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Kwi-Gon Kim

Low-Carbon Smart Cities

Tools for Climate Resilience Planning

Springer

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Foreword

Climate change, disaster risk management, and dramatically increasing urbanization-associated challenges have come to the forefront of global discussion on the agenda of sustainable development and sustainable "human-friendly" living. The recent Paris Agreement has highlighted the urgent need for and recognized the criticality of immediate action to deliver a sustainable and livable planet and world to the future generations.

For over 3 decades, the notions of green cities, eco-cities, climate resilient cities, and cleaner cities have been evolving and tested to address the challenges facing the cities, the citizens, and the planet and mitigate the threats to cities and by city expansion. However, these approaches have tended to be disconnected, spot, or sectoral initiatives rather than fully integrated and coordinated and driving city planning. In addition, financing has remained a major challenge, deterrent and a Gordian knot. Yet, the rapid expansion in urbanization and urban dwellers—whereby in about 30 years close to 70% of the world population will be living in cities—is forcing policy makers, researchers, technicians, planners, civil society, and the world community to roll up their sleeves and waste no time in finding new viable and affordable options and taking actions to deal constructively with this unavoidable reality.

In parallel, the world has witnessed an explosion and revolution in terms of technological development and especially in the fields of ICT and IoT-based and supported innovation, opening an infinite world of options and permeating all fields of activity. "Connectivity" has become the new trend.

Based on decades of teaching, research, exploring, advising, guiding, and implementation, brainstorming with scientists, politicians, practitioners, civil society, researchers, private sector around the world, Prof. Kim Kwi-Gon is now proposing a challenging, creative, and stimulating approach to connect the various agenda and dots of low-carbon sustainable cities through an integrated "global climate city platform" supported by and making the best use of new technologies—in particular—in the field of ICT, to plan, build, and manage the new "low-carbon smart cities."

Along with it he makes the business case that adopting this approach could generate new stimulus for the economies with the development of new research, technologies, businesses, investment, and job opportunities.

This proposal offers a comprehensive, detailed, and circular journey through the key components of an ICT-facilitated, ICT-connected, and ICT-integrated "low-carbon smart city" implementation. It takes us through an extensive analysis of current challenges and trends, new ICT-supported planning models bringing about increased efficiency and resilience through circularity and connectivity, new integrated planning approaches in terms of process and methods, the thoroughly documented presentation of selected practices and case studies of methods and techniques for climate resilient and "low-carbon smart city" planning and learnings derived from them, financing challenges and options, research needs and opportunities to implement this vision, to the description of the proposed comprehensive global climate smart city platform and smart grid itself—unlocking the value added of digitalized urban eco-systems built through public–private partnerships, but also the challenges and threats facing increased digitization and connectivity, as well as plans for future development.

While this comprehensive analysis and proposal does not have the pretention to offer all the options, solutions and answers for all the potential questions and challenges in implementing "low-carbon smart cities," it provides a solid platform for policy, technical and partnership discussions, dialogue, testing, actions, research and the development of a new efficient, interconnected, ICT-supported approach to addressing some of the key current and future challenges of climate change, exponential city expansion and "human-friendly" sustainable development.

Each chapter is an open door to further exploration and development, but eventually all the elements of these various chapters have to come together—with the help of ICT—to bring about a fully integrated, circular, and connected approach to the effective implementation of "low-carbon smart cities."

Anne-Isabelle Blateau
Former Director of the UNDP Seoul Policy Center
Seoul, Korea

Preface

Very recently, there has been a remarkable and innovative interest in urban planning issues. A major impetus was provided by climate change which is one of the biggest development challenges of our times. The Paris Climate Change Agreement and Post-2015 Sustainable Development Goals (SDGs) in 2015 and the New Urban Agenda in 2016 sought to accelerate the impetus for evolution of climate smart urbanism. Much of the discussion on low-carbon smart city issues and on climate resilience planning is about the better application of ICT and smart connect-tech in every aspect of urban planning. However, there will always be pressure for innovation planning. How much better tools for low-carbon, resilience planning would be to mitigate the potential emissions of GHG or to reduce disaster risk of future urbanization at the planning stage.

Climate resilient and low-carbon smart cities can be defined as one that has digitalized connections of all sectors and functions, in which everything is connected, acknowledging sustainability, resiliency, circularity, efficiency, and connectivity of the city. It incorporates climate mitigation and adaptation policy goals at each stage of planning process and with urban policy. Low-carbon, resilient smart city planning is at the developing stage. This is not mandatory. There is no internationally recognized city climate planner certification system yet. However, its importance has spread worldwide and receives a significant boost all over the world with the introduction of ICT and innovation connect-tech. Low-carbon resilient smart city planning is an approach in good business. It is also an area where many of the planning practitioners in both public and private sectors have limited experience.

This book provides a comprehensive introduction to the various dimensions of low-carbon, resilient smart city planning. It has been written as a seminal book with many case studies and with trial-and-error test bed examples. It should be of considerable value to those in practice for integrated solutions to unfinished urban agenda–policy decision makers, planners, developers, business people, and various interest groups.

This book is structured into eight chapters. The first provides an introduction to the impact of urbanization on urban ecosystem and their services, and overview of

planning responses to climate change with selected case studies and introduces the concept of climate resilient and low-carbon smart urbanism: city climate urbanism. Chapter 2 provides planning models for climate resilient and low-carbon smart cities as an urban innovation for sustainability, efficiency, resiliency, circularity, and connectivity. Chapter 3 examines integrated planning approach to climate resilient and low-carbon smart cities in terms of process and methods. Chapter 4 addresses methods and techniques in more detail through selected practices. Chapter 5 takes a look to urban CDM-based approach and carbon financing banking system as a carbon governance approach. Chapter 6 examines research needs related to technology and smart urban investments. Chapter 7 describes implementation of climate smart cities through global climate smart city platform solution. Chapter 8 considers possible future developments.

Although this book has, to some extent, a planning orientation, it does draw extensively on application of ICT and smart technology innovation in urban environmental planning, and it should be of interest to readers from many different disciplines. This book seeks to highlight innovation practice and to offer enough insight to methods and techniques, and to provide market opportunities through valuable platform/guide to practitioner and investors.

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Abbreviations

3Cs	Carbon-Centered Comprehensive
B/C	Benefit-Cost
BAU	Business-as-Usual
BIM	Building Information Modeling
BINT	Bio-Nano-Information Technology
BIT	Bus Information Terminal
BSI	British Standard Institute
CBA	Costs and Benefits Analysis
CBI	Confederation of British Industry
CBS	Carbon Banking System
CCPP	Climate Change Preparation Projects
CCTV	Closed-Circuit Television
CDM	Clean Development Mechanism
CDMEB	CDM Executive Board
CER	Certified Emission Reduction
CH_4	Methane
CHP	Combined Heat and Power
CHP/DH	Combined Heat and Power/District Heating
CO_2	Carbon Dioxide
COP22	Conference of the Parties to the United Nations Framework Convention on Climate Change 22
CPS	Cyber-physical Production System
CSF	Connected Smart Factory
CT	Carbon Trust
CTCN	Climate Technology Centre and Network
DNA	Designated National Authority
DOE	Designated Operation Entity
DSS	Decision Support System
DT	Data Technology
EC	European Community

ECBA	Extended Cost-Benefit Analysis
EE	Energy Efficiency
E-grid	Energy Grid
EIA	Environmental Impact Assessment
EMIS	Environmental and Ecological Management Information System
EP	Environmental Profile
EPA	Environmental Protection Agency
ESS	Energy Storage System
ETS	Emission Trading Scheme
EU	European Union
EV	Electric Vehicle
FCEV	Fuel Cell Electrical Vechicle
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GI	Green Infrastructure
GIS	Geographic Information System
GPC	Global Protocol for Community-scale Greenhouse Gas Emissions
GPD	GHG Projection Diagnostics
GPS	Global Positioning System
GSA	Great Suva Area
GWP	Global Water Partnership
HFC	Hydro Fluro Carbon
ICT	Information and Communication Technology
ICZM	Integrated Coastal Zone Management
IDC	Intelligent Digital Connections
IDMP	Integrated Drought Management Program
IoE	Internet of Everything
IoT	Internet of Things
IP	Indigenous People
IPCC	United Nations Intergovernmental Panel on Climate Change
IPS	Indoor Positioning System
ISDR	United Nations Secretariat of the International Strategy for Disaster Reduction
ISO	International Organization for Standardization
IT	Information Technology
IUTC	International Urban Training Center
IWRM	Integrated Water Resources Management
JI	Joint Implementation
KECO	Korea Environment Corporation
KEI	Korea Environment Institute

KLC	Korea Land Corporation
KOICA	Korea International Cooperation Agency
KP	Kyoto Protocol
LC_2	Livable Cities Initiatives
LCE	Low-Carbon Economy
LED	Light Emittig Diode
LED	Low Emission Development
LEDS	Low Emission Development Strategy
LEED	Leadership in Energy and Environmental Design
LFG	Landfill Gas
LID	Low Impact Development
MAB	Man and Biosphere
MEET	Munster Electrochemical Energy Technology
MKWD	Metro Kidapawan Water District
MP^2D	Methods, Procedures, Planning and Development
MR	Monitoring Report
MW	Megawatt
N_2O	Nitrous Oxide
NAMA	Nationally Appropriate Mitigation Action
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organization
NIMBY	Not In My Back Yard
NMM	New Market Mechanism
NO_x	Nitrogen Oxide
NYCDEP	New York City's Department of Environmental Protection
NYU	New York University
OECD	Organization for Economic Co-operation and Development
OLED	Organic Light Emitting Diodes
PAHD	Public Authority for Housing Development
PDD	Project Design Document
PHEV	Plug-in Hybrid Electric Vehicle
PIMFY	Please In My Front Yard
PoA	Program of Activities
PPP	Public–Private Partnership (P3s)
PUD	Planned Unit Development
PV	Photovoltaic
R&D	Research and Development
RC	Reverse Carboning
RE	Reverse Engineering
RFID	Radio Frequency Identification
SC	Smart City
SCAM	Smeared Concentration Approximation Method
SCS	Sustainable Community Strategy
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment

SMG	Seoul Metropolitan Government
SNU	Seoul National University
SWG	Smart Water Grid
SWOT	Strength, Weakness, Opportunity, and Threat
t	Ton
TD-SOS	Transdisciplinary Systems-of-Systems
U-CDM	Urban Clean Development Mechanism
UK	United Kingdom
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
Vi-world	Virtual World
VR	Virtual Reality
WCCD	World Council City Data
WTO	World Trade Organization
ZED	Zero Emission Development

Introduction

The Smart City for Integrating Climate and Disaster Risk Considerations into Urban Planning

Key Areas to Implement our Sustainability Goals: Smart, Inclusive, and Green Growth

Climate change is the term commonly linked to the issue of global warming and cooling resulting from the increased emissions of GHG. The term *climate change* refers to any distinct change in measures of climate lasting for a period of time, that is, major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer (Momoh 2012). Climate change may result from the following:

- Natural factors, such as changes in the Sun's energy or slow changes in the Earth's orbit around the Sun.
- Natural processes within the climate system, for example, changes in ocean circulation.
- Human activities that change the atmosphere's composition (e.g., burning fossil fuels) and the land surface (e.g., cutting down forests, planting trees, and expanding cities and suburbs).

Global warming is an average increase in temperatures near the Earth's surface and in the lowest layer of the atmosphere. Increases in temperatures in the Earth's atmosphere can contribute to changes in global climate patterns. Global warming can be considered part of climate change along with changes in precipitation, sea level, and so on.

Global change is a broad term that refers to changes in the global environment, including climate change, ozone depletion, and land-use change.

The key implications of climate change include the following:

- Energy: Increased temperatures will cause an increase in energy bills as consumers use more air-conditioning.

- Health: Extremes of temperature such as excessive and long-term exposure to heat will contribute to disease.
- Agriculture and wildlife: Irregular weather variability implies lack of proper water supply, and increased temperature may result in worsening crop production and, ultimately, rising food costs.
- Water resources: Temperature and weather irregularity increase the possibility of flooding and droughts and impact the quality and availability of global freshwater supply. As the water supply is affected, farmers will need to irrigate crops.

Pope Francis warns about climate change. He said it is a moral issue because it affects the poor. The sense of urgency is needed.

On 10 September, 2014, the UN General Assembly has adopted a resolution that paves the way for the incorporation of sustainable development goals into the post-2015 development agenda. In adopting the "Report of the Open Working Group on Sustainable Development Goals (SDGs) established pursuant to General Assembly resolution 66/288," the Assembly decided that the Open Working Group's outcome document would be the main basis for integrating the SDGs into the future development agenda.

The resolution states that other inputs would also be considered during the intergovernmental negotiation process at the upcoming General Assembly session.

At the opening of the 69th session of the General Assembly on 16 September, the body's new President, Kahamba, Kutesa, declared the theme of the 2014 general debate "Delivering on and implementing a Transformative Post-2015 Development Agenda" and said the framework must strive to eradicate poverty and hunger and promote sustained and inclusive economic growth. The Post-2015 SDG has been formally adopted by the UN General Assembly in September 2015.

Officials from 175 countries signed the Paris Agreement on climate action in New York City on Friday (22 April, 2016), signaling a crucial milestone in international efforts to combat climate change. Very recently, the USA and China have confirmed their ratification of historic Paris Agreement, tipping the balance in favor of a quick entry into force of the Agreement by the end of 2016. Finally, it has been enforced on 4 November, 2016. So far, 87 countries have ratified the Agreement. This Agreement encourages the ratified countries to prepare the Low Emission Development Strategy (LEDS) and Nationally Determined Contribution (NDC).

The climate smart city planning can be used as a sustainable tool for green economic development with particular emphasis on climate resilient and low-carbon cities within the broad framework of the sustainable development goals.

Integrated Approach to City Climate Planning and Design: Smart Connect-tech Business for Planning and Scientific Imagination, and Technological Advancement to Avoid Climate Impacts

What sort of changes in the current planning, management, and governance of humans settlements are needed to face the changing environment including the climate change and increasing disaster risks in cities?

A city's structure is the spatial pattern of its differentiated parts and functions, and its physiology deals with the interaction that occurs between these specialized units. Spatial planning is an important tool for integrating environment and disaster considerations into development plans (UNEP/ISDR 2008).

Current urban planning system, however, proves to be limited to coordinate its cross-sectoral or cross-cutting plans efficiently and systematically with the sustainable development agenda. Multi-sectoral development-oriented zoning can enable governments and other stakeholders to assess possible land-use options for development and to choose the best options on the basis of possibilities, limitations, and values derived from the application of the GIS and GPS techniques.

Poverty issue is critical in choosing the best options for zoning. Poverty contributes to both environmental degradation and vulnerability to hazards and should be addressed accordingly.

Measures to reduce poverty include agricultural expansion, which may require wetlands to be filled, and activities in coastal areas, such as shrimp farming, that considerably degrade the environment or change the entire ecosystem. It is therefore vital that causal link between development, disaster risks, and environmental degradation is recognized in poverty-reduction activities (UNEP and ISDR 2008).

It is predicted that about 50 billion machine-to-machine connections will be achieved by 2020. Bearing in mind that people are becoming more connected than ever, 5 billion people have mobile devices, the usage is increasing, and the ICT infrastructures have been capable of sharing information on every front; together, they can help us monitor energy, resource efficiency, and impact of emissions through enabling energy efficiency, in sectors such as land use, energy, industry, water, waste, and buildings.

Therefore, ICT, which is the connect-tech, can facilitate controlling climate change attributes when deployed with appropriate ingredients and composition. Smart city planning model compositions for climate resilient and low-carbon cities not only entail usage of ICT infrastructure but also associated past, present, and future knowledge bases for carbon reduction and disaster risk management techniques to be developed in a holistic manner.

Main context-aware challenges and attributes that are to be considered in this book are the scenarios with regard to rapid urbanization, global warming, hyper-growth, new value creation, and rapid adoption rate of digital infrastructure.

There are new opportunities to combine the existing smart city (SC) models and climate resilient and low-carbon city models with the help of the evolution of the Internet and availability of low-cost real-time digital technology, tools, and infrastructures. However, this transformation has to start with willingness to address climate and low-carbon development.

These techniques could be used to improve the efficiency, sustainability, circularity, resiliency, and connectivity of policy, planning, technology, governance, and economic tools designed for climate resilient and low-carbon cities. They could

contribute to build a new urban industrial ecosystem based on new types of information.

Smart city planning for climate resilient and low-carbon cities incorporates strategic urban growth while keeping under control (or reducing) greenhouse gas (GHG) emissions for green growth benefits through the automation and Internet control system technology development to GHG emissions and climate change adaptation.

ICT such as virtual reality technique is helping to achieve sustainable development goals in human settlements. It is time to act to incorporate smart city concept with ICT into climate resilient and low-carbon city planning and development with a package program for networked connections of people, urban structure and process, and knowledge data.

Building "Big Data" and "Cloud Sourcing" infrastructure is another crucial area as city information base for "Low-Carbon Smart Cities: Tools for climate resilience planning."

Smart Solution for "NIMBYism": Urban Climate Governance for "PIMFY"

Smart city planning is an important means of promoting stakeholder engagement to drive climate action.

In 2008, the city of Gwangju, Korea, has adopted the carbon banking system which is a voluntary GHG reduction campaign in the manner of governance approach to climate change at the household level. In this system, the consumption of electricity, city gas, and drinking water is digitally monitored through the respective meters in each household. The results of monitoring can be used for reporting, verification, and certification (MRV) process of the carbon banking system.

It is a public–private partnership (PPP) project. This project has seen as a collaborative and collective effort among many stakeholders including city government and private consulting company.

They developed the operating system which maps out main steps of carbon banking system together with the roles of main actors. These actors are engaged in the carbon banking process. The process starts with signing ceremony for Agreement on the carbon smart model city between central and local governments, and ended up with issuance of carbon points by private banks.

Niederberger (2014) states that, in current practice, stakeholder engagement frequently encouraged in two contexts:

- as an element of good governance (normative justification), with citizens typically in the role of watchdog, ensuring government;
- to facilitate the performance of government functions (instrumental justification), with citizens as more or less active participants, which has been greatly facilitated by the Information and Communication Technology (ICT) revolution and better access to information.

For the operating system of carbon banking system, the emphasis has been on the exercise of citizen as participants and stakeholders as partners.

Behavioral engineering is intended to identify issues associated with the interface of technology and the human operators in a system and to generate recommended design practices that consider the strengths and limitations of the human operator (Wikipedia 2015)

People's changing attitude toward potentially harmful landfills being located near homes is best exemplified by the landfill cases. The smart landfill operation to generate electricity with methane gas from landfill site is a good example.

The modern climate smart technology helps the public be aware that the hazardous materials would not pose threats as long as they are properly treated and managed with ICT, and produce harm to the surrounding community. Information technology (IT) and data technology (DT) help these things a lot.

Environmental racism is another critical climate issue. Ethical implications of NIMBYism are apparent in the poor community where action is not taken by the government for years.

The disproportionate environmental burden placed on low-income, minority communities is due to the disparity in access to political power and decision making (Wikibooks 2015).

City-Minded International Cooperation: Climate Planning-oriented New Urbanism and Climate Diplomacy

Then, the next question would be "how cities are working together with their international partners to study, teach, and implement climate planning methods and tools into their city's framework."

The Post-2015 sustainable development goals (SDGs) are now becoming an international norm for the "climate diplomacy." Goal 11 encourages member states to make cities and human settlements inclusive, safe, resilient, and sustainable. Furthermore, 11a suggests that, by 2020, they will increase the number of cities and human settlements adopting and implementing integrated policies and plans toward inclusion, resource efficiency, mitigation and adaptation to climate change, and resilience to disasters.

Nowadays, many cities clearly see addressing city climate change as a way to drive growth and competitive advantage in their jurisdictions.

Addressing climate change will lead to development of new business industries in cities. This is the most commonly cited economic opportunity for many cities.

The climate change-related report entitled "The Colour of Growth" published by the Confederation of British Industry (CBI) states that environment-friendly approach to British industries is necessary for growth. Low-carbon economy creates the value of $5,000 billion every year all over the world, which is more than the rate of world GDP growth.

Cities can adopt a variety of strategies for attracting new businesses. Two strategies that cities frequently mention are clustering and incentivizing new business. The clean-tech clusters focus on companies and technologies related to sustainable transport and sustainable energy, but also water and solid waste

technology. Many cities are actively recruiting new companies with tax reduction, spaces, and other incentives.

It is clear that attracting new businesses and investing in redevelopment, energy savings, sustainable transportation, and other green infrastructure will improve the quality of life for citizens, relaunch the economy, and create new green jobs in cities.

This movement motivates the emergence of "climate planning-oriented new urbanism" inspired by the new type of city-minded international cooperation and emergence of global ICT companies. Climate diplomacy, green growth and green economic development, connect-tech development, and new climate economy have played important roles in promoting climate-oriented new urbanism.

New urbanism is an urban design movement which promotes walkable neighborhoods containing a range of housing and job types. It helps citizens reduce energy consumption and subsequently reduce greenhouse gas (GHG) emissions.

It arose in the USA in the early 1980s and has gradually influenced many aspects of real estate development, urban planning, and municipal land-use strategies.

Now, it is time to look at how the climate development and knowledge base influence urban planning and design.

Our task now is to mainstream city climate planning into urban planning policy. This is only possible by creating the planning conditions necessary to integrate the full effects of climate change into the urban planning process. Creating these conditions involves looking at the importance of climate diplomacy in the negotiations. This work has been focused on how a truly global, ambitions, and legally binding Agreement to limit emissions can be achieved at the city scale. The UK's Foreign Secretary, William Hague, has said "Climate change is perhaps the twenty-first century's biggest foreign policy challenge" (Fig. 1).

Fig. 1 Elegy for the North Pole performed in glacier: Warning of global warming. *Source* Chosun Daily Newspaper, A1, No. 29688, 21 June, 2016

Several New Urbanists have popularized terminology under the umbrella of the New Urbanism including sustainable urbanism, tactical urbanism, ecological urbanism, and landscape urbanism. This book promotes what the author describes as a variant of the New Urbanism called the Climate Urbanism, which is intended to be a more climate-oriented.

It promotes the principles of climate resilient and low-carbon smart cities, including:

- Consider the intrinsic suitability of land by smart zoning of certain areas;
- Create digitally connected smart urban form for the resource and energy efficiency with smart energy grid;
- Manage ground and surface water resources to achieve the right balance between the needs of society and requirements of the environment through the integrated water resources management with smart water grid;
- Implement district energy projects with smart heat grid;
- Mange natural and human-induced disasters, and control flood plain and flood risk for the benefit of people and the natural environment and the protection of property;
- Maintain and, where possible, improve the quality of air, land, and water through the prevention and control of pollution, and by applying the "polluter pays" principle;
- Achieve reductions in waste through minimization, reuse and recycling, and improved standards of handling and disposal;
- Conserve and enhance the natural, cultural and historic value of the city, its landscapes, and biodiversity for ecotourism;
- Retain, improve, and promote coastal areas for the purpose of coral reef conservation, appropriate recreational use, and public access and enjoyment;
- Reduce Greenhouse Gas (GHG) emissions through climate change mitigation measures, and
- Promote green infrastructure development in a holistic integrated manner.

The term "climate urbanism" is used to signify smart city efforts, but it includes human settlement development issues for the Post-2015 Development Agenda and SDGs.

The term "climate resilient and low-carbon smart cities" is used as an alternative to the term "eco-cities" for resiliency, efficiency, circularity, sustainability, and connectivity. It may be regarded as the new model of eco-city development planning and development with particular emphasis on urban climate issues. This book assesses how climate resilient and low-carbon smart city planning differs from conventional city planning (Fig. 2).

The need for the climate resilient and low-carbon cities with Intelligent Digital Connections (IDC) can be justified through existing programs such as IBM, CISCO, and World Bank programs.

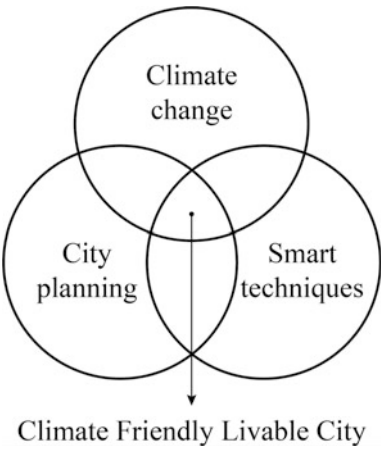

Fig. 2 Three pillars of climate smart city

The World Bank has an active work program in the areas of cities and climate change, smart cities with ICT, and also more broadly in the area of sustainable cities. It also promotes the Urban Climate Planner Certification System (World Bank Task Force to Catalyze Climate Action 2014).