UNDERSTANDING AND EVALUATING SUSTAINABLE URBAN TRENDS: CASE STUDIES FROM CHINA AND JAPAN

(SUMMARY)

By

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DECLARATION

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ABSTRACT

The advent of the Brundtland's Report *Our Common Future* in 1987 and the successful launching of the Rio Earth Summit in 1992 has built international consensus on "sustainability" as a new paradigm for development. The development of "eco-cities" has become an international phenomenon for the creation of more sustainable urban areas. Subsequently, the negotiation of the Kyoto Protocol in 1997 supported another global wave of "low-carbon cities" development. Additionally, since the early 2000s, the development of information and communication technologies has become the impetus for an innovation-oriented sustainable urban trend known as the "smart cities". However, despite the enthusiastic advancement of these new urban models worldwide, there is still a lack of consensus regarding systematic approaches or methods for the standardization and evaluation of these trends.

This thesis aims to investigate and examine three global trends of sustainable cities with case studies from China and Japan, in both quantitative and qualitative perspectives, to understand their defining features and components. Furthermore, this thesis intends to propose and develop a methodical approach for the evaluation of these urban development models to have flexibility in relation to local inputs, and applicability to other similar urban initiatives or projects.

For the "eco-cities", this thesis reviews studies regarding concepts, frameworks and indicator systems, A large amount of literature on the selection of indicators under a singular framework in China is observed rather than having a quantity comparison from a broader scope. To obtain a quantitative sense of how effective China's eco-cities are compared to other best practice in the international arena, two cases from China and Japan have been selected to examine their indicator values under the national eco-city framework of China. Gaps between economy related indicator values are identified, suggesting lower average economic values and energy efficiencies of Chinese eco-cities. Targets concerning the waste sector are also lower for China than in Japan. The environmental indicator values show lower levels than in the other two cases as well, while social indicators entail a specific methodological approach for measurements in China. Suggestions are made in the discussion section based on the outcomes of the aforementioned comparisons, to provide a reference for the future development of other eco-cities.

The ensuing study on low-carbon cities employs a qualitative view of these policies such as "garden city" to "low-carbon city" to determine the how the environment-related urban environmental policy developed during different periods in China. Case studies of leading low-carbon cities are examined and analyzed to obtain insights regarding their urban

environmental policies as well as the implications of their successes and limitations. The major findings indicate that government policy and financial support played a significant role in transforming the industrialized city of Kitakyushu into a center of low-carbon sustainable practices in Japan's case. Local autonomy and flexibility in policymaking and civic participation profoundly contributed to the successful switch to renewable energy. These experiences could serve as useful references for China's low-carbon city development from different perspectives.

Next, the literature regarding smart city phenomena is thoroughly reviewed. Despite a lack of universal consensus, there seems to have been two major streams of SC concepts with overarching strategies for comprehensive SC development, with specific focuses on utilizing information and communication technologies to improve the quality of life. Key features and components of smart cities are then summarized, consolidated into a proposed framework consisting of two main objectives, six domains, and two means for implementation. Furthermore, a customized smart city index for the City of Kitakyushu in Japan is proposed as a case example for the application of the proposed framework. The outcomes of this section provide new approaches for understanding smart city concepts and evaluating the on-going smart cities in Japan and potentially in other countries.

As a continuation of the previous section, a further refined selection of indicators from the proposed smart city index based on stakeholder inputs from Kitakyushu City is conducted. These indicators are then weighted by expert opinion surveys using the analytical hierarchy process (AHP) method. This weighted smart city index can be useful for prioritization of policy implementation or selection of key performance indicators (KPIs). More importantly, this integrated approach consisting of three main steps from conceptual understanding to index development and indicator weighting is found to be customizable and potentially applicable to other urban development models in different local settings. This finding would contribute to a more insightful understanding of sustainable urban projects and their evaluations for policy makers, urban planners and city managers.

The findings and outcomes of this dissertation contribute to the existing literature on urban sustainability with elaborated studies on "Eco-city", "Low-carbon City" and "Smart City" in terms of comprehension and evaluation. The conceptualized integrated method for urban development evaluation can offer practical references for policy makers, and urban managers, as well as to academia for further research.

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Confucius once said, “At fifteen, I set my heart upon learning. At thirty, I planted my feet firm upon the ground.” In my case, I didn’t know just how little I knew at fifteen. At thirty, I now know that I know little, especially upon the completion of this dissertation. Pursuing a PhD is perhaps the most challenging endeavor I have undertaken, and it would never have been remotely possible without the help, support and encouragement from these people in my life.

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DEDICATION

To my most beloved father, who passed away on July 11, 2016

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ACRONYMS

ACEF	ACEF
AHP	AHP
AHP	Aggregated Weights
BOD	Biochemical Oxygen Demand
CAS	Chinese Academy of Sciences
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
CR	Consistency Ratio
EIU	Economist Intelligence Union
EU	European Unions
EV	Electric Vehicles
GCR	Group Consensus Ratio
GDP	Gross Domestic Product
GHG	Green House Gases
ICE	International Electronic Commission
ICT	Information and Communication Technologies
IGES	Institute for Global Environmental Strategies
ISO	International Organization for Standardization
KPI	Key Performance Indicators
MAB	Man and Biosphere
MAUT	Multi-attribute utility theory
MEP	Ministry of Environment Protection
METI	Ministry of Economy, Trade and Industry

MoC	Ministry of Construction
MHURD	Ministry of Housing, Urban-Rural Development
NAIADE	Novel Approach to Imprecise Assessment & Decision
NDRC	National Development and Reform Committee
NGO	Non-Governmental Organization
NO2	Nitrogen Dioxide
NPO	Non-for Profit Organization
OECD	Organization for Economic Co-operation and
P	Prosperous
PM10	Particulate Matter of 10 Microns in diameter or smaller
PM2.5	Particulate Matter of 2.5 Microns in diameter or smaller
PPM	Parts Per Million
QoL	Quality Of Life
RGMM	Raw Geometric Mean Method
SC	Smart City
SEG	System Evaluation Group
SO2	Sulfur Dioxide
UN	United Nations
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural

1 INTRODUCTION

1.1 Background of Research

Twenty-five centuries ago, the great philosopher Aristotle defined cities as "Built Politics". In the 21st century, cities are the most complex and dynamic eco-systems globally and the centers of scientific, cultural and social innovations (Glaeser, 2011; Hall, 1998), yet still face human-lead, dynamic and shifting challenges (Mega & Pedersen, 1998). The recorded history of human civilization can also be identified as the process of globalization and urbanization (Calderoni et al., 2012).

According to the United Nations (UN), the global population reached 7.2 billion in 2013 and is expected to reach 8.1 billion by 2025, and 9.6 billion by 2050. More than half of them (53% in 2015) are living in urban areas, and the urbanization rate is expected to reach 59.9% by 2030, and 67.2% by 2050 (United Nations, 2015). Continent-wise, the highest urbanization rates are seen in North America (81%), Latin America and the Caribbean (80%), Europe (73%), and Oceania (70%) while Asia and Africa's urbanization rates are still below the world average with 47% and 40% perceptively (United Nations, 2015).

The promising prosperity of civilization that advanced alongside fast urbanization also brought devastating "side effects" for human societies such as resource scarcity, energy crisis, eco-and-environmental hazards, climate changes related disasters, slums, poverty, pandemic and the list goes on. Particularly the developing countries in Asia and Africa are experiencing the world's worst urban environmental pollutions, and this poses enormous threat to human health. The United Nations Environmental Programme (UNEP) estimated that urban air pollution causes one million premature deaths each year and costs 2% of the GDP in developed countries and 5% in developing countries (Fook & Gang, 2010, p. 2).

Long before the creation of modern days' environmental urban policy, great visionaries like Ebenezer Howard (1850-1982) had already appealed for a new way of harmonious human nature relationship – the "Garden City" (Imura, 2010). As global consensus gradually aligned on the realization that "business as usual" development mode could no longer guarantee the effective long-term prosperity for human societies, the pursuit of a different paradigm for development has been explored continuously, particularly in the urban development context.

The subsequent mergence of "New Towns" of the UK spread around the world and shaped the modernist urban planning doctrine during the rapid urbanization after the Second World War (WWII). The Ecological Modernization (EM) was developed as a macro-theoretical model addressing the importance of sustainable development that emerged at a later stage. Other concepts like "Regenerative Development" and "Positive Development" also presented different approaches in addressing more effective ways to plan and develop cities from complex social, ecological and physical challenges in the urban sphere(Boğaçhan, 2016).

Two significant publications in the 1970s and 1980s initiated and accelerated the global consciousness on "sustainable development" or "sustainability", namely, the Club of Rome's *Limits to Growth* (Meadows et al., 1972) and the Brundtland Commission's Report *Our Common Future* (World Commission on Environment and Development, 1987). The first one, though comparatively less acknowledged than the later one, presented from an historical point of view the arguments made by Thomas Malthus in a modern context regarding population overgrowth, and the excessive burdens imposed on ecological limits of agricultural products leading to the consequently depopulation. And over one decade later, the Brundtland Report brought forth the concept of "sustainable development" which, though vague in definitive terms, heated up the conversations and dialogues in the world's forums for leaders of the globe (Holden et al., 2008).

Later in 1992, when the United Nations Conference on Environment and Development (also known as the "Earth Summit") took place in Rio de Janeiro, "sustainable development (or sustainability)" became the core principle for urban and environmental developments. After the ratification of the Kyoto Protocol (and a range of subsequent international conventions) by the majority of countries in 1997, "low-carbon" became a "new norm" for sustainable development. These international conventions and protocols have given rise to some new global trends for urban development such as "Green City", "Eco-City", and

“Low-carbon City”, with the most recent urban trend under the information era – known as the “Smart City”.

Post-colonial urban theory emphasizes that cities vary in shapes, sizes and forms with distinctive cultural and historical backgrounds. Therefore urban development needs to be framed into local context and contents. Though seeking universality in single sustainable urban framework or indicator set may appear dimly possible, having a certain flexible and customizable method or approach that is subject to locality would presumably benefit project developers and stakeholders.

Numerous sustainable city (or urban) projects, initiatives and programmes have been developed or being pursued on globally. They vary in geographical features, socio-demographic contexts, and implementation scales. On the one hand, various organizations, institutes and scholars have spent great efforts in developing relevant concepts, frameworks or indicator systems (or index) under the broad sustainability framework: on the other hand, there is not yet any single or universally accepted framework that applies to all the different conditions of various regions.

This thesis aims to examine the three most recent urban development trends, namely, “eco-cities”, “low-carbon cities” and “smart cities” under an East Asia setting. China and Japan are selected as the two major case study areas (with other international references) to provide better understandings of these urban trends regarding concepts, frameworks and evaluation method such as indicator systems or indexes. And finally, a method or approach with high customizability from local context is proposed based on the previous steps taken. This thesis would fill in the existing research gap of lacking such method in understanding and evaluating urban trends, and shed some light on meaningful and practical methodologies for urban studies.

1.2 Thesis Objectives and Research Questions

The sustainable urban development trend or sustainable cities continuum manifest an array of different concepts, models and categories. Concepts like “Garden Cities”, “Green

Cities", "Eco-Cities", "Low-carbon Cities", "Intelligent Cities", "Smart Cities" and many more can all be regarded as part of the overarching "Sustainable City" metanarrative.

The objectives of this thesis, besides answering the research questions, are to distill or propose a customizable and pragmatic method or approach for understanding the urban development trends and their evaluations. The outcomes of this thesis would provide some insightful references in translating the urban policy goals and objectives into reality with different local conditions.

This thesis revolves around two overarching research questions distilled from this era of urban sustainability seeking and discerning, namely,

1) **How to understand sustainable urban development trends such as "eco-city", "low-carbon city" and "smart city" in specific local contexts;**

2) **How to analyze and evaluate these sustainable urban trends using a proper methodical approach with local and regional inputs.**

To answer these two major research queries, a set of subsidiary questions was developed under the urban sustainable trends selected for this thesis. These urban trends can be developed into two parts according to their chronological occurrence and relevance. The first tackles the topics of "eco-city" and "low-carbon city"; the second part discusses and analyzes "smart city" and the "evaluation scheme or method". The following arrangement of questions have been embedded in each chapter to navigate the research flows of this thesis. The specific research questions are detailed in their corresponding chapters:

Regarding "Eco-cities"

- What are "eco-cities" in terms of origin, concept, frameworks and indicator systems? And what is the current status of eco-city development in China and Japan?
- Given the many studies regarding eco-cities, how exactly are China's eco-cities performing compared to other best practices on a global stage?

Regarding "Low-carbon Cities"

- What constitute "low-carbon cities" and their development status globally? And what is the current status quo of developing low-carbon cities in China with international references.
- What could be the implications or references from international examples for China's?

Regarding "Smart Cities"

- What is the current status quo of "smart cities" given their infancy stages as the newest global trend for urban development?
- Given the diversity in its interpretation, are there any common features that smart cities should incorporate or mutual framework for its comprehensions?

Regarding "Evaluation Scheme or Methods"

- What are the current evaluation systems for smart cities, and how are they evaluated?
- What could be effective methods or mechanism for smart city index or indicator systems for evaluating smart cities or other sustainable cities?

1.3 Adopted Methodologies

There are several methods adopted and applied for the four major research packages included in Chapter 3 to Chapter 6. The specific steps and descriptions are detailed in each chapter; here I generally summarize the major methodological approaches:

In Chapter 3, I first conduct systematic reviews of eco-cities regarding definitions, frameworks, indicators and related works both abroad and in China. I take a quantitative approach for comparing and analyzing China's eco-city standards with a best-practiced case study from Japan, to obtain a quantified sense of their performances for later policy analysis and recommendations. The data used for these comparisons are from governmental records and documents, official statistics, in some cases, interviews are conducted for specific information or data that are not available through published records.

Chapter 4 starts with an in-depth review of the low-carbon city and its relative development status quo focused in China and Japan. Another Case of a German City is included as comparison. Different from the previous chapter, a qualitative approach is adopted for answering my research questions. Field trips are conducted for data collection, in-person interviews for case study analysis, based on which, a series of policy recommendations is proposed regarding the low-carbon city developments in China. Secondary data were also used in the absence of primary data for analysis.

The next two chapters (5 & 6) take an integrated approach combining both qualitative and quantitative methods. After thoroughly reviewing the literature on smart city concepts and framework, and a policy analytical pool is then applied to analyze them. Based on these results, an encompassing conceptual framework is proposed and applied with a case study in Japan. I then propose an index with carefully designed indicator identification and selection and steps, and establish a compete index for smart city evolutions. Then I conducted an experts survey for quantitatively weighting of the indicators. And finally, the approaches and steps taken were summarized into an integrated method for the evaluations of sustainable urban development models.

Literature and data are from peer-reviewed publications, and published governmental or organizational records with high credibility. Primary data for the indicator selections are collected in workshops of local stakeholders in Kitakyushu City. Indicator weighting were calculated by the excerpt survey results.

1.4 Structure of the Dissertation

The remaining parts of this dissertation are arranged and summarized as follows:

Chapter 2 reviews the major works, theories and thoughts regarding urban studies in general, and concepts and development of the studies or researches on eco-cities, low-carbon cities, and smart-cities. This chapter offers general information regarding both theories and current practices of the topics enlisted in the thesis.

Chapter 3 investigates the urban policy frameworks and the current practices in China's major cities, with comparative introductions between the past standards of Chinese eco-cities and that of the current ones, on both national and provincial levels. Furthermore, this chapter compares the eco-city standards with the Suzhou Case in China and an international acknowledged Japanese eco- city of Kitakyushu by analyzing the key indicators from selected eco-city case studies.

Chapter 4 reviews these policies with particular focus on the "low-carbon" cities in China. Additionally, two case studies of Kitakyushu city in Japan and Rhein-Hunsrück District in Germany are examined and analyzed to obtain enlightening factors in terms of their urban policies as well as the references and implications from their successes and limitations. These experiences could offer insightful references to China's low-carbon urban developments from different perspectives.

Chapter 5 summarizes the key features and components of smart city and proposes a conclusive framework for smart cities that consists of double-objectives, six domains and two means for its realization. Furthermore, this chapter proposes a customized indicator system based on the SC framework for measuring the "smartness" of the smart cities in Japan, and includes a case study of the city of Kitakyushu. The outcome of this chapter provides some new insights to the methodological approaches adopted to assess the on-going smart city initiatives in Japan.

Chapter 6 further improves the proposed smart city conceptual framework of Chapter 5. Under this framework, I have further refined the selection of smart city indices based on the inputs from the stakeholders in the City of Kitakyushu. Revisions and modifications have been made to the proposed SC Index. The Analytical hierarchy process (AHP) is applied for the weighting of indicators by experts' survey. Finally an integrated approach is recognized as the outcome. This integrated approach is found to be highly customizable and adoptable for potential applications to other urban development models in different contexts for both framework development and index composition.

Chapter 7 summarizes the major findings of the thesis and denotes the contributions and significance of the research outcomes as well as the limitations for each conducted topic. Further discussions are conducted and the possible perspectives and directions are pointed out for future research.

2 REVIEW OF LITERATURE

This chapter [1] reviews some prominent urban theories are claimed to be the fundamental frameworks of the urban studies discipline. Major definitions and concepts, frameworks and historical developments, as well as major and influential studies are reviewed regarding a range of topics from Garden City to Eco-Village and Eco-City, from Low-carbon City to Smart City. Due to the arrangement of the thesis, additional and more specific reviews of literature are conducted in subsequent chapters.

[1] Some of the contents regarding eco-villages and low-carbon cities from this chapter have been published as two book review articles in the journal *Asia Pacific World (Zou, 2015a, 2015b)*.

3 ECO-CITY DEVELOPMENT IN CHINA: INTERNATIONAL PERSPECTIVE AND COMPARISON

China's growing international dominance and influence has been witnessed and acknowledged across the world. But its annual GDP growth contributed by rapid urbanization and industrialization comes with severe environmental costs, especially in urban areas. Determined not to repeat some industrialized countries' mistake of "treatment of environment comes after the development of economy", China has set up a number of laws and regulations to safeguard the sustainable development in urban areas. Eco-city development is one of the early national attempts in curbing the derailed urbanization trajectory.

This chapter[2] reviews the urban policy frameworks and current practices in China's major cities, with the comparative introductions between the past standards of Chinese eco-cities and that of the current, on both national and provincial levels. Furthermore, this chapter compares the existing eco-city standards with international acknowledged examples in Japan and Germany by analyzing the key indicators from selected eco-city case studies.

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[2] Based on this chapter, a journal paper has been published as Zou, X. & Li, Y. (2014). "How 'Eco' are China's Eco-Cities: An International Perspective", *International Review for Spatial Planning and Sustainable Development*, 2(3), p18-30.

4 LOW-CARBON CITY DEVELOPMENT IN CHINA: LESSONS AND REFERENCES FROM OTHER COUNTIRES

Succeeding the global urban trend of eco-city development, the low-carbon city became the next “norm” for a new trend of urban development towards sustainability. “Low-carbon” has become the very core element of this wave. To pursue the urbanization in a sustainable and low-carbon manner, the Chinese government has strenuously enacted an array of corresponding urban policies. This chapter[3] reviews these policies with particular focus on the “low-carbon” cities in China, and finds that China’s major objective towards low-carbonization is to reduce CO2 emissions with proper adaptation plans. A strong focus is placed on governmental interventions that result in positive civil effects regarding carbon reduction. Additionally, two case studies from other countries are introduced to offer lessons and references for China’s low-carbon city development.

[3] Bases on this chapter, a paper has been published as Zou, X., & Li, Y. (2015). “Developing Tailor-Made Urban Environmental Policies for China’s Low Carbon Cities - Implications from Japan and Germany”. In Feng, S., Huang, W., Wang, J., Wang, M. & Zha, J. (Eds.), *Low-carbon City and New-type Urbanization.* (pp. 273-284): Springer Berlin Heidelberg. .

5 UNDERSTANDING SMART-CITY DEVELOPMENTS: A NEW FRAMEWORK AND ITS APPLICATION IN JAPAN

The Smart City (SC) concept is a new global trend for urban development, and is now gaining incremental popularity worldwide. Through an extensive literature review, it is found that despite lacking universal consensus, there have been two major streams of SC concepts with overarching strategies for comprehensive SC developments or with specific focuses on utilizing information and communication technologies (ICT) to improve the quality of life.

This chapter[4] summarizes the key features and components of smart cities and proposes a conclusive framework for smart cities that consist of double-objectives, six domains and two means for its realization. Furthermore, this chapter proposes customized indicator system based on the SC framework for measuring the “smartness” of the smart cities in Japan based on a case study of the City of Kitakyushu (or Kitakyushu City). This chapter provides some new insights to the methodological approaches adopted to assess the on-going smart city initiatives in Japan.

[4] Based on this chapter, a journal paper is to be published as Zou, X., & Li, Y. (2016). “Recapitulating Smart City Concepts: A Proposed Framework and its Application in Japan”. *International Review for Spatial Planning and Sustainable Development*.

6 A NEW EVALUATION APPROACH FOR SUSTAINABLE CITIES: FROM SMART CITY CONCEPT TO INDICATOR WEIGHTING

In this chapter[5], further improvement is made to the proposed smart city conceptual framework as outlined in Chapter 5. Under this framework, I have further refined the selection of indicators based on the inputs from the stakeholders in the City of Kitakyushu. Revisions and modifications have been made to the proposed index. The Analytical Hierarchy Process (AHP) is applied in the weighting of indicators by an expert survey. Finally an integrated approach is developed as the outcome.

This integrated approach is found to be highly customizable and adoptable for potential applications to other urban development models in different contexts for both framework development and index composition. The findings of this study would contribute to a more insightful understanding of the smart city and its evaluation for policy makers, academia, urban managers, and practitioners. Furthermore, this integrated approach can also be adapted to understand and evaluate sustainable cities in general with local inputs.

[5] A journal paper based on this chapter is being prepared for journal submission.

7 CONCLUSIONS

7.1 Chapter Introduction

Human history is somehow a history of urbanization and globalization. Cities are the complex and dynamic systems where the exchanges of information, economic and social activities. With the speed of technology advancement and industrialization, development-led prosperity became a low-hanging fruit for the urbanized sphere, and contributed to the formation of more cities at even bigger scales. In the mean time, urban "illnesses" resulted from the disruptions of ecological system and ambient environment, climate changes, energy and resource crisis, various millennium challenges have devastated human societies on planet earth. A paradigm shift or change is desperately craved and needed from the long-term perspective. Starting from the early UK's urban model of "Garden Cities" in late 1890s, continuous trends of pursuing in the pursuit of sustainable cities, such as "Eco-cities", "Low-carbon Cities" and "Smart Cities" have been seen on a global scale, with incremental momentum in the past decades.

Despite the multitudinous sustainable city projects developed or being undertaken worldwide, there are still gaps in comprehending or understanding the constitutions of these sustainable urban development models. Moreover, the vacancies in systematic approaches or methods for standardizing and evaluating these sustainable movements or urban trends have made developing such projects within urban boundaries quite ambiguous and imprecise in terms of policy implementation and regional replicability. This thesis attempted to answer the overarching questions of how to understand and how to evaluate these sustainable cities of major sustainable urban trends in an East Asia setting, with selected case studies from two leading powers of China and Japan.

Amongst a number of urban categories or development models, three major sustainable urban trends were identified and selected for this thesis, namely, "eco-cities", "low-carbon cities" and "smart cities" based on both academic and country policy relevance. The first identified trend of "eco-cities" is studied in a Chinese context with a comparison of Japan's case, in terms of the concept, definition and indicator systems. The second trend of “low-carbon cities” also focused on China’s situation with two case studies from Japan and Germany for comparison and reference. The third urban global trend of smart cities was framed within the Japanese background for in-depth analysis with case study of the City of Kitakyushu. And an integrated approach from concept understanding to index for evaluation and final weighting of indicators was distilled that can be generalized and applied to sustainable cities in general.

7.2 Research Findings and Contributions

7.2.1 Research Findings

An “Eco-city” can be regarded as the result of the globally reached consensus regarding paradigm shift towards sustainability in urban development. The focus, despite of its vagueness in terms and multifold interpretations, is to rebalance the economic development with ecological and environmental system and solve the “urban illnesses” in our society. Protecting the environmental conditions manifested as one of the core principles of this global trend for sustainable urbanization.

China’s efforts of pursuing harmonious development between human and nature can be traced back to the oriental concept of “Shanshui City”. From analyzing the Chinese Eco-city development, it is observed that China’s Eco-cities aim to promote more sustainable growth regarding economic, environmental, and social aspects as national policies. The focus has begun to weigh in more towards the environment instead of economic development.

However, when compared to regional leading country of Japan, there are a number of categories out performed by the Japanese case in terms of efficiency and performance of energy sector, waste treatment and recycling sector, and pollution emission in particular. This indicates the challenges faced by such a geographically vast country like China with diverse local development levels and having one set of top-down national standards. More importantly, further improving and updating of the relevant guiding policies with more explicitly defined methods is definitely needed.

Low-carbon cities bring forth a more clear and measurable standard or principle "decarbonization" or "low-carbonization" for urban development. This global trend arose as a specific reaction towards the common foe of "climate change" and "global warming" faced by all human kind. And the development of the Kyoto Protocol in 1997 has globalized this "new norm" in urban sustainable developments.

China is currently the world's largest gross GHG emitting country, and Japan ranks the third in GHG emission after China and India in Asia (in 2013). To reduce GHG emissions, they have proposed and developed common but differentiate strategies. China focuses more on "CO2 emission reduction and adaptation plans" with strong government intervention and civil participation. While Japan's focus is on development of "low-carbon society" and "climate change resilience" that facilitated by sound science and technology applications.

Since late 1990s, many noticeable adjustments can be observed in China's urban development trajectory towards sustainability. The quick adaptation of low-carbonization as a national development objective reflects the international response to global warming and climate change. Additionally, a shift from top-down to bottom-up urban policy development approach is seen from the previous Garden City and Eco-city to Low-carbon City in China, due to its gigantic geographic coverage and local geopolitical characteristics.

However, there is still a lack of explicitness in definition or even overlapping in different urban development models. Sometimes, the low-carbon title or the political incentives behind these "environmentally-friendly city" designations outweigh the actual commitment in reducing carbon in the city developments. Also, there are many international practices that can offer excellent lessons or references to China's low-carbon city development.

The "smart cities" trend can be regarded as the most recent urban development model in the information era. With the rapid advancement of information and digitalization, ITCs such as big data and sensors, innovative means for gathering and processing information and data are being developed for city development and management, also known as "big-data based smart urban management".

As the information and digitalization process accelerates in China, smart city development has been incorporated into the national development strategies that features in “the Internet plus extended industries” mode and ICT infrastructure development. While Japan’s digitalization levels are higher than China, therefore Japanese smart city development has it own characters of goals, implementations and evaluation.

After reviewing and analyzing the current smart city concepts and frameworks, I conclude and propose a version conceptual framework for smart city as: “A city pursuing the twofold goal of improving quality of life while simultaneously realizing urban sustainability. The framework’s major contents include both hard and soft urban domains such as “Governance”, “People & Urban Living”, “Economy”, “Infrastructure”, “Energy & Mobility”, and “Environment”. The active involvement of stakeholders and implementation of information and communication technologies (ICTs) are the major instruments for implementation.”

It was then applied in a case study of Kitakyushu City of Japan using a customized Smart City Index consisting of 6 domains, 18 aspects with 36 measuring indicators. This was followed by an expert opinion survey to support an AHP method for indicator weighting. This additional step for indicator development proved to be very informative and useful in the selection of key performance indicators (KPIs) from numerous inventories and the prioritization of indicators for better or effective policy implementation.

In particular, the introduction of AHP as an indicator weighting mechanism or tool provides more rationality in the integration of indicator weights into the proposed index. Despite of certain limitations, the application of AHP in this thesis for expert survey provides some new insights of how “sustainable city” indicators could be further evaluated.

7.2.2 Research Contributions

The most important contribution of this thesis, besides the case studies and the existing body of literature regarding these urban development trends, is the conceptualized methodology (or methodological approach) from conceptual framework composition, to index or indicators selection and index development, to the final indicator weighting that has been distilled from these studies. It can be summarized as follows:

- First, defining the scopes and proposing a framework for urban/city development (i.e. eco-city, low-carbon city, smart city). This is achieved by having reliable sources of policy inputs such as those from the key decision makers or stakeholders, or from highly regarded literature.
- Second, developing an index or indicator system for measurement and evaluation based on the proposed framework. This required us firstly to identify indicator sources under specific goals or objectives, then to conduct a fine selection of supporting indicators based on SMART principles, and finally to integrate them into a complete index.
- Third, weighting or evaluating the proposed indicators using the Analytical Hierarchy Process (or other mathematical methods such as weighted preferences or Z score etc.). This can be realized by identifying expert groups for survey (could also be those people who are have expert knowledge of the intended areas) by questionnaires or workshops. And finally a weight is assigned to each individual indicator.

As an original contribution to the existing approaches for understanding and evaluating urban development, this integrated methodology will contribute to the pragmatic action that are flexible and adjustable with local context for policy and decision makers, urban managers, and key stakeholders from academia and industries.

7.3 Limitations

Urban sustainable development is a topic too broad to tackle or explain in a single dissertation. It can also be a simple term such as “development, which meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Therefore it is vital to consider and study it within proper local frames or boundaries. Due to the scope and research encompassed within this dissertation, there are several limitations regarding certain methods or process designs incorporated into the studies.

For the quantitative indicator comparisons of China's eco-cities with the case study from Japan, the baseline scenario was chosen from MHURD's standards. As is pointed out repeatedly throughout this thesis, various geo-political and geo-cultural situations can lead to different standards upheld and adopted in different regions or places. Not all the indicators are directly comparable, nor were the all the relevant data available. Even though Suzhou city is a very representative well-developed city in China, it can only represent Chinese cities with limited geo-social features.

For the low-carbon city research, a qualitative approach was taken to derive in-depth knowledge and references for improving China's low-carbon urban policies through field studies and in-depth interviews with key stakeholders in the selected cities of Japan and Germany. However, although the lessons learned from the two cases may offer some good references, they need to be presented to the key decision or policy makers in China before any concrete suggestions could be translated into reality. It would be helpful to have also selected two corresponding Chinese cities where the policies recommendations for low-carbonization could be compared, implemented and tested.

In regards to the smart city research, not like many studies where ICTs are given the most weight in consideration for either conceptualization or index development, I have considered it as a means to realize the urban development goals of improving life quality and pursing sustainability. But it is not my intention to claim that these ICTs like big data, sensors etc. are less important. On the contrary, the very core nature of smart cities are to utilize them for better urban goal or policy implementations. Thus the proposed smart city conceptual framework or index could lead to some disagreement due to the lack of ICT related contents in proportion. On the other hand, I also rigorously reiterate that locality needs to be integrated from the beginning in the policy design for smart cities.

The last search package of the integrated approach has improved upon the above-mentioned limitations of the smart city study to certain extent. This integrated approach consists of a three-step mechanism with customizable sub-steps. But it is only based on one local case study of Kitakyushu City in Japan as of this time. For the expert option surveys, there are only 60 experts invited for this study, thus the sample size might not be that reliable. This also resulted from the adopted survey analytical tool of AHP, which has number limits in calculating the item evaluating inputs. For the questionnaire itself, some of feedback may be less accurate due to the unfamiliarity with the scale selections for some people. Improvement is definitely needed for such clarification in the instruction part of future surveys.

This integrated approach is summarized and distilled mainly from the three case studies enlisted in the thesis, therefore it might be confounding when applied to another model of sustainable urban or another different geographical setting. That is also the reason this approach needs to be flexible and customizable. And other major regret is that one of the main players of East Asia – South Korea was not included in this thesis, mainly due to the research scope and data availability. It may be very informative to see the smart city developing in Korea, given the high development in ICT infrastructures.

7.4 Future Research Perspectives

Ever since the industrial revolution, the momentum of human urbanization has continuously increased. A number of urban development trends have occurred along the timeline of human advancement during this time period. From Garden City and Green City, to Eco-City Low-carbon City, and to the current Smart City, all of them attempt to restore a balance between nature and the human sphere, between economic development and sustainability. The focus of each urban model differs, and there is not any proven “best” means or strategy that could meet the needs of all the parties involved. Under such a predicament, one effective tactic is to determine the most suitable way instead of the best way for preserving our common future in this urbanized era.

I have investigated several problems under the three major urban mega-trends in the recent decades, but there is more to be done. One topic that would be particularly interesting and worth further research, is to apply this proposed integrated approach to localization in different countries and regions. Only through application and feedback will this mechanism demonstrate its true value due to its high flexibility and customizability. Another topic that could be further explored is the up scaling of the proposed SC index for measuring smart city performance in Japan. There are also several issues that could be further researched regarding the eco-/low-carbon cities in China, in terms of performance evaluation and policy recommendations with specific case study cities.

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APPENDIX

Table A 1 Smart City Index Weighting Inputs Breakdown

SC Governance			P 1	P 2	P 3	P 4	P 5	P 6	P 7	P 8	AW	Rankings
Perception of transparency of bureaucracy			7.2%	7.0%	49.0%	44.0%	17.0%	52.0%	45.0%	37.0%	**32.3%**	**1**
Perception of fight against corruption			13.6%	12.0%	10.0%	21.0%	6.0%	4.0%	22.0%	15.0%	**13.0%**	**4**
Monitoring environmental performance			38.2%	39.0%	18.0%	22.0%	48.0%	17.0%	3.0%	8.0%	**24.2%**	**2**
City representatives per (1000) residents			3.5%	4.0%	4.0%	7.0%	11.0%	16.0%	3.0%	3.0%	**6.4%**	**5**
Female city representatives per (1000) residents			6.1%	7.0%	4.0%	3.0%	8.0%	4.0%	4.0%	8.0%	**5.5%**	**6**
Public participation in environmental decision-making			31.4%	32.0%	15.0%	3.0%	11.0%	8.0%	24.0%	29.0%	**19.2%**	**3**
GCR	**67.70%**	CR	11.7%	9.0%	9.0%	6.0%	9.0%	8.0%	10.0%	9.0%		
SC Economy			**P 1**	**P 2**	**P 3**	**P 4**	**P 5**	**P 6**	**P 7**	**P 8**	**AW**	**Rankings**
% of budget of local government allocated for environment			5.0%	24.0%	27.0%	5.0%	28.0%	45.0%	12.0%	11.0%	**19.6%**	**3**
R&D expenditure in % of GDP			12.0%	42.0%	47.0%	21.0%	2.0%	19.0%	19.0%	12.0%	**21.8%**	**1**

Use of electricity per GDP	16.0%	8.0%	7.0%	13.0%	42.0%	16.0%	23.0%	38.0%	**20.4%**	**2**
Use of water per GDP	16.0%	10.0%	6.0%	28.0%	4.0%	12.0%	10.0%	20.0%	**13.3%**	**5**
Gross city product per capita	27.0%	10.0%	9.0%	21.0%	17.0%	5.0%	13.0%	6.0%	**13.5%**	**4**
Households below poverty line	23.0%	6.0%	4.0%	11.0%	7.0%	3.0%	23.0%	14.0%	**11.4%**	**6**
GCR **57.20%** CR	4.0%	8.0%	7.0%	8.0%	10.0%	10.0%	10.0%	9.0%		
SC People &Urban Living	**P 1**	**P 2**	**P 3**	**P 4**	**P 5**	**P 6**	**P 7**	**P 8**	**AW**	**Rankings**
Number of doctors per 1000 population	38.0%	36.0%	6.0%	6.0%	50.0%	19.0%			**25.8%**	**1**
Number of hospitals per 1000 population	5.0%	17.0%	4.0%	6.0%	18.0%	3.0%			**8.8%**	**6**
Number of environmental staffs in city government per 1000 population	11.0%	9.0%	19.0%	5.0%	2.0%	10.0%			**9.3%**	**5**
% of industries compliant with emission control regulations	9.0%	4.0%	32.0%	38.0%	9.0%	10.0%			**17.0%**	**3**
% of vehicles compliant with emission control regulations	11.0%	7.0%	29.0%	17.0%	6.0%	10.0%			**13.3%**	**4**
Adult literacy rate	26.0%	28.0%	10.0%	27.0%	15.0%	47.0%			**25.5%**	**2**

GCR	**74.00%**	CR	6.0%	10.0%	8.0%	10.0%	10.0%	10.0%				
SC Infrastructure			**P 1**	**P 2**	**P 3**	**P 4**	**P 5**	**P 6**	**P 7**	**P 8**	**AW**	**Rankings**
Energy consumption of residential buildings			22.0%	17.0%	11.0%	7.0%	11.0%	56.0%			**20.7%**	**3**
Energy-efficient building standards			14.0%	16.0%	29.0%	17.0%	9.0%	3.0%			**14.7%**	**4**
Green spaces per capita			59.0%	4.0%	6.0%	64.0%	70.0%	27.0%			**38.3%**	**1**
Accessibility of smart grid			5.0%	64.0%	53.0%	12.0%	10.0%	14.0%			**26.3%**	**2**
GCR	**68.00%**	CR	9.0%	10.0%	9.0%	7.0%	10.0%	10.0%				
SC Energy & Mobility			**P 1**	**P 2**	**P 3**	**P 4**	**P 5**	**P 6**	**P 7**	**P 8**	**AW**	**Rankings**
Share of renewable energy in total energy use			41.0%	69.0%	28.0%	30.0%	50.0%	59.0%	41.0%	56.0%	**46.8%**	**1**
CO2 per capita from energy use			46.0%	10.0%	48.0%	12.0%	6.0%	25.0%	21.0%	31.0%	**24.9%**	**2**
Green mobility share			6.0%	7.0%	12.0%	35.0%	22.0%	12.0%	15.0%	4.0%	**14.1%**	**3**
E-vehicle in commercial vehicle shares			6.0%	15.0%	12.0%	23.0%	22.0%	4.0%	23.0%	8.0%	**14.1%**	**3**

GCR	**79.10%**	CR	1.0%	9.0%	7.0%	8.0%	6.0%	9.0%	8.0%	10.0%		
SC Environment			**P 1**	**P 2**	**P 3**	**P 4**	**P 5**	**P 6**	**P 7**	**P 8**	**AW**	**Rankings**
Air quality (indicated by SO2, Total Suspended Particles etc.)			11.0%	4.0%	31.0%	44.0%	3.0%	13.0%	19.0%	30.0%	**19.4%**	**2**
% of population with access to adequate and clean water			5.0%	3.0%	4.0%	21.0%	37.0%	51.0%	48.0%	35.0%	**25.5%**	**1**
Water quality (measured by BOD, COD contents etc.)			11.0%	8.0%	23.0%	22.0%	16.0%	7.0%	19.0%	20.0%	**15.8%**	**4**
Per capita waste generation			42.0%	15.0%	9.0%	7.0%	4.0%	4.0%	3.0%	5.0%	**11.1%**	**5**
% of total municipal solid waste (MSW) collected & treated			21.0%	22.0%	9.0%	3.0%	6.0%	13.0%	5.0%	5.0%	**10.5%**	**6**
% of total wastewater treated or recycled			10.0%	48.0%	24.0%	3.0%	34.0%	13.0%	5.0%	5.0%	**17.8%**	**3**
GCR	**57.60%**	CR	9.0%	10.0%	8.0%	6.0%	10.0%	6.0%	9.0%	8.0%		

Note: “P” stands for “Participant”

“GCR” stands for “Group Consensus Rate”

“CR” stands for “Consistent Ratio”

“AW” stands for “Aggregated Weight”

Table A 2 Expert Survey Questionnaires

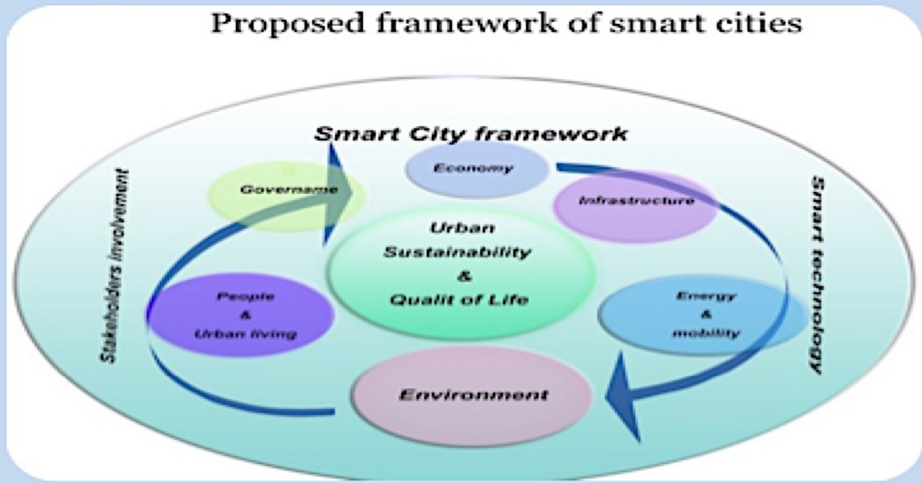
We have proposed a Smart City (SC) conceptual framework and developed a SC Index (or Indicator System) for its evaluation. Currently, we are trying to develop a weighting mechanism for the Smart City Index for a easy selection of key perfromance indicators (KPIs)at a later stage. **We'd like to have your expert opinion in judging and evluating the importantce of indicators under each domain (or aspect) by using analytical hierarchy process (AHP), simply put, pair-wise comparisions.**

Please choose one or more fields according to your expertise and epeicalization:	Governance	Economy	People & Urban Living	Infrusctructure	Energy & Mobility	Environment	← Choose & Click

Proposed SC Framework

We define the Smart City to posess double-fold goals of improving the quality of life (QoL) and pursuing urban sustainability. There are (but not limisted to six domains, namely, "governance", "economy", "people & urban living", "instrastructure", "energy & monility", "environment", and the two instruments to realize them are though the implmentatino of information & communication technologies (ICTs) as well as the involvement of stakeholders.

3D Conceptual Diagram



2D Conceptual Diagram

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Your Inputs Below

Which indicator do you think is **more Important** for **measuring a City's Smartness** in the aspect of "**Governance**"? (Choose one at each row)

	Indicators (A)				VS	Indicators (B)			
1	**Transparency of bureaucracy**				vs	**Fight against corruption**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
2	**Transparency of bureaucracy**				vs	**Monitor its environmental performances**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
3	**Transparency of bureaucracy**				vs	**City representatives per (1000) resident**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
4	**Transparency of bureaucracy**				vs	**Female city representatives per (1000) resident**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
5	**Transparency of bureaucracy**				vs	**Public participation in environmental decision-making**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
6	**Fight against corruption**				vs	**Monitor its environmental performances**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
7	**Fight against corruption**				vs	**City representatives per (1000) resident**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
8	**Fight against corruption**				vs	**Female city representatives per (1000) resident**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
9	**Fight against corruption**				vs	**Public participation in environmental decision-making**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
10	**Monitor its environmental performances**				vs	**City representatives per (1000) resident**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
11	**Monitor its environmental performances**				vs	**Female city representatives per (1000) resident**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
12	**Monitor its environmental performances**				vs	**Public participation in environmental decision-making**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
13	**City representatives per (1000) resident**				vs	**Female city representatives per (1000) resident**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
14	**City representatives per (1000) resident**				vs	**Public participation in environmental decision-making**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9
15	**Female city representatives per (1000) resident**				vs	**Public participation in environmental decision-making**			
	☐ 9	☐ 7	☐ 5	☐ 3	☐ 1	☐ 3	☐ 5	☐ 7	☐ 9

Please Leave your comments, if there is any

Your Inputs Below

Return to Coverpage

Which indicator do you think is more Important for measuring a City's Smartness in the aspect of "Economy"? (Choose one at each row)

	Indicators (A)	VS	Indicators (B)
1	% of budget of local government allocated for environment	Vs	R&D expenditure in % of GDP
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
2	% of budget of local government allocated for environment	Vs	Use of electricity per GDP
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
3	% of budget of local government allocated for environment	Vs	Use of water per GDP
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
4	% of budget of local government allocated for environment	Vs	Gross city product per capita
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
5	% of budget of local government allocated for environment	Vs	Household below poverty line
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
6	R&D expenditure in % of GDP	Vs	Use of electricity per GDP
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
7	R&D expenditure in % of GDP	Vs	Use of water per GDP
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
8	R&D expenditure in % of GDP	Vs	Gross city product per capita
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
9	R&D expenditure in % of GDP	Vs	Household below poverty line
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
#	Use of electricity per GDP	Vs	Use of water per GDP
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
#	Use of electricity per GDP	Vs	Gross city product per capita
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
#	Use of electricity per GDP	Vs	Household below poverty line
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
#	Gross city product per capita	Vs	Gross city product per capita
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
#	Gross city product per capita	Vs	Household below poverty line
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9
#	Household below poverty line	Vs	Household below poverty line
	☐9 ☐7 ☐5 ☐3 ☐1		☐3 ☐5 ☐7 ☐9

Please Leave your comments, if there is any

Return to Coverpage

Your Inputs Below

Which indicator do you think is **more Important** for **measuring a City's Smartness** in the aspect of "**People & Urban Living**"? (Choose one at each row)

#	Indicators (A)	vs	Indicators (B)
1	Number of doctors per 1000 population	Vs	Number of hospitals per 1000 population
2	Number of doctors per 1000 population	Vs	Number of environmental staffs in city government per
3	Number of doctors per 1000 population	Vs	% of industries complied with emission control regulations
4	Number of doctors per 1000 population	Vs	% of vehicles complied with emission control regulations
5	Number of doctors per 1000 population	Vs	Adult literacy rate
6	Number of hospitals per 1000 population	Vs	Number of environmental staffs in city government per
7	Number of hospitals per 1000 population	Vs	% of industries complied with emission control regulations
8	Number of hospitals per 1000 population	Vs	% of vehicles complied with emission control regulations
9	Number of hospitals per 1000 population	Vs	Adult literacy rate
10	Number of environmental staffs in city government per	Vs	% of industries complied with emission control regulations
11	Number of environmental staffs in city government per	Vs	% of vehicles complied with emission control regulations
12	Number of environmental staffs in city government per	Vs	Adult literacy rate
13	% of industries complied with emission control regulations	Vs	% of vehicles complied with emission control regulations
14	% of industries complied with emission control regulations	Vs	Adult literacy rate
15	% of vehicles complied with emission control regulations	Vs	Adult literacy rate

Rating options for each row: ☐9 ☐7 ☐5 ☐3 ☐1 ☐3 ☐5 ☐7 ☐9

Please Leave your comments, if there is any

Your Imputs Below

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Which indicator do you think is **More Important** for **measuring a City's Smartness** in the aspect of "**Infrastructure**"? (Choose one at each row)

	Indicators (A)	Compare A & B	Indicators (B)
1	**Energy consumption of residential buildings**	Vs	**Energy-efficient building standards**
	☐9 ☐7 ☐5 ☐3	☐1	☐3 ☐5 ☐7 ☐9
2	**Energy consumption of residential buildings**	Vs	**Green spaces per capita**
	☐9 ☐7 ☐5 ☐3	☐1	☐3 ☐5 ☐7 ☐9
3	**Energy consumption of residential buildings**	Vs	**Accessibility of smart grid**
	☐9 ☐7 ☐5 ☐3	☐1	☐3 ☐5 ☐7 ☐9
4	**Energy-efficient building standards**	Vs	**Green spaces per capita**
	☐9 ☐7 ☐5 ☐3	☐1	☐3 ☐5 ☐7 ☐9
5	**Energy-efficient building standards**	Vs	**Accessibility of smart grid**
	☐9 ☐7 ☐5 ☐3	☐1	☐3 ☐5 ☐7 ☐9
6	**Green spaces per capita**	Vs	**Accessibility of smart grid**
	☐9 ☐7 ☐5 ☐3	☐1	☐3 ☐5 ☐7 ☐9

Your Imputs Below

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Which indicator do you think is **More Important** for **measuring a City's Smartness** in the aspect of "**Energy & Mobility**"? (Choose one at each row)

	Indicators (A)	Compare A & B	Indicators (B)
1	**Share of renewable energy in total energy use**	Vs	**CO2 per capita from energy use**
	☐9 ☐7 ☐5 ☐3	☐1	☐3 ☐5 ☐7 ☐9
2	**Share of renewable energy in total energy use**	Vs	**Green mobility share**
	☐9 ☐7 ☐5 ☐3	☐1	☐3 ☐5 ☐7 ☐9
3	**Share of renewable energy in total energy use**	Vs	**E-vehicle in commercial vehicle shares**
	☐9 ☐7 ☐5 ☐3	☐1	☐3 ☐5 ☐7 ☐9
4	**CO2 per capita from energy use**	Vs	**Green mobility share**
	☐9 ☐7 ☐5 ☐3	☐1	☐3 ☐5 ☐7 ☐9
5	**CO2 per capita from energy use**	Vs	**E-vehicle in commercial vehicle shares**
	☐9 ☐7 ☐5 ☐3	☐1	☐3 ☐5 ☐7 ☐9
6	**Green mobility share**	Vs	**E-vehicle in commercial vehicle shares**
	☐9 ☐7 ☐5 ☐3	☐1	☐3 ☐5 ☐7 ☐9

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Your Inputs Below

Which indicator do you think is more Important for measuring a City's Smartness in the aspect of "Environment"? (Choose one at each row)

No.	Indicators (A)				VS	Indicators (B)			
1	**Air quality (indivated by SO2, Total Suspended Particles etc.)**				vs	**% of population with access to adequate and clean water**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
2	**Air quality (indivated by SO2, Total Suspended Particles etc.)**				vs	**Water quality (measured by BOD, COD contents etc.)**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
3	**Air quality (indivated by SO2, Total Suspended Particles etc.)**				vs	**Per capital waste generation**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
4	**Air quality (indivated by SO2, Total Suspended Particles etc.)**				vs	**% of total municipal solid waste (MSW) collected & treated**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
5	**Air quality (indivated by SO2, Total Suspended Particles etc.)**				vs	**% of total waste water treated or recycled**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
6	**% of population with access to adequate and clean water**				vs	**Water quality (measured by BOD, COD contents etc.)**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
7	**% of population with access to adequate and clean water**				vs	**Per capital waste generation**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
8	**% of population with access to adequate and clean water**				vs	**% of total municipal solid waste (MSW) collected & treated**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
9	**% of population with access to adequate and clean water**				vs	**% of total waste water treated or recycled**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
10	**Water quality (measured by BOD, COD contents etc.)**				vs	**Per capital waste generation**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
11	**Water quality (measured by BOD, COD contents etc.)**				vs	**% of total municipal solid waste (MSW) collected & treated**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
12	**Water quality (measured by BOD, COD contents etc.)**				vs	**% of total waste water treated or recycled**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
13	**Per capital waste generation**				vs	**% of total municipal solid waste (MSW) collected & treated**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
14	**Per capital waste generation**				vs	**% of total waste water treated or recycled**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9
15	**% of total municipal solid waste (MSW) collected & treated**				vs	**% of total waste water treated or recycled**			
	☐9	☐7	☐5	☐3	☐1	☐3	☐5	☐7	☐9

Please Leave your comments, if there is any