **fully “green economy”**
 - societies more environmental-friendly and therefore more profitable
- In general way, the **conceptualization of Smart Cities** follows from
 - the **economic** and **technological** changes that relate to globalization
 - a need to combine **economic competitiveness** and **urban development**, in a **sustainable** manner and style, preserving—or by creating—an outstanding **quality of life**

Smart City - Characteristics

- A majority of Smart City proposals consists of four main attributes
 - **Sustainability:** the ability of a city to maintain the balance of eco system in all sustainability aspects, while serving and performing city operations
 - Infrastructure and governance, pollution and waste, energy and climate change, social issues, economics, and health
 - **Quality of Life:** indicates emotional and financial well-being of urban citizen
 - **Urbanization:** focuses on technological, economical, infrastructural, and governing aspects of the transformation from rural environment to urban environment
 - **Smartness:** the desire to improve social, environmental, and economic standards of the city and its inhabitants

Smart City - Characteristics

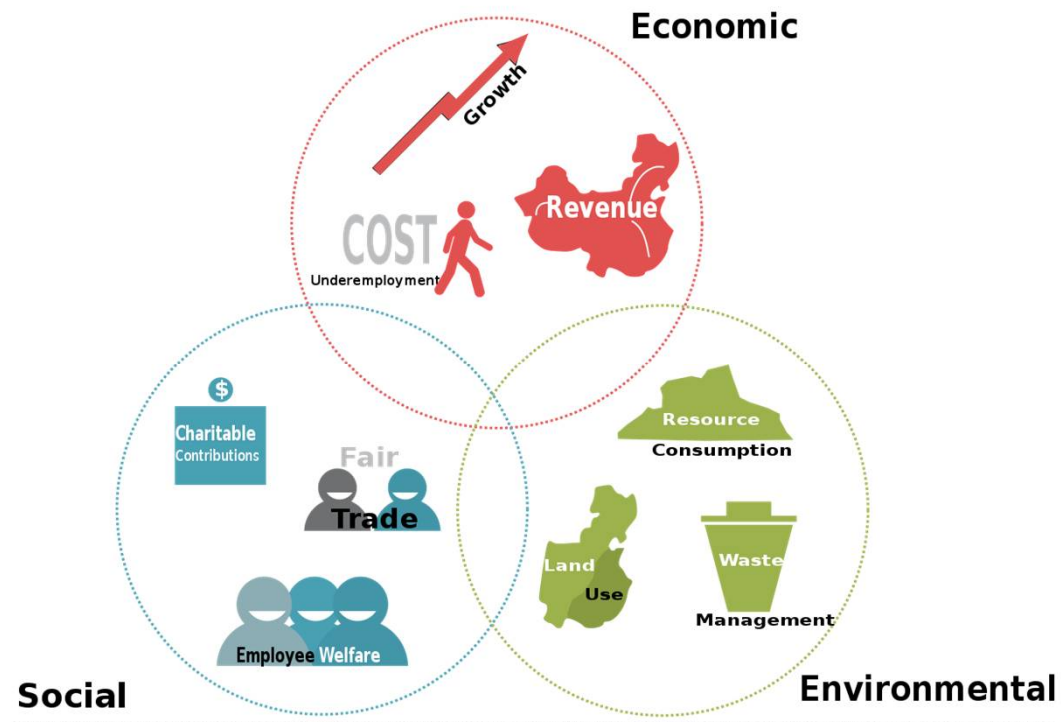


Smart City - Sustainability

- From 1980s, sustainability has been considered as a **predominant paradigm** in urban development
- Prevalent attention on sustainability played a major role in the emergence of smart cities
- The **triple bottom line concept** contemplates about interrelationship and interdependence among **sustainability sub-attributes**, which are:
 - Infrastructure and governance, pollution and waste, energy and climate change, social issues, economics, and health
- Cities of the modern world are increasingly developing by utilizing **natural resources**
 - it is crucial to consider the **scarcity of non-renewable energy sources** (carbon, petrol, gas)
 - **safe guarding natural heritages and energy sources** has become a compelling demand in maintaining sustainability of smart cities

Smart City - Sustainability

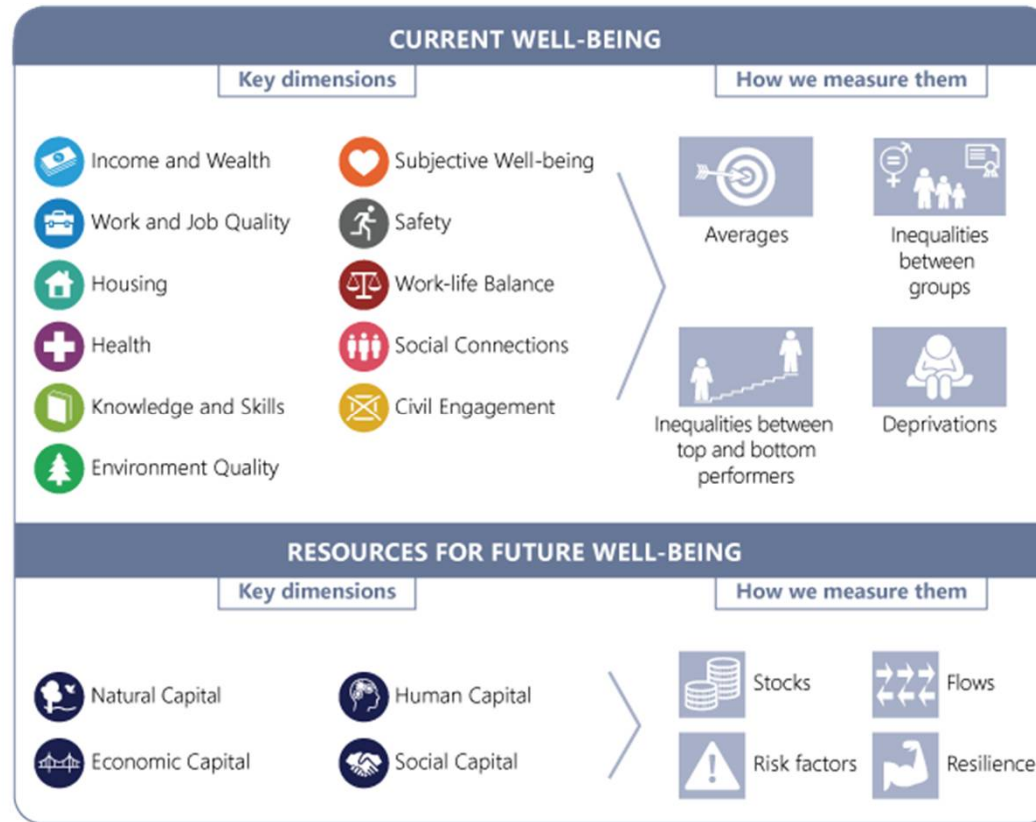
The triple bottom line



Smart City - Quality of Life

- **Quality of Life (QoL)** is a personal perception of each person deriving from needs and opportunities, how they are perceived and how are really met
- QoL indicates emotional and financial well-being of urban citizen
- Improvements in QoL level of citizens are made by including **innovative solutions**, which reduces social participation barriers
- Quality of city service provision is upgraded, while augmenting the QoL and financial state of skilled employees
 - social policies are introduced to **recognize and to employ skilled citizens**
 - **financial and emotional well-being** of both employees and citizens satisfy QoL enforcement

Smart City - Quality of Life



Measuring Well-being and Progress: Well-being Research <https://www.oecd.org/statistics/measuring-well-being-and-progress.htm>

Smart City - Urbanization

- The smart city is the ideal solution to **manage challenges arise with drastic urbanization**
- Some of the **major challenges** followed by urbanization are waste management, air pollution, traffic congestion, adverse human health effects, resource scarcity, and infrastructure aging
- Urbanization in a smart city focuses on enhancement of economic growth and advancements of technology
- Numerous factors related to urbanization in a smart city are identified that **positively influence the urban wealth**
 - attention to urban environment, level of education, accessibility to ICT, use of ICT in public administration

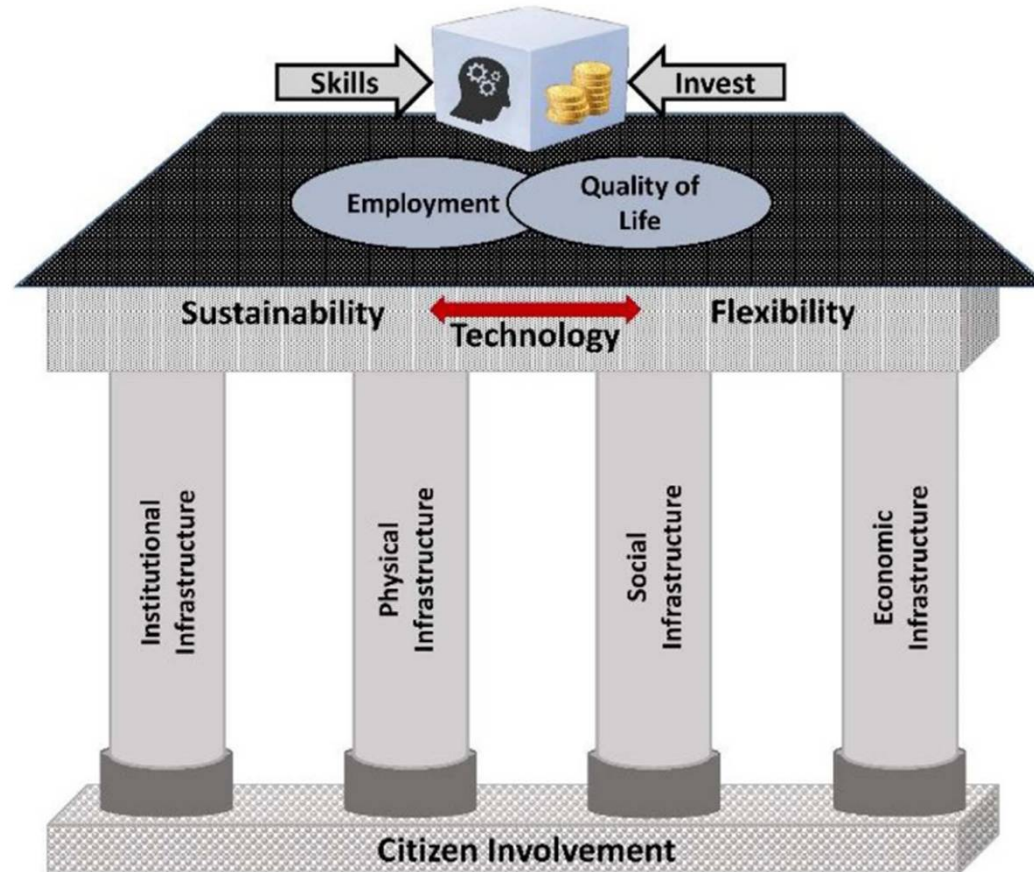
Smart City – Smartness

- Smartness of the city aims on **improving the living standards of urban community** in terms of economic, social, and environmental aspects
- The smartness of a city describes its ability to bring together all its resources, to effectively achieve specific goals
- Smartness is realized both through material instruments (such as mobility infrastructures or environment preservation) and through people behaviors in living, working, studying and so on
- Smartness is also influenced by human capital, e-government, length of public transport network, per capita gross domestic product (GDP), and employment

Smart City - Pillars

- A Smart City may be considered as constituted by 4 pillars/themes
 - Institutional infrastructure
 - Physical infrastructure
 - Social infrastructure
 - Economic infrastructure

Smart City - Pillars



Smart City - Institutional Infrastructure

- The **institutional infrastructure** of a smart city associates with participation in decision making, public and social services, transparent governance, and political strategies and perspectives
 - Involving and working with citizens have significant positive influence on utilizing **human capital**
 - **Governance** has remarkable role in coordinating between citizens and administrative bodies
 - **Technocratic governance** is another key feature that presumes all city services and features are addressable through **technical solutions**
- The institutional infrastructure integrates public, private, civil, and national organizations when necessary to provide **interoperation between services**
 - **consolidation of different administration bodies** serves citizens more reliably, efficiently, and effectively

Smart City - Physical Infrastructure

- Physical infrastructure consists of **natural resources** and **manufactured infrastructure** that ensure sustainability of resources to continue city operations at present and future
- Physical infrastructure also includes the quality of **ICT infrastructure** as well as the quality and availability of smart object networks
- Physical infrastructure is further extended to green buildings, green urban planning, and smart energy
- Smart city **utilizes technology to serve better service management**, while increasing the sustainability of natural resources
 - a majority of smart city initiatives focus on **conserving natural resources** of the city i.e. waterways, green spaces, and sewers

Smart City - Social Infrastructure

- The social infrastructure of a smart city comprises of **intellectual capital, human capital, and QoL**
- Citizen awareness, responsibility, and commitment play a key role in spreading the smart city concept
- Even though the smart cities are well organized, utilize advance technologies, and equipped with sophisticated equipment, the **sustainability is not guaranteed without social awareness** that concerns about people and their relationships
- Comparative to a conventional city, **smart city serves human to utilize and grow their potential to live a quality life**
 - competent and better educated citizens tend to gather around smart cities
 - knowledge based urban development is considered as a key factor in modern smart cities

Smart City - Economic Infrastructure

- Smart economy is the **utilization of best practices and applications of e-commerce and e-business** to escalate the city productivity
 - unceasing and steady economic growth and job growth, which flourishes a smart city
 - a concept that reaches the boundaries of both micro and macro economy
- Smart economy comprises of novel innovations in ICT, manufacturing and service provision related to ICT, and integration of advanced technologies that **improve the reliability and performance of economic management**
- **Key indicators** used to evaluate the performance of economic infrastructure
 - Public expenditure on research and development (R&D), GDP per head of city population, gross inland energy consumption indicator, and employment rate

Smart City - Challenges



Smart City - Challenges

- **Design and maintenance cost** is one of the major challenges for realistic smart city implementation
- Cost is categorized as design cost and operational cost
 - **Design cost** is the financial capital for deploying the smart city. Smaller the design cost, higher the probability of real-world implementation
 - **Operational costs** incur due to daily city operations and maintenance tasks. Minimal operational costs are highly demanded to assure the sustainability of service provision without additional financial burden on municipal. However, the cost optimization throughout the lifetime of a smart city is still a quite challenging task

Smart City - Challenges

- **Heterogeneity** is another key concern of smart city architectures
- Smart cities consist of multi-vendor and multi-purpose sensors, appliances, devices, etc.
- **Platform incompatibilities** resulting from heterogeneity hinder the ability to integrate and inter-operate at the application level
- Smart cities focus on designing, identifying, and purchasing hardware and software that **enables aggregation of these heterogeneous sub systems** at the application level, although facilitating universal access is a tedious and challenging task,

Smart City - Challenges

- **Infrastructure security and information security** are highly enforced in smart cities, even though high security incurs additional expenditure on design and maintenance
- Cities adapted technology to improve lives of residents, visitors, and businesses. Parallel growth of technology and **malicious threats** have caused a huge controversy about securing smart cities and their operations from possible attacks
- Malicious attackers may generate **false data** to manipulate sensing results or launch **denial-of-service (DOS) attacks**, disrupting the sensing, transmission, and control to degrade the quality of intelligent services in a smart city
- An **attack** on a city management system (CMS) that coordinates myriads of tasks gives a wide range of options to cause adverse effects
 - An attack on Illinois water utility control system in 2011 has destroyed a water pump and cut off water supply for 2200 residents

Smart City - Challenges

- **Data confidentiality, privacy, and trust** are another pivotal features of any smart city
- Citizens communicate with core smart city services via computers, smart phones, and other smart devices
- **Pervasive video surveillance** captures a tremendous number of images and video clips, which may be utilized to infer local residents' trajectories and inherently endanger their privacy
- The urban network gathers a variety of data including **highly sensitive citizen data**, which are vulnerable for numerous security threats, e.g., data leakage, eavesdropping
- Maintaining these security measures to **ensure privacy and safety of citizens' data** has become a highly challenging and essential task in smart cities

Smart City - Challenges

- **Preserving city environment and resources** for future generations by minimizing carbon footprint and efficiently utilizing resources are key concerns of modern smart cities
- Therefore, modern cities are focusing on **renewable energy sources** to reduce the carbon footprint, while ensuring the sustainability of city operations and non-renewable energies
- **Waste management** is another critical issue in modern smart cities due to environmental pollution and land filling
- The utmost goal of smart waste management is to **expedite collection and separation processes**
- Scarcity of resources and population growth are the main issues to be addressed for successful waste management procedures

Smart City - Challenges

- **Failure management** is also a key concern for any smart city development project
- **Failures** can occur subsequent to natural disasters (e.g., floods, earthquakes, tornados) and system failures, such as infrastructure breakdown and network unavailability
- Designing sustainability defines **immediate recovery strategies** to overcome a failure and to revert the city operations back to normal
- Nevertheless, identification and implementation of recovery strategies and fault tolerance strategies **increase both design cost and operation cost**
- The challenge would be to implement failure recovery mechanisms with minimal effect to cost and operational efficiency

References

- Bhagya Nathali Silva, Murad Khan, Kijun Han, Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities, *Sustainable Cities and Society*, Volume 38, 2018, pp. 697-713.