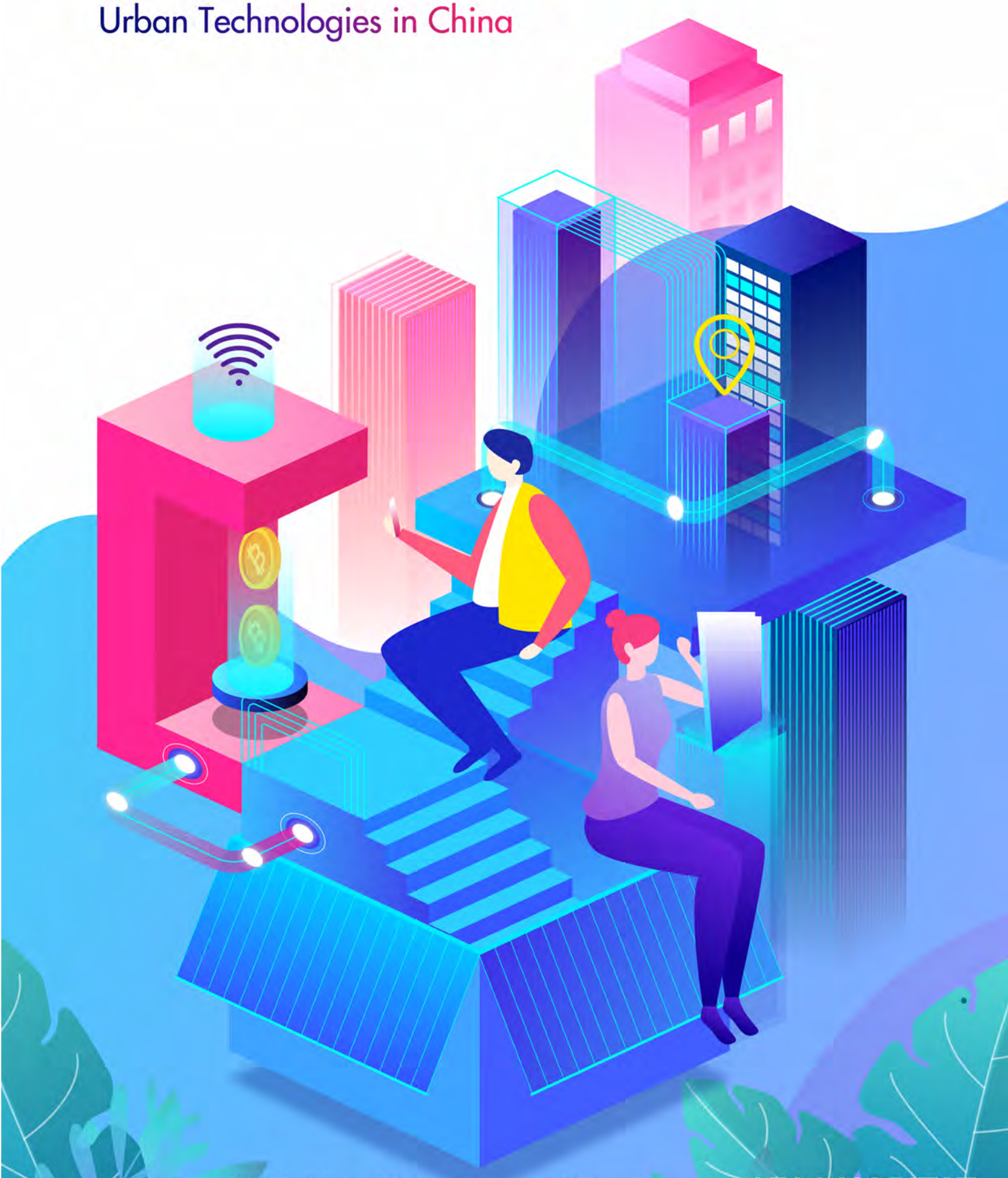
2020

Future Cities Advisory Outlook

Urban Technologies in China



Report of the UN-Habitat China Future Cities Council

UN-HABITAT
FOR A BETTER URBAN FUTURE

2020 FUTURE CITIES ADVISORY OUTLOOK

URBAN TECHNOLOGIES IN CHINA

萬向集團 WANXIANG GROUP
XinChao 新潮传媒
UN HABITAT FOR A BETTER URBAN FUTURE

United Nations Human Settlements Programme (UN-Habitat)

Preface

We live in an era of urban world. We live in a world of changing. Much of it is now driven by technologies such as big data, IOT, AI, digital twin, edge computing etc. The impact of smart technologies to cities are far more than imagination. Cities are engines of growth, innovation and prosperity. Cities are also at the frontline of technological changing.

But we also see cities are facing great challenges from modern technologies. Some cities are capable in dealing with technologies, but many of them are left behind.

1.5 million people are added to the urban population every week. And, millions of high-tech applications are deployed in cities every day. We are at a unique moment in human history. The policies and investments made in the next two decades will determine the quality of life on this planet for generations to come. We believe if we work together with a common faith of innovation and inclusiveness, we will bring new habitat models and better future cities for all.

It gives me great pleasure to present the first Future Cities Advisory Outlook. I am grateful to each member of the Council, and many organisations and individuals we consulted.

Cities must be sustainable. No one can predict what cities will evolve to be. But the leading cities of tomorrow will be those cities successfully adopt the merits of technologies. We hope this report will contribute to helping more people and cities to have an improved understanding of technologies to the urban sustainable development. And together we can contribute to make a better world for all.

Lu Weiding
Chair of UN-Habitat China Future Cities Council
Chairman and CEO of Wanxiang Group

CONTENTS

Chapter 3

A Wider Use of City Brains .P41

Chapter 4

Conclusions and Recommendations .P61

EXECUTIVE SUMMARY

Beijing, China

Executive Summary

Technology changes everything. From artificial intelligence to driverless cars, technology is changing human settlements dramatically. New and rapidly developing technologies hold incredible promise for the advancement of human welfare. But they are not risk-free. They also hold the potential to generate more inequality and negative consequences. We must raise our level of ambition to ensure that new technologies are designed, managed and used for the benefit of all. It is also true in smart urban development. It is the technology sector that delivers the smart city initiative. Meanwhile, urban policy makers and urban planners are often trying to tackle urbanization issues with traditional planning tools. China is at the forefront of urbanization and innovation. It is a major pioneer in promoting new technologies and apply them in cities. The Chinese technology sector offers us powerful new ways to achieve our shared commitments to each one of the Sustainable Development Goals (SDGs). The SDGs have set global targets for development to be achieved by 2030. The targets of SDG 11 on sustainable cities and communities is a very important one to lift even more people out of poverty and to seek a better quality of life for all, and a sustainable future for our planet. Sustainable urbanisation, together with climate change and data governance are amongst the most significant challenges of development in front of us.

Realizing the importance of the change and urgency of the issue, in April 2019 UN-Habitat China initiated UN-Habitat China Future Cities Council (CFCC), which invites far-sighted Chinese technology entrepreneurs and CEOs to contribute their forward thinking on the future of cities, especially how smart technologies can impact the sustainable urban development. Ms. Maimunah Mohd Sharif, United Nations Under-Secretary-General and UN-Habitat Executive Director addressed on the initiating ceremony of CFCC," With this UN-Habitat China Future Cities Council initiative, the UN-Habitat China country programme wants to listen to the Chinese private sector on how they can to help Chinese cities to realise the targets of SDG11, to make cities and human settlements inclusive, safe, resilient and sustainable."

The Future Cities Advisory Outlook 2020: Urban Technologies in Chinese Cities brings the first repo rt of CFCC. Chapter 1 introduces the overview urbanisation and its challenges in the world and in China. It depicts the urban technologies development. Then, it explains the global smart city development and the 3 stages of smart cities development in China, especially the most recently future cities.

Chapter 2 goes deep to present current China national initiatives and city level policies on smart cities and the key urban technologies and their application in Chinese cities. A comparation of 16 major urban tech use in Chinese cities and their contribution to SGDs has been analysed. This Chapter also provides detailed case studies of different urban tech in Chinese cities.

Chapter 3: A Wider Use of City Brains presents the most comprehensive smart city solutions in China. It analyses the most influential smart city flatforms in China from its development process, main providers, key functions, different types, geographical deployment etc. It also provides 2 key applications of city brain. It argues that as a city level artificial intelligence system, city brain is being deployed more and more in cities, it is a new way to manage cities with a lot of benefits, but they are facing challenges, such as the accuracy of modelling results, data safety etc. The impact of city brains needs to be studied and monitored.

Based on the preceding 3 chapters, we conclude the following pri ority recommendations deserver attention:

1. Place smart technology at the heart of urban innovation, high-quality transformation

and prosperous future

R1.1 We recommend that fully evaluate and depict the potential of urban technology to urban innovation, governance and socio-economic growth.

R1.2 We recommend that carefully study the change to urban forms, types and completeness being brought by smart urban technologies.

R1.3 We recommend that establish a standard for security and maintenance of smart urban system.

2. Enhance institutional and individual capacity

R2.1 We recommend that establish different tiers of smart urban technology facilitators from regional to country and city level to help governments, civil society, and private sector to get better understanding of urban technologies

R2.2 We recommend that monitor technological developments, identify trends, inform policy makers and the public of emerging risks and opportunities and provide data for decision making.

R2.3 We recommend that strengthen capacity development for small and medium cities or towns and marginalised people to create an inclusive smart future of no one and no place left behind.

3. Fund and finance smart urban infrastructure

R3.1 We recommend that work with city governments to establish integrated spatial and smart infrastructure plans that can underpin a pipeline of proper business models and bankable smart city projects.

R3.2 We recommend that scale diverse financing instruments to fund smart urban infrastructure, including help cities to access international finance for smart city development.

R3.3 We recommend that establish incentive financing and taxation mechanism to smart urban infrastructure.

4. Coordinate and support local urban smartization in cities

R4.1 We recommend that establish smart city leaders working team in cities to coordinate the overall formulation of smart city plan and deployment of smart urban facilities.

R4.2 We recommend that the capacities of local urban professionals, including urban planners, transport planners, architects etc need to be equipped with updated knowledge on smart infrastructures.

R4.3 We recommend that create better integration of spatial planning and smart infrastructure and make best land use in smart age.

5. Build a multi-stakeholder system to foster innovation and inclusive future cities

R5.1 We recommend that ensure a collaborative smartinisation action in cities among local governments, urban tech providers, smart city operators and citizens.

R5.2 We recommend that encourage diverse models of smart city construction and operation to create a multi-participation, including local governments, private companies, social capitals, research institutes, citizens etc.

R5.3 We recommend that sustainable investing and operational models of smart cities need urgently to be considered and prevent the financing and operational risks.

6. Proactively plan for a just transition to smart future cities.

R6.1 We recommend that enhance age and gender equality in smartinisation process by educating all people since only the people get smart then a city can be smart.

R6.2 We recommend that do not create smart technology gentrification to urban poor.

R6.3 We recommend that undertake international pilot projects and cities and provide best practice cases for reference.

CHAPTER 1

INTRODUCTION

Shanghai, China

Chapter 1 - Introduction

Today more than half of the Chinese population lives in cities. In the past 40 years since the Reform and Opening Up, China has experienced high growth rates of urbanization. Up to now, urban development in China has basically completed infrastructure construction and started to transform from external construction to internal governance. On one hand, the extensive development mode in the past has caused a series of problems such as excessive consumption of resources, serious environmental pollution and insufficient public services. With the rapid urbanization process, traffic congestion, environmental pollution and other urban problems become prominent; On the other hand, with the improvement of people's economic level, more liveable, convenient and safe city life has become people's new pursuit. Meanwhile, a new round of scientific and technological revolution and industrial transformation are accelerating, providing a rare historical opportunity for China's future development. Driven by increasingly mature artificial intelligence, big data, cloud computing and other technologies, smart cities have successfully entered the urban construction track and achieved rapid development under the guidance of the government and the support of enterprises.

1.1 Rapid urbanization as a context of emergence of smart cities in China

Since the 1980s, China experienced a rapid increase in the rate of urbanisation. Comparing with the major developed countries in the world, which the process of urbanisation took 110 years until the urbanisation rate reached 80%. (Fig.1.1) However, the percentage of urbanisation in China has already reached 59.58% in 2018, which only took 38 years. It is also expected that the rate of urbanisation can reach 70% by 2035 and 80% by 2050 (Fig 1.2).

In 2011, China's urbanization rate exceeded 50% for the first time, which means that China's urban population exceeded the rural population for the first time. The urbanization growth rate tends to slow down, and the focus of urban development shifts from increment to stock. The problems of congestion, pollution, safety and management that only a few big cities once faced have become the problems that most cities need to solve. At the same time, the complexity of the urban system has been increased and the diversity of demands has been enhanced, which requires the operation of Chinese cities to be more efficient and the management to be more sophisticated.

1.2 Challenges facing Chinese cities

Urbanization is often coupled with economic growth and also higher living standards, higher average education. But urbanization also brings great challenges to cities. According to the UN, world urban population

Fig 1.1
Urbanization in Major Countries of the World

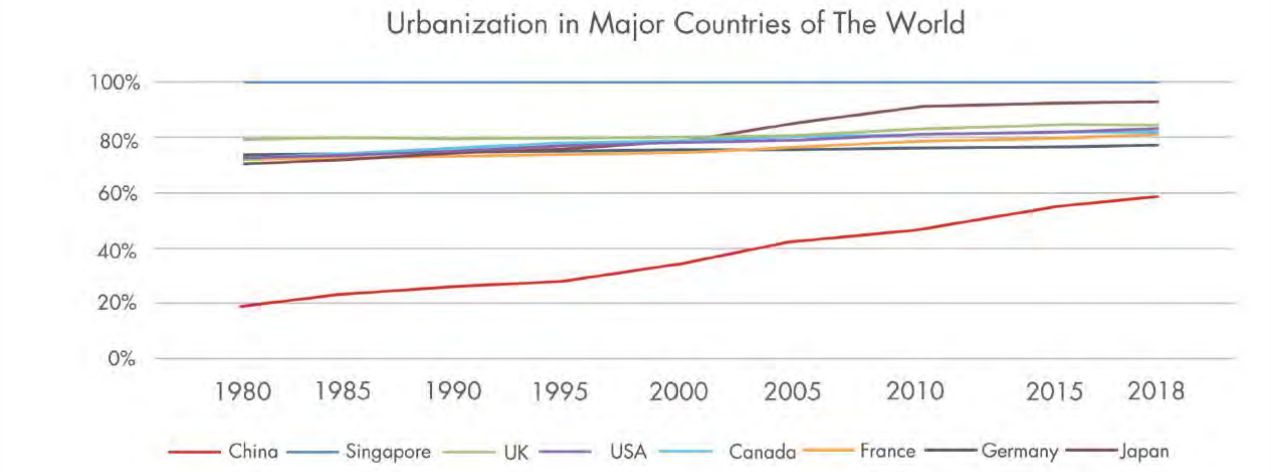


Fig 1.2
The Changing Trend of China's Population And Urbanization Level: 1950-2050

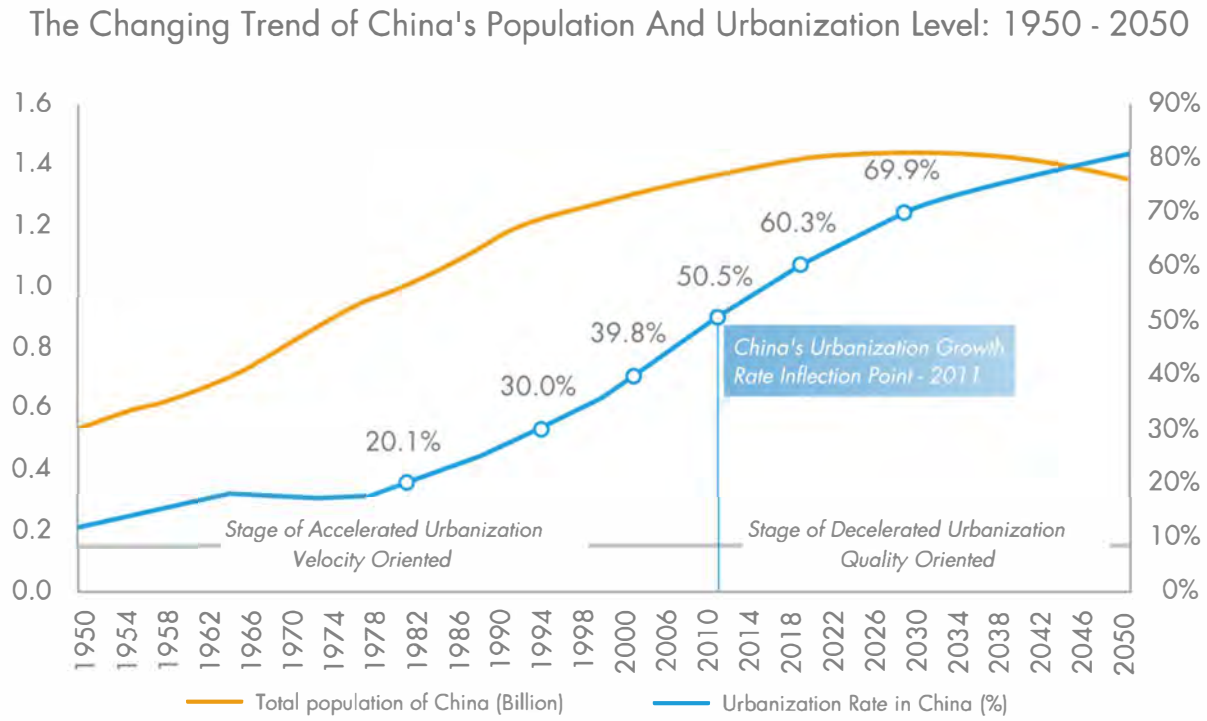


Fig 1.3
Urbanization Projection and Challenges in the World

Source: UN-Habitat (2019)

is projected to 70% in 2050. Cities only account 2% Earth land area, but it creates 70% global GDP, consumes more than 60% global energy, produces 70% global greenhouse emissions and creates 70% global solid waste. (Fig 1.3) The Chinese cities are also no exception to those challenges.

From the view of urbanization, "6 imbalances" is the major issues of urbanization in China.

-Population payment imbalance

The phenomenon of dual urban population is one of the fundamental manifestations of inadequate urbanization development. There are great differences in income level and public service supply between the registered urban population and migrant workers.

-Regional imbalance

Due to the huge size of China, the imbalance of social and economic development among regions, urbanization also has obvious regional differences. The urbanization level of China is obviously higher in

the east and lower in the west. Zhejiang province in the Yangtze river delta, for example, had 68 percent urbanization in 2017, while Guizhou, in the southwest, had only 46 percent, which is a significant gap.

-City level imbalance

Chinese cities have administrative levels, and high-level cities have greater economic and social management authority, which brings unequal development opportunities between different levels of towns.

-Imbalance in new cities and old cities

As urban population increase, some place to put the new city district as the main direction of the urban space development, the government's investment mainly concentrated in the new city district, a concern for the old is not much, not enough, new visual contrast between the old big, to accelerate the pace of new town development, even under the administrative push will be off to the new town, better public service resources of the city of some old first began showing signs of decline.

-Imbalance between government debt and fiscal revenue

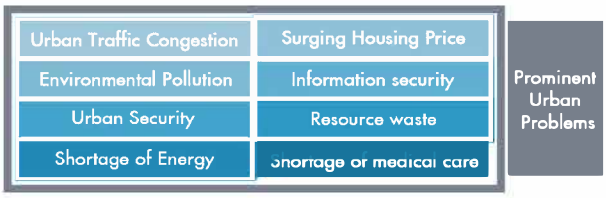
Financing for urban development is a common practice in all regions at present. On the one hand, this is due to insufficient fiscal revenue, on the other hand, the long-term nature of infrastructure construction requires financing to be Shared over a longer period of time. A large amount of debt is financed by land mortgage and the repayment of principal and interest by land sales.

-Imbalance and insufficient phenomena in the development of urbanization

First, the urban land use efficiency is not high; Second, the urban development model is single, and residents' participation is not high.

Specifically, the major urban challenges in China contains the following aspects: urban traffic congestion, environmental pollution, urban security, shortage of energy, surging housing price, information security, resource waste, shortage of medical care etc. (Fig 1.4)

Fig 1.4
Prominent Urban Problems in China



1.3 Technology development as a chance for the solutions of the city problems

Cloud computing, Internet of things, big data and emerging technologies such as artificial intelligence and the traditional mechanical, physical, chemical and biological disciplines constantly fusion, rendering more breakthroughs, physical world, the digital world, biological world, disruptive technology constantly emerging, new economy, new industries and new forms, new model, in a revolutionary way for traditional industries have a significant impact and impact, to the human production mode, life style and way of thinking will produce an unprecedented impact.

With internet communication technology (ICT) development in the field of security, transportation, finance, and other large-scale commercial use, and coupled with artificial intelligence, cloud computing, big data, Internet of things of a new generation of network communication technology synergy, it led to the development of smart which is rich in technical support, makes smart city perception connected, interactive sharing and promotes the development of smart cities much faster.

New technologies are also playing a more and more significant role in daily life for most of the Chinese, especially for those so-called the "tech-savvy "young an urban population. They are turning to their smart-phones

for more and more services by various apps. The online market is more massive than imagination, for example, hard-working professionals and students who usually squeezed on time, therefore the access to ordering groceries, food, and clothes online has certainly taken off. All the development and changes are because of the high number of mobile and internet users in China. It is also partly due to the cheapness of Chinese smart-phones. This all being made possible by the high number of mobile and internet users in China. According to the latest report of US KPCB Ventures, in 2019, the number of smart-phone users in China has reached 354 million, surpassing the United States to become the country with the largest number of smart-phone users in the world . The high degree of smart-phone use makes it possible that the population can benefit more from what new digital technology can offer.

1.4 The emergence and development of smart cities in China

The term Smart City has grown to become such an encompassing concept that defining smart city is increasingly difficult. Despite its extensive use, there is no universal definition.

The smart city concept has been put forward since IBM launched the term in 2008. Some of the technologies were imaged to make cities smart, are now seen as fundamental parts of urban operations in many parts of the world.

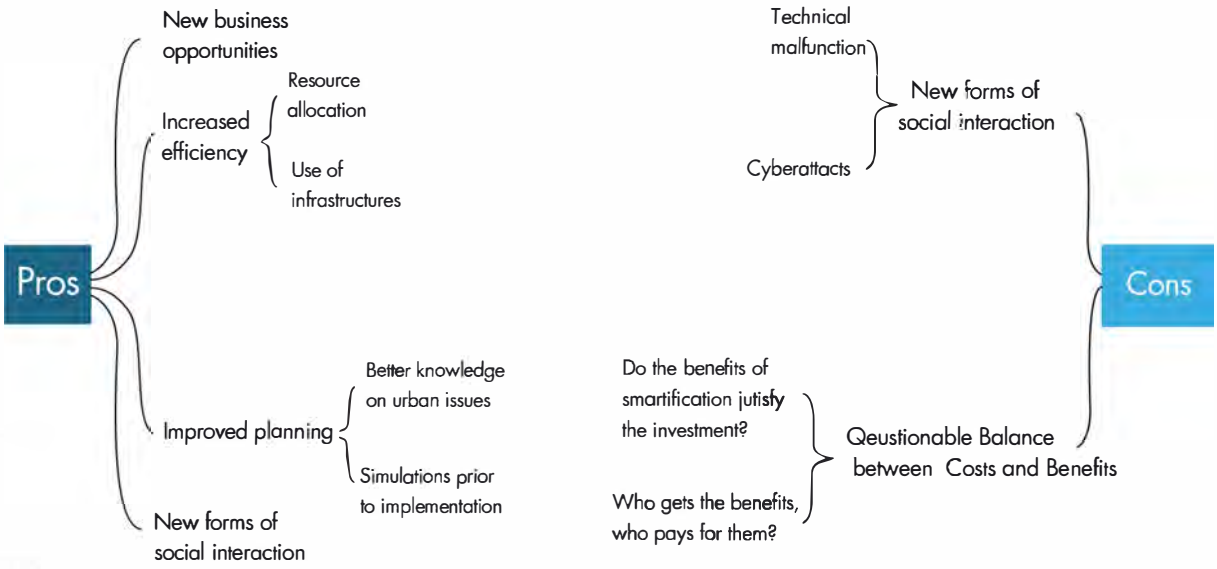
Among various definitions of smart city, some defines smart city as: "Smart cities provide applications covering the public and commercial fields, enhance and create values. Based on the infrastructure and operating system, multiple application types are produced." Some defines it as "smart cities are a new concept and model based on information and communication technology (ICT) that comprehensively perceives, analyses, integrates and handles all kinds of information in urban ecosystems, and realizing the interconnection among the various systems, timely giving intelligent response and decision for various needs in urban management, optimizing the urban resource scheduling, and improving the urban operational efficiency as well as the quality of daily-life of citizenship." This definition emphasises the role of technologies for the development of smart cities.

After 2010, the concept of smart city experienced a brief conceptual popularization in China and entered a stage of explosive growth. At the national level, this outbreak is manifested in the intensive release of relevant policies, guidance opinions and pilots in 2013 and 2015. At the local level, the top-level design and planning of smart cities, infrastructure and public service projects have been actively promoted. According to incomplete statistics, the number of smart cities plan to build China has exceeded 500 in 2018.

Since the concept of a smart city has been proposed, and quickly developed in recent years, it has gradually moved to implement. However, a question about why should such a city to be built, and what are the advantages and disadvantages of the new model compared with traditional urban development ones?

First of all, for sure, there are lots of possible benefits to using technology to upgrade cities, including lowering the cost of information flow and creating interaction models. It can also test the effects of specific policies or measures before the implementation. Furthermore, it can generate new industries, both giving rise to new job opportunities and economic growth. Further, it can provide new opportunities for energy saving and social connection. Smartification also allows for improves resource allocation, for example, through shared technologies. Today, umbrellas, bikes, and power banks can easily be accessible shared through phone apps. On a grander scale, smart meters can ensure better energy use and reduce problems related to peak grid

Fig 1.5
Prons and Cons of Smort Cities



capacity.

However, the risks of smart cities cannot be ignored. As an increasingly high number of public services becomes controlled digitally, the risk of cyberattacks or shutdowns increases. One must, therefore, be aware of how smartification also can entail increased vulnerability. The effects of cyberattacks could be wide-ranging such as traffic stagnation, the shutdown of water and electricity, loss of control over the Internet of Things (IoT), and can even result in causalities. There are also economic risks associated with smart city development. Based on experiences from China and beyond, the failure of smart city development is often related to an uneven balance of costs and benefits. Last but not least, privacy is another vital concern due to the large use of digital devices such as smart cameras. (Fig 1.5)

1.5 The stakeholders of smart cities

As we think about the stakeholders in smart cities, the overall structure of smart cities can help us understand. In the report of JD Cloud (2019, 10), it is pointed out that the structure of smart cities includes the facility, platform and application layers. The facility layer is the sum of various kinds of infrastructure in the cities. The platform layer is the core of the technology-enabling city, and the application layer consists of citizens, enterprises and government. The multi-stakeholders of smart cities is depicted in Fig 1.6.

As more and more cities are building smart cities, people-oriented smartification is becoming more and more important. Fig 1.7 shows a better citizen-centered development system of smart cities.

In general, the government is the manager and leader of smart cities, the enterprise is the provider as well as the recipient of the service, and the citizens are users of services. In addition, research institutions may act as pioneers in the recommendation of policies and technologies. The report of Roland Berger believes that the success of smart cities depends mainly on the actions of three key groups. They are urban planning departments, suppliers and national and regional governments.

While the public sector is central in coordinating smart city development, much of the technological expertise and capabilities are within private companies. Rightfully, an essential aspect of smart cities is the cooperation of different stokeholds, including civil society, technologists, academics, and the private sector. Commercially

Fig 1.6
Multi-stokeholders of Smart Cities

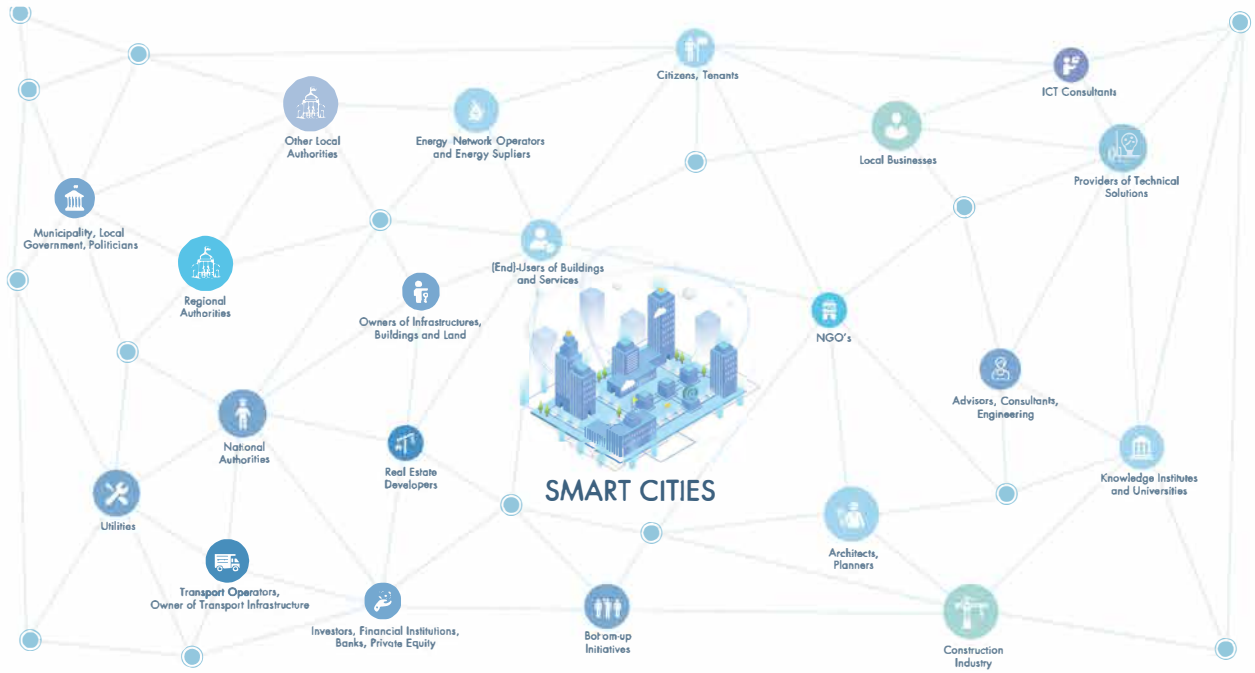
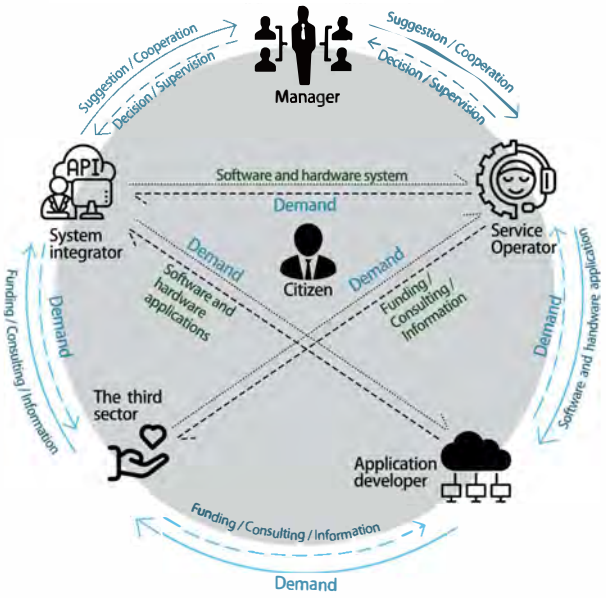


Fig 1.7
Put Citizen at the Heart of Smart Cities Development



developed technologies are a crucial part, still regulations and standards need to be provided by governments at the local, provincial and national level.

Furthermore, governments need to ensure that services are provided to those who need it, and also distributed on a non-commercial basis, including health care, education, and also to some extent, transport.

1.6 Future Cities: beyond smart cities

Based on the analysis of smart cities, in this report, we propose the concept of "Future Cities". We see the future cities as the trend of further development of smart cities. Currently, there is no universal definition of future cities. However, China has already proposed the concept of "smart society", it is also the trend of the development of smart cities. In the report of, it is pointed out that smart society focuses on "people-leaded".

The work definition of the future cities in this report is: the future city is a new urban development concept and model that uses science and technology to achieve a shared, safe, inclusive, resilient, and sustainable development.

Therefore, in this report, we seek to move beyond smart cities and advocate the building of Future Cities. Future cities not only differ from smart cities in having even higher technological capabilities, it also seeks goes beyond in terms of social inclusion.

CHAPTER 2

CURRENT NATIONAL INITIATIVES AND TECHNOLOGIES IN CHINESE CITIES

Shenzhen, China

Chapter 2 - Current National Initiatives and Technologies in Chinese Cities

2.1 Current National and Local Initiatives

The Chinese central government has actively led the development of smart cities, starting with the first designated policy documents in 2012, proliferating gradually into 2019. This is based on the unique characteristics of the Chinese governance model, which is this case manifest themselves in two ways. First, smart cities have been developed through a top-down governance model, where strategic decisions are made in the government and CCP after which central government bodies launch policy documents. These central policies subsequently lead to more specific policy documents across ministries, regulators, and local government. Second, smart cities have been developed through pilot projects, in which different technologies, governance models, or supporting mechanisms are tried out in practice. Lessons are then learned from each pilot, which feeds into the development of existing and new pilots in order to develop best practices for smart city development. Based on these governance characteristics, it is critical to understand the content and chronology of national policies in terms of smart city guidance and smart city pilots.

2.1.1 Overarching policies

Smart city development is based on and a product of the Chinese government and CCP strategic long term policy documents. A key policy document of this type is the 5-year plans, of which the "12th 5-year plan" launched in 2010 specifically encourages the development of information technology, information industries, and smart cities. As part of implementing the plans, the government's "2015 Work Report" as presented by Premier Li Keqiang highlighted smart technologies and smart cities as priorities for his administration. In terms of its approach to economy development, the "New Development Model" as introduced by President Xi Jinping in 2015 which emphasizes innovation, coordination, green, openness and sharing, are all key features in smart cities. Lastly, President Xi Jinping at his 2017 "19th Party Congress Address" specifically mentions smart cities, and calls for a people-centered approach to building a smart society. As an outwards facing initiative the Belt and Road Initiative also emphasis "digital, networked and smart development", under which in 2019 the Belt and Road Sustainable Cities Alliance has been established.

2.1.2 Sector specific policies

Based on the overarching policies and as a part of turning them into practice on the ground, various government bodies launch sector specific policies, amongst which many include content directly related to smart cities. As smart cities are an embodiment of technology, sustainability, and urbanization, policies in these three areas form a critical underpinning. In terms of technology a number of central government ministries have launched related policies, amongst which the most important include the "Several Opinions on Promoting Consumer Spending on Information Technology and Expanding Domestic Demand" in 2013,The "Inter Plus Action Plan" in 2015, and the "Guidance of Improving Big Data Action" in 2015 all by the State Council, as well as the "Promoting Smart Transport Development Plan" 2017-2020, by the Ministry of Transport. In terms of sustainability, while a long list of policies and performance targets exist in 5-year plans and requirements from the Ministry of Ecology and Environment, the key policies worth taking note of include the concept of an "Ecological Civilization" which was enshrined in China's constitution in 2012, the "War on Pollution" declared by Premier Li Keqiang in 2014, as well as China's "Nationally Determined Contribution" to the Paris Agreement on Climate Change in 2015. Lastly, in terms of urbanization policies, in

Table 2.1
Smart city guidance key policy documents overview

Issuance date	Issuing body	Policydocument name	Key contents
2012 November	MOHURD	The Provisional Administrative Measures for National Smart City Pilot Program	Set out the eligibility for enrolling in the national smart city pilot program. Application submission period commenced with a three stage rollout of pilots from 2013-2015
2014 August	NDRC, MIIT, MOST, MPS, MOF, MLR, MOHURD, MOT	The Guidance on Promoting Healthy Smart City Development	2020 smart city rollout targets, as well as priorities on public services, urban management, liveable environment, intelligent infrastructure and long-term network security
2015 October	Standardization Administration of China, Cyberspace Administration of China, NDRC	Evaluation Indicators for New-Type Smart Cities	Clear smart city evaluation standards. Carry out 50 evaluations by 2020 to refine and implement the evaluation standards system
2016	NDRC, MIIT, Cyberspace Administration of China	New-type of Smart City inter-ministerial coordination working group	Ensuring efficient implementation by clarifying mandates of each body, coordinating implementation, sharing information, and setting joint goals
2018	China National Information Technology Standardization Network	GB/T 36333-2018 Smart City Top Level Design Guide	Guidelines for implementing smart cities through a standardized approach. Includes lessons learned from earlier pilots and local level policies

Source: Author's compilation

addition to MOHURD continuously issuing policies, other central guiding policies are the "National New-Type Urbanization Planning 2014-2020" issued by the State Council in 2014, as well as the "Urban Development Guidelines" issued by the CCP Central Committee and the State Council in 2016 promising to make China's cities more livable, efficient, and green.

2.1.3 Smart city guidance policies

Based on China's governance characteristics as well as the overarching and sector specific policies, China has issued a number of designated smart city policies since 2012 across central government ministries and regulators. In this process, each government body has played a unique role. In organizing such efforts, working groups have been established spanning the relevant government bodies such as the "National Smart Cities Standardization Coordination Group" setup in 2015, as well as the "New-type of Smart City inter-ministerial coordination working group setup in 2016". The key bodies and their roles are the following:

- **The National Development and Reform Commission (NDRC)** works as a key stakeholder in promoting and driving smart cities from the perspective of new urbanization, as well as in terms of harmonizing policy with economic objectives

- **The Ministry of Industry and Information Technology (MIIT)** participates in the policy, standard, and evaluation processes from the informatization and technology acceleration perspective.

- **The Ministry of Housing and Urban-Rural (MOHURD)** leads and organizes smart city pilot identification and implementation practice. Furthermore, the Digital City Engineering Research Center is managed by MOHURD and has conducted a series of surveys and research projects to analyze common challenges and provide suggestions for solutions

- **The Ministry of Finance (MOF)** assists with capital allocation, monitoring, and control of budgets in smart cities, including through local Bureaus of Finance.

- **Local governments** play the implementing role, by both launching local policies as well as by managing

and monitoring implementation.(Table 2.1)

2.1.4 Smart city pilot policies

Following the direct mention of smart cities in the 12th 5 year plan in 2010, Ningbo became the first city to launch a pilot. Such pilots were systematized following the launch of the "Provisional Administrative Measures for National Smart City Pilot Program" by MOHURD in 2012, with pilots starting implementation in 2013. As a central support scheme USD 15 billion was allocated to these pilots through the China Development Bank. With an acknowledgement that both technologies as well as capital needs to come from the private sector, the pilots put great emphasis on private sector engagement such as through PPP models. Highlighting the importance of private involvement in the pilots, the International Telecommunications Union predicts 80% of smart city construction investment to originate in the private sector.

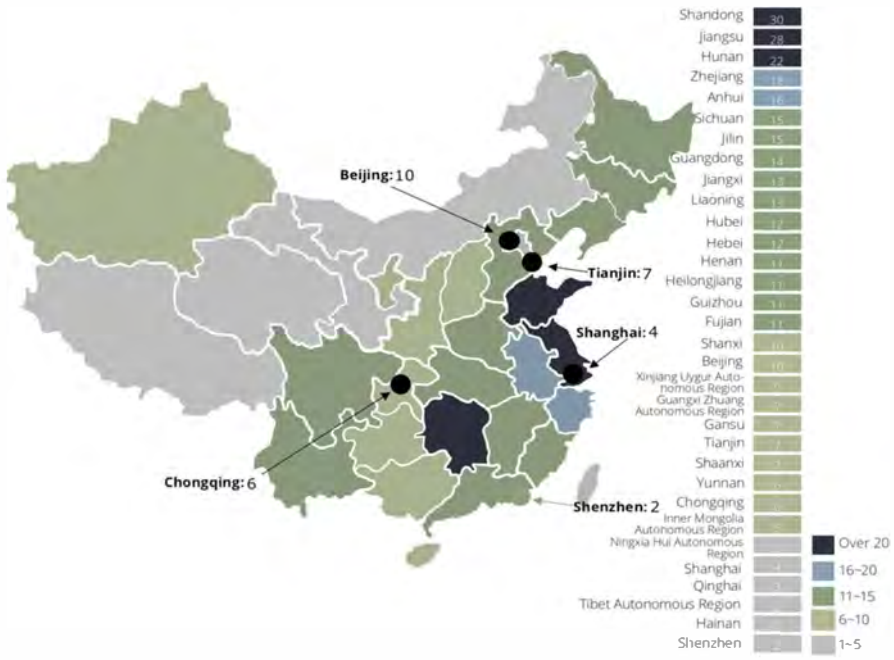
Such pilots were not only orchestrated through MOHURD but by different ministry level government bodies alone and together, as shown in table 2.2 below. By the end of 2017, such central ministry led pilots counted 572, with numerous more local initiatives. Geographically speaking, these pilots are spread across every province of China although with a higher concentration in coastal provinces with both higher GDP per capita as well as residence concentration as shown in figure 2.1 below.

Table 2.2
Pilots under each government body

Government Body	Issuance date	Pilot name	Pilot number
MOHURD	2015 April	Third National Smart City Pilot Program	97
	2013 August	Second National Smart City Pilot Program	103
	2013 January	First National Smart City Pilot Program	90
MIIT	2015 December	Second National IT Usage City Pilot Program	36
	2013 November	First National IT Usage City Pilot Program	68
MIIT & NDRC	2015 January	Second Broadband China Pilot Cities	39
	2014 January	First Broadband China Pilot Cities	39
NRDC and othe	2014 June	Information for the People Test Cities	80
MOST and others	2013 January	Smart Cities Test Practice	20
			Total: 572

Source: Airui (2019). China Smart Cities Development Report

Fig 2.1
Geographic distribution of pilots



Source: Deloitte (2018). Super Smart Cities: Hoppier Society with Higher Quality

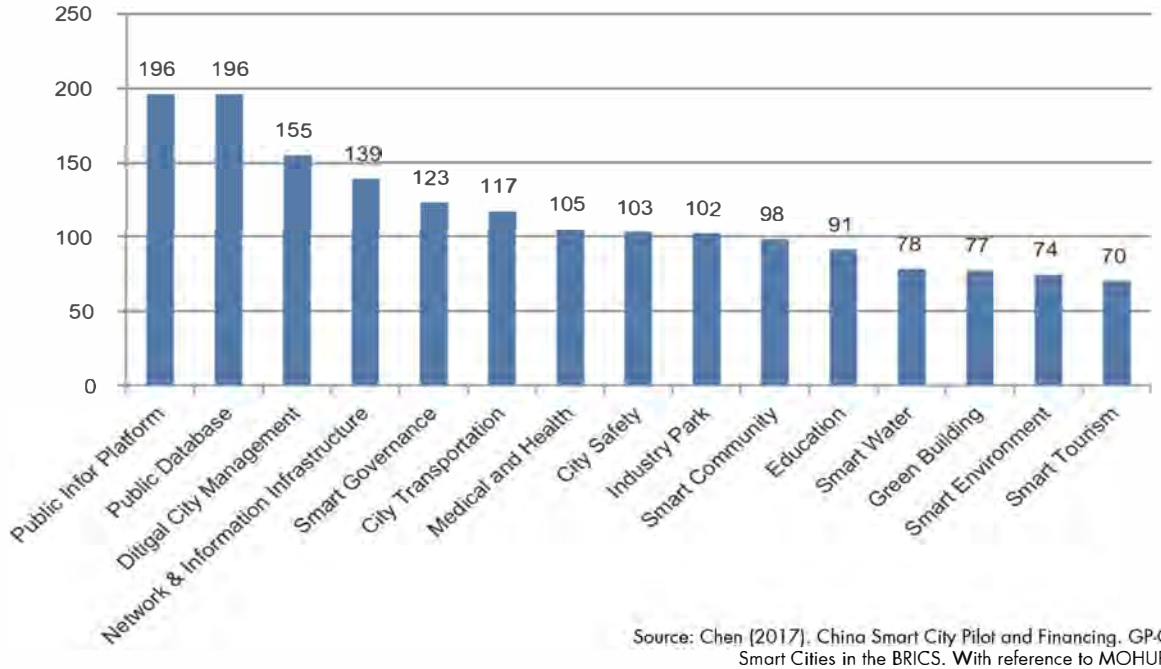
This spread allows for greater localization of smart city technologies, ensuring that smart cities are relevant for cities across the country rather than only for certain types. When it comes to technologies, MOHURD provides statistics on its pilots, showing a prioritization of smart cities technologies relate to governance, as shown in figure 2.2 below. This prioritization, may however differ in non-MOHURD orchestrated pilots on which similar comparable statistics do not exist.

Following a rapid proliferation of smart cities from 2013-2016, pilot projects led by the national ministries and commissions have been gradually reduced since then. This has been part of the development focus of smart cities shifting from concept to practice, from central guidance to local implementation. At the same time, concerns of rising public debt levels has limited the possibility to launch financial support schemes or initiatives which will inherently incur substantial public costs at central or local levels, which smart cities inevitably do, especially in the short term. This may explain why there is a strong correlation between smart city performance and GDP per capita, as identified by Deloitte, further arguing that cities with lower GDP per capita rates prioritize traditional sources of growth rather than focusing on leapfrogging to smart city development.

At the national level, standardization policies such as the "GB/T 36333-2018 Smart City Top Level Design Guide" have been released, providing an increasingly solid basis of guidance and standards to be used in implementation. Simultaneously, at the local level, more and more districts and cities have issued regulations and policies related to smart cities, creating a continuously maturing environment for smart cities. This trend means that today smart cities cannot sustain the same level of growth in numbers as in the past, and the further development of smart cities will increasingly depend on a city's own financial capacity rather than central government support.

Amongst the more than 500 smart city pilots, the most mature and ambitious are found amongst China's largest and richest cities such as Beijing, Shanghai, Guangzhou, Shenzhen, Hangzhou, and Xiong'an. As these cities are on the global forefront of implementing smart city initiatives, assessing their progress can provide valuable lessons for smart cities in China and across

Fig 2.2
Pilots under MOHURD breakdown by technology



Source: Chen (2017). China Smart City Pilot and Financing. GP-ORF Series: Smart Cities in the BRICS. With reference to MOHURD statistics

Table 2.3
Comparison of six key pilots

City	Initiation year	Key policy documents	Technology focus	EO Intelligence score (out of 100)	Deloitte Super Smart Cities Index (out of 100)
Beijing	2012	"Smart Beijing Activity Outline", "Beijing 12th 5-year plan city digitalization and digital infrastructure construction plan"	Digital company development, cashless society, smart parking	85.1	70
Guangzhou	2012	"Implementation Principles Related to Smart Guangzhou", "2035 Guangzhou"	Public health, environmental protection, smart transportation, e-government	76.4	63
Hangzhou	2015	"Hangzhou Smart Usage of IT Economy Overall Plan 2015-2020" "Hangzhou City Data Brain Plan"	City brain, smart transport, security, city management, health, tourism	85.6	69
Shanghai	2011	"Action Plan 2011-2013 of Shanghai Municipality for Building Smart City "Outline of the 12th Five-Year Plan for the Economic and Social Development of Shanghai"	Smart transport, digital public services, smart city technology	85.7	71
Shenzhen	2018	"Shenzhen New Type Smart City Establishment Overarching Plan"	Smart transportation, smart government, industry services, livelihood, healthcare	78.4	72
Xiong'an	2017	Hebei Xiong'an New Area Development Outline", "Xiong'an New Area Rongdong District Smart City Special Plan"	Smart city planning, data sharing, AI autonomous driving,	N/A	N/A

Source: Author's compilation

the globe. While the prior four are mature smart cities, Xiong'an is worth mentioning as a case of planning a city as a smart city from its inception rather than making an existing city smart at a later stage.

In comparing the cases as in table 2.3 above, two key similarities are apparent. First, all cities begin their smart city development through the launch of designated policy documents, which provide comprehensive guidance on principles, goals, and technologies. Comparing these documents in detail, they follow a similar structure and are all well aligned with the national level policies listed in the tables above. Second, while each city emphasizes its competitive advantages in certain technologies, most cities are implementing similar solutions within smart transport, cashless society, and online public services platforms

2.1.5 Shanghai

Smart city development in Shanghai started with the 2011 publication of the "Action Plan 2011-2013 of Shanghai Municipality for Building Smart City".(Table 2.4) This made Shanghai the first municipality to have a designated city-wide policy on smart cities, although Ningbo was the first self-proclaimed Chinese smart city. Additionally, from hosting the World Expo in 2010 on "Better cities, better life" Shanghai showed an early commitment to smart city initiatives. Similarly to the case of Beijing, this policy was launched as a way of implementing an underlying development strategy, namely the "Outline of the 12th Five-Year Plan for the Economic and Social Development of Shanghai". The Action Plan is also one of the most comprehensive and detailed smart city policy documents seen in China, and would later inspire a number of other cities. Following its

Table 2.4
Smart City in Shanghai

Smart City initiation year	Key policy documents	Technology focus	EO Intelligence score	Deloitte Super Smart Cities Index
2011	"Action Plan 2011-2013 of Shanghai Municipality for Building Smart City", "Outline of the 12th Five-Year Plan for the Economic and Social Development of Shanghai"	Smart transport, digital public services	85.7	71

launch, the Shanghai municipality has issued a number of policies, and most recently in 2019 the city set up a designated smart city small leading group. The original action plan outlines six areas:

1.**Guiding principles:** Step by step and adaptable implementation.

2.**Information Infrastructure:** Establishing comprehensive IT infrastructure including data centers

3.**Information Sensing and Intelligent Application:** Private and public coordination and cooperation

4.**New Generation of IT Industry:** Being forward-looking and prepared for new technologies

5.**Information Security Protection:** Supervision and support of participants

6.**Main Support Measures:** Comprehensive support including for technology pilots.

Based on being both a pioneer in smart city development as well as establishing substantial support schemes, Shanghai has successfully placed itself on the forefront on smart city technologies consistently listed amongst the top of Chinese smart city rankings. This leading role is particularly clear when it comes to smart transport. By combining information technology and smart infrastructure, Shanghai strengthened information infrastructure and cybersecurity to promote the real-time collection of data of the public transport. This was used for both efficient traffic management by adjusting traffic lights by traffic flows, by digital parking fees, and by providing information to find and book parking spaces. Digital public service provision has been another priority for Shanghai, which led to the establishment of a Citizen Cloud. This works as a platform that aggregates more than 100 government services for residents, including drivers' license information, healthcare records, as well as numerous community services. By December 2017, more than 7 million people, which is about one third of the city's population, was already using the app.

2.1.6 Beijing

Efforts towards making Beijing a smart city started in 2012 with the launch of the policy document "Smart Beijing Activity Outline". This policy document was launched as part of implementing the underlying strategic digitization policy called the "Beijing 12th 5-year plan city digitization and digital infrastructure construction plan".(Table2.5) The smart city policy aim was to turn Beijing from a digital Beijing to a smart Beijing by 2015, by integrating existing smart technologies and developing the infrastructure required to develop more technologies. This was coordinated through a goal-oriented list of activities, within which a number of key technologies would be applied, namely:

1.**Intelligent city operation:** Managing the application of smart city technologies.

2.**Digital life:** Providing information at convenience and encouraging digitization.

3.**Enterprise networks:** Using online enterprise procedures and innovation.

4.**Government services integration:** Digitizing public

Table 2.5
Smart City in Beijing

Smart City initiation year	Key policy documents	Technology focus	EO Intelligence score	Deloitte Super Smart Cities Index
2012	"Smart Beijing Activity Outline". "Beijing 12th 5-year plan city digitization and digital infrastructure construction plan"	Digital company development, cashless society, smart parking,	85.1	70

services based on citizen needs.

5.**Information infrastructure:** Improving high speed data availability.

6.**Smart platforms:** Establishing government and citizen digital platforms.

7.**Application and industry:** Encouraging high end IT industries and innovation.

8.**Developing an innovative environment:** Supporting legal environment and access to financing.

9.**Organizing implementation:** Clear performance indicators and distribution of tasks.

In terms of smart city technologies, Beijing has focused on providing the underlying smart city environment conducive for the market to develop technologies on its own, rather than providing a list of prioritized technologies. The logic is that this environment will create a smart city and smart economy based on market terms, which will increase economic efficiency and provide economic growth. As such, Beijing has some of China's best provision of technologies for cloud computing, big data, mobile internet, and broadband network, including an early rollout of 5G in 2020. This has for example supported the development of the Zhongguancun area, which is home to a long list of Chinese digital companies.

Examples of technologies rolled out in Beijing include 'going cashless', with online payment possible for most transport and retail, such as using mobile phones to pay for public transport rides by scanning QR codes or using NFC technology. This technology was implemented in 2017 covering Beijing's 10 million daily subway rides as well as public busses. Another example is 'smart parking' by which cameras scan cars' license plates allowing the owner to digitally pay parking fees. As of mid 2019 this is already rolled out and functioning across the central city districts, aiming for complete city coverage by the end of 2019.

2.1.7 Guangzhou

Smart city development in Guangzhou started in 2012 with the launch of the "Implementation Principles Related to Smart Guangzhou". (Table 2.6) This policy document provided an overarching direction of smart city implementation, setting out a number of strategic technologies. By 2018, after a number of years of implementation of smart city technologies, Guangzhou launched "2035 Guangzhou" master plan of making Guangzhou a livable and vibrant global city. This is arguably the most far sighted policy document seen in China's smart city development. The principles launched in 2012 still provide the core underpinning of smart city development in Hangzhou, outlining 6 goals:

1.**Strategic IT infrastructure:** Not only meeting needs of today's technologies but anticipating needs of future technologies.

2.**Establish a smart public management system:** Platforms for citizen access and service coordination.

3.**Develop smart industries:** Increase investment in technology hardware and software.

4.**Launch next generation technologies:** Incentivize

Table 2.6
Smart City in Guangzhou

Smart City initiation year	Key policy documents	Technology focus	EO Intelligence score	Deloitte Super Smart Cities Index
2012	"Implementation Principles Related to Smart Guangzhou", "2035 Guangzhou"	Public health, environmental protection, smart transportation, e-government	76.4	63

implementation of new groundbreaking technologies.

5.**Improve citizen IT capabilities:** Online training for citizens of all ages

6.**Comprehensive smart city environment:** Legal, financial, administrative coherence and support for implementing stakeholders.

Guangzhou has been pioneering a number of technologies also seen in other cities, as well as several unique technologies. As with numerous other smart cities, Guangzhou has been rolling out a smart transport system. A sensor platform covers the main districts such as primary and secondary roads, as well as city entrances and exits, in order to provide real-time monitoring and control of the passenger traffic volume and flow at passengers at transportation hubs.

In particular smart health systems has been developed further in Guangzhou than in other places. The city has launched a regional health information platform that collects patient records from the city's five main municipal hospitals, currently storing over million electronic health records of residents. The platform simultaneously allows hospitals and patients to easily access relevant healthcare records when needed. This has allowed for the development of a smart medical app, which works as a one-stop online platform for citizens to make appointments, pay hospital fees, as well as have prescription medicines delivered to their homes. Another innovative scheme is the Green City Digital Platform which collects air quality data detected by sensors across a city and predicts values for the upcoming days, allowing measures to be taken in advance to reduce pollution levels and protect people from exposure.

2.1.8 Shenzhen

Smart city development in Shenzhen was officially launched at a later stage than elsewhere, although Shenzhen is home to one of China's high tech manufacturing hubs. As Launched in 2018, the "Shenzhen New Type Smart City Establishment Overarching Plan" lays out the principles, goals, and prioritizes for the timeline of 2018-2020.(Table 2.7) The plan takes into account Shenzhen's strategic advantage in high-tech hardware manufacturing, focusing for example of linking hardware together through an IoT system, as well as providing access for software developers to use the hardware as basis to develop smart solutions. The plan outlines six goals, towards which smart city development must contribute:

1.**Comprehensive city awareness:** Technologies should collect all relevant data on security, transport, environment, and more.

2.**One-step public services:** Online access to public service through ID number and face scan.

3.**Overall data availability:** Access to databases of all collected data to be used for big data solutions.

4.**Connected responsiveness:** Using data for public security by increasing speed, accuracy, and coordination.

5.**Incentivizing innovation:** Developing platforms and data exchange for public usage.

6.**Smart circumstances:** Public, private, and social coordination via designated platforms.

In terms of technologies, Shenzhen has a focus on smart

Table 2.7
Smart City in Shenzhen

Smart City initiation year	Key policy documents	Technology focus	EO Intelligence score	Deloitte Super Smart Cities Index
2018	"Shenzhen New Type Smart City Establishment Overarching Plan"	Smart transportation, smart government, industry services, livelihood, healthcare	78.4	72

transportation, smart government, healthcare, industry services, and livelihood. While the prior three are implemented with similar technologies as in numerous other Chinese cities, Shenzhen sets itself apart on the latter two.

When it comes to supporting smart industries with services, Koubei, an online to offline local life services platform under Alibaba, is collaborating with businesses to develop smart shopping and logistics methods. This includes integrating online and offline channels with QR codes to provide industry solutions for merchants. As such, it works as a smart IoT platform linking up different sectors including transportation, logistics and community life, to take advantage of the presence of the whole smart city supply chain present in the city.

In terms of smart livelihood, the Shenzhen Municipal Public Security Bureau provides online police services and three kinds of household registration migration services, through its online platform. Citizens can save time queuing and directly log on to the online service platform to perform registrations online, and manage household matters by logging in with facial recognition.

2.1.9 Hangzhou

Smart city development in Hangzhou began in 2015 with the issuance of the policy document "Hangzhou Smart Usage of IT Economy Overall Plan 2015-2020". (Table 2.8) Since then, another three policy documents have been launched, the first two giving more detail on how implementing the overall plan through IT infrastructure construction and coordination contributes to turning Hangzhou into a smart city in the future, while the last policy document as of February 2019 focuses specifically on the city brain concept. Following a similar structure to most of Chinese smart city policy documents, the plan outlines a number of key priorities while Hangzhou's plan differs by putting the emphasis on developing the IT economy as a means towards smart city development:

1.**Prioritizing smart industry:** Facilitating and allocating resources to strategic technologies.

2.**Smart public services:** Providing services through online platforms.

3.**IT economy infrastructure:** Establishing and integrating IT infrastructure as prerequisite for all smart city technologies.

4.**Integrating smart industry:** Using IT technologies in the overall city planning and management.

5.**Designated working group:** Ensuring consistency in implementation and continuation of policies and initiatives.

While implementing a number of solutions seen in other cities such as smart transport, e-government, and healthcare, Hangzhou's unique smart city technology is its ambition in developing a city brain as a new concept. This means developing a system that collects data, analyzes, and acts instantaneously. Its first application is within transport where the city brain uses cameras systems and sensors to collect real-time data on road conditions in terms of traffic, accidents, and weather. This data is then used in the AI hub, managing traffic signals at intersections increasing efficiency of traffic flows and allowing emergency vehicles to avoid

Table 2.8
Smart City in Hangzhou

Smart City initiation year	Key policy documents	Technology focus	EO Intelligence score	Deloitte Super Smart Cities Index
2015	"Hangzhou Smart Usage of IT Economy Overall Plan 2015-2020" "Hangzhou City Data Brain Plan"	City brain, smart transport, security, city management, health, tourism	85.6	69

red lights. This system as applied to the transport sector initially, can later be expanded to other sectors while eventually becoming a single integrated cross-sector smart platform working throughout the city. More details on this concept and its implementation are given in chapter 3 below.

Hangzhou furthermore has one of the most advances smart security systems in China. This covers a public safety control network managing by the police, which is based on cloud computing, big data, and a Mobile Police System. From this outset the 110 Social Emergency Response Platform has been effective in improving police performance by increase response time and information accessibility.

2.1.10 Xiong'an

As a city to be built from scratch, Xiong'an was launched in April 2017 with the ambitions of being a smart and sustainable city at the core. Issued in April 2018, the "Hebei Xiong'an New Area Development Outline", highlighs how smart technologies will be applied through the city's development. In that sense it has not been necessary for Xiong'an to issue designated smart city policy documents, because the city inherently has the ambition to be smart, which is clear in all policy documents. Yet, to develop such smart city technologies the policy document "Xiong'an New Area Rongdong District Smart City Special Plan" was launched in October 2018, outlining a plan for concentrating technology companies in that district.(Table 2.9) The "Hebei Xiong'an New Area Development Outline" document is much longer and more comprehensive than designated smart city policies seen in other cities, since the outline is the strategic document for establishing a city from scratch to become a modern, low-carbon, innovation-driven smart city with a population of more than 5 million. The outline provides a list of priorities towards with smart city technologies will be applied, described in the four components of chapter 8 titled "Establishing a Green Smart City":

1.**Ensuring green and low-carbon development:** Using the best technologies on the market to protect the environment while simultaneously developing new solutions.

2.**Establish a green city management system:** Constructing infrastructure and systems required to manage, water, energy, traffic, security, and more.

3.**Reasonable openness and coordination:** Ensuring multi-level openness of the smart city system to involve private sector and the public to stay continuously engaged.

4.**Systematically establish a big data city:** Ensuring digitization of the city's development, and ensuring databases and systems of enforcement.

While using smart city technologies as the very basis for establishing the Xiong'an New Area, a number of specific technologies sets the new city apart from other smart city initiatives in China. As a prestigious example, Xiong'an is pioneering China's AI autonomous vehicles. Self-driving busses are already on the roads in Xiong'an, and such vehicles will have designated lanes on high-ways to Beijing. The companies developing the technologies have also been allowed to do tests in Xiong'an. In terms of implementing technologies certain challenges encountered in other cities can be avoided. For example, since the smart city construction will established from a blank slate, the issue of data silos can be avoided. To ensure this, Xiong'an has created a digital group to build a data management integrated

Table 2.9
Smart City in Xiong'an

Smart City initiation year	Key policy documents	Technology focus	EO Intelligence score	Deloitte Super Smart Cities Index
2017	Hebei Xiong'an New Area Development Outline", "Xiong'an New Area Rongdong District Smart City Special Plan"	Smart city planning, data sharing, AI autonomous driving,	N/A	N/A

Table 2.10
Comparison of Smart City Technologies

Technology	Private sector companies	SDGs addressed	Most advanced Cities	Challenges
Mobility	Wanxiang, JDD, Huawei	SDG 9: Industry, Innovation, & Infrastructure SDG 11: Sustainable cities and communities SDG13: Climate action	Shanghai, Beijing, Guangzhou, Hangzhou	Camera infrastructure, data access, legal support,
Buildings and housing	Wanxiang, Founder	Goal 8: Decent work and economic growth, Goal 11: Sustainable cities and communities, Goal 13: Climate action	Hangzhou, Guangzhou, Shanghai	High up-front costs, complicated and uneven legal circumstances
E-Payment	JDD, Alibaba, Tencent	SDG 5: Gender Equality, SDG 9: Industry, Innovation, and Infrastructure, SDG 10: Reducing inequalities, SDG 12: Responsible Consumption and Production.	Hangzhou, Shanghai, Beijing,	Proliferation of smartphones and mobile internet, up-front costs of retrofitting commuter infrastructure
Smart governance	JDD, Founder, Alibaba	SDG 11: Sustainable Cities and Communities, SDG 16: Peace, Justice, and Strong Institutions, and SDG 17: Partnerships for the Goals	Shanghai, Hangzhou, Suqian, Changsha, Chengdu	Universal access to platforms, physical and digital infrastructure
Energy	Wanxiang, AI Park, State Grid Corporation of China, China Southern Power,JDD	SDG 7: Affordable and Clean Energy, SDG 11: Sustainable Cities and Communities, and SDG 13: Climate Action	Shanghai, Guangzhou, decentralized pilots	Physical infrastructure costs, risks from system transformation
Environment	Wanxiang, Institute of Public and Environmental Affairs,	6: Clean Water and Sanitation, SDG 11: Sustainable Cities and Communities, SDG 15: Life on Land.	Qingdao, Wuhan, Beijing	Balancing environmental and economic goals, commercializing new green technologies
Resilience	Wanxiang, Xinchao	SDG 10: Reducing Inequality, SDG 11: Sustainable Cities and Communities, and SDG 13: Climate Action	Shanghai, Wuhan, Sanya, Beijing	Integrating sponge technology into city planning, short term expenses
Waste Management	Aihuishou, Xiaohuanggou, Dabashou	SDG 9: Industry, Innovation, and Infrastructure, SDG 11: Sustainable Cities and Communities, SDG 12: Responsible Consumption and Production.	Ningbo, Shanghai, Hangzhou	Collection and recycling standards, replacing informal waste collection
Security	Huawei, HIK Vision, Intillifusion	SDG 5: Gender Equality, SDG 11: Sustainable Cities and Communities, and SDG 16: Peace, Justice, and Strong Institutions.	Hangzhou, Shenzhen	Data integration and availability, personal data security.
Gender equality	Alibaba, Tencent, Didi	SDG 5: Gender Equality, SDG 8: Decent Work and Economic Growth, SDG 16: Peace, Justice, and Strong Institutions.	Hangzhou, Shenzhen, Guangzhou, Beijing	Including gender issues in smart city policy and planning
Employment	51job.com, Zhaopin	SDG 8: Decent Work and Economic Growth, SDG 9: Industry, Innovation, and Infrastructure, SDG 10: Reducing Inequality.	Xian, Shanghai, Shenzhen	Labor force adaption, unemployment stemming from automation
Household and daily life	JD , Huawei, Wanxiang, Tencent, Ele.me, Alibaba	SDG 10: Reducing inequality, SDG 11: Sustainable Cities and Communities, SDG: 12 Responsible Consumption and Production	Ningbo, Shenzhen, Shanghai, Guangzhou, Beijing,	Providing inclusive services to low-income sand less technically capable segments of society
Inclusive finance and crowd funding	JD , Alibaba, Tencent, Demohour, ZhongChou, AngelCrunch	SDG 5: Gender Equality, SDG 9: Industry, Innovation, and Infrastructure, SDG 10: Reducing Inequality.	Hangzhou, Shenzhen, Beijing	Smartphone and internet access, information reliability and confirmation
5 G	Huawei, China Mobile, China Unicom	SDG 9: Industry, Innovation, and Infrastructure, SDG 11: Sustainable Cities and Communities,, SDG 12: Responsible Consumption and Production.	Xiongan, Beijing, Fangshan, Shanghai	Construction costs, national security concerns inhibiting efficient rollout
Health	JDD, Alibaba, Tencent	SDG 3: Good Health and Well-being, SDG 10: Reducing Inequality, SDG 11: Sustainable Cities and Communities	Ningbo, Guangzhou, Hangzhou, Wuhan, Shenzhen	Reaching low-income segments, health industry transformation
Education	Tencent, Xuetangx, Wangyigongkaike	SDG 4: Quality Education, SDG 8: Decent Work and Economic Growth, SDG 10: Reducing Inequality	Guangdong province, Hangzhou	Ensuring quality above dissemination, transforming education system

Source: Author's compilation

system for data sharing. This includes China Telecom and ZTE cooperating to build a commercial IoT platform for data acquisition, which is already in use in other cities for intelligent parking lots, manhole covers and street lights. In supporting this and in order to enhance data transmission, the three major carriers are deploying 5G infrastructure aiming for completion in 2020.

2.2 Urban Technologies Being Implemented Today and in the Near Future

Based on the Chinese government's smart city policy documents and implemented through more than 500 pilot cities, China is home to a wide range of smart city technologies. While smart city technologies can be categorized in many different ways as seen in the literature on the topic, this section presents a list of Chinese technologies with particular potential to support the SDGs in China and across the globe, as categorized by their sector or technology. These technologies are summarized in table 2.10 below, and presented in detail subsequently.

In terms of the types of companies present in China's smart city technology industry, it is clear that China's largest IT hardware, software and online companies are active across many technologies. These include in particular Huawei, Wanxiang, Alibaba, Tencent and JD Digital. This is simply based on the nature of most Chinese tech companies, which diversify themselves across technologies, sectors, and increasingly also geographies by internationalizing. This ambition furthermore provides the prerequisite for using Chinese smart city technologies to promote sustainable urbanization at a global scale.

Considered as a whole, the technologies address a wide range of SDGs, comprehensively promoting sustainable urbanization. Yet, while contributing to some SDGs, technologies can also have negative externalities that need to be considered, in particular as consumption of goods and services may increase and electricity demand may expand. As summarized below, the SDGs towards which Chinese smart city technologies are particularly impactful include SDG 9: Industry, Innovation, & Infrastructure, SDG 11: Sustainable cities and communities, Goal 12: Responsible consumption and production, and SDG13: Climate action.

Considering the cities where smart city technologies are most mature, the clear pattern is that China's largest cities with the highest GDP per capita are overrepresented. This is natural as the IT infrastructure underpinning smart city technologies requires massive expenditures, as well as because using the technologies require a certain number of people with a high purchasing power. By most measures, these cities are Shanghai, Beijing, Guangzhou, Shenzhen, and Hangzhou as elaborated upon in detail above. That being said, smart city pilots and technologies exist throughout the country and many smaller town are pioneering new technologies addressing the specific needs of their local circumstances.

The challenges for scaling up implementation varies across technologies as some have reached maturity in terms of both scale and time, while other technologies remain in early pilot stages. Still, a number of key challenges are present in most cases. These include the development of the basic IT infrastructure of connectivity and censors, such as for managing traffic flows by traffic lights. It also includes data availability as much data is not available to the public and for companies, inhibiting its use for smart city technologies, such as for patient records in smart health services. A final challenge is found in the legal system which may both be lacking, inhibiting, or unstable, which increases the risks of the business models of technologies, such as the changing requirements for on-demand transport services.

In terms of their interdependencies and parallel impacts, the implementation of the solutions creates a complex dynamic which can be approached by a theory of change. In that sense, some technologies have to be in place and some challenges have to be met, in order to effectively implement other solutions. Concretely, the dynamics can be categorized as a list of channels which include but are not limited to the following. First, some SDG targets and indicators are prioritized before others, such as short term unemployment before long term

climate action. Second, the digitization of payment and consumer behavior seen over the last 5 years especially, has provided the prerequisite for more complex services like online asset management or housing rental services. Third, while early technologies had to deal with a lacking and unpredictable regulatory environment, this challenge is being gradually addresses, lowering the transaction costs of later entrants such as for bike sharing business models. Lastly, pilot cities with adequate infrastructure and resources can pave the way in the short term, for other cities to follow in the long term, simultaneously increasing the smart city market size making it more attractive for businesses to get involved, which may lead to a multiplier effect.

As an example of the complexity and dynamics autonomous vehicles provide a case in point. In this instance both a 5G rollout, a comprehensive regulatory system, and a number of companies willing to invest in capital intensive R&D, all have to be set in place before autonomous driving can scale up. We are currently seeing a few number of companies and cities piloting this technology, carrying the blunt of the short term costs and risks affiliated, before the technology matures and the technology can be scaled up in the long term.

Essentially, the general trend is that the more solutions being implemented, the lower the transaction costs for rolling out newr solutions. This can be exemplified by the developing of e-governance apps which cover different cities and functions, by copying and improving on existing models. Ultimately, the transaction costs of implementing new technologies and solutions as well as of integrating these are reduced to the extent that comprehensive systems of combined solutions can be carried out, which is what is often referred to as a 'city brain'. In terms of rollout timelines we are today seeing a great number of parallel and often similar solutions with only few integrated and comprehensive technologies. We can expect such integration to accelerate in the medium term, while the long term seamless integration is clear trend to expect. More details on how this concept integrates the individual technologies of table 2.10 is given in chapter 3 below.

2.2.1 Mobility

Mobility is one of the most mature smart city technologies in China. Most such technologies rely on tying data collection from censors and interconnected physical infrastructure, with apps. These technologies work in particular towards increasing transport efficiency, easing congestion, and reducing air pollution. As such they work towards fulfilling a wide range of SDGs, in particular SDG 9: Industry, Innovation, & Infrastructure, SDG 11: Sustainable cities and communities, and SDG13: Climate action. (Table 2.11)

In China there are three key technologies with particular potential:

- **Smart parking systems:** By installing sensors in each parking space, occupancy can easily be detected, as well as real time information about the nearest parking space and the prices. Such systems can also be linked to e-payment which will decrease the time needed to get in and out of car parks. The most mature case of this technology is seen in Beijing, where the system will

Table 2.11
Mobility

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
Wanxiang, JDD, Huawei	SDG 9: Industry, Innovation, & Infrastructure SDG 11: Sustainable cities and communities SDG13: Climate action	Shanghai, Beijing, Guangzhou, Hangzhou	Camera infrastructure, data access, legal support

CASE STUDY: Huawei and Shenzhen airport: Huawei and Shenzhen Airport are following the Platform + Ecosystem strategy to build a future-ready digital platform. Based on ICT infrastructure, the two parties have integrated IOT, big data + AI, video cloud, geographic information system, and integrated communication platform resources. Handling 50 million passengers a year, Huawei's "smart" solution is saving flyers 15% of their time queuing, using facial recognition and big data analytics to reduce manual passenger identification. Furthermore, ground lighting and aircraft path planning supported by Huawei's IoT technology facilitate the movement of about 1,000 flights a day, cutting the average time from landing to disembarking by 20% to about 15 minutes.

cover the entire city by the end of 2019.

- **On demand transport:** Today, the ride hailing company Didi Chuxing is facilitating 30 million rides a day on national basis. Yet, more sustainable on-demand solutions are also being employed in China today such as on-demand bus services. Various ride hailing services include car-pooling, with smart algorithms and big data used to optimising route-planning.

- **Car-sharing:** This solution adds flexibility to the transport system and develops the sharing economy. In 2010, CC Clubs pioneered China's car-sharing industry, and started to providing mobility services with a small fleet for the Alibaba business campus. By 2018, there were more than 40 car-sharing operators with more than 40,000 vehicles in China, mainly in Tier 1 and 2 cities.

Across the different mobility technologies key challenges for scaling up implementation include the lack of a stable regulatory environment. This was seen with Didi where changing regulations on driver and car registration location limiZted drivers from working in cities such as Beijing. Another common challenge is lack of access to road condition data, which is useful for optimizing choice of transport option and route-planning.

2.2.2 Buildings

Smart buildings use censors and data processing capacity to collect and analyze data as well as make decisions based upon it, both during construction, usage, and maintenance stages. This makes it possible to use water, electricity and other resources more efficiently, improve security, and improve ease of access. Such technologies can work towards Goal 8: Decent work and economic growth, Goal 11: Sustainable cities and communities, and Goal 13: Climate action.(Table 2.12). The most impactful smart building technologies existing in China today include the following:

- Green buildings: A number of technologies can improve the environmental footprint on buildings, such as censors, building materials, and harmonization with local natural environment. With an ambitious goal of 50% of new constructions certified as "Green building" by 2020, such technologies are being rapidly implemented today.

- Smart construction: Virtual reality (VR) technologies can streamline the design process, collect input from users, and identify design flaws early in the construction the process, increasing efficiency of the construction process. 3D modelling is a mature technology and by combining building information modelling (BIM) technology with VR headsets, both architects, carpenters, and future users can now completely enter the virtual environment. This technology has been maturing in China since MOHURD included it a target in its 12th 5-year plan in 2011.

- Smart locks: Rather than using traditional keys, many locks in buildings and apartments use digital solutions, such as swiping cards, scanning via an app, typing codes, and scanning faces, all digitally connected to be managed online. In pilot communities in Hangzhou, such technologies have been part of reducing police

Table 2.12
Buildings

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
Wanxiang, Founder, Ke.com	Goal 8: Decent work and economic growth, Goal 11: Sustainable cities and communities, Goal 13: Climate action	Hangzhou, Guangzhou, Shanghai	High up-front costs, complicated and uneven legal circumstances

CASE STUDY: Wanxiang Innova City: The purpose of the initiative is to establish a smart city where 90,000 people will study, research, work, and reside in an environmentally friendly and smart settlement. Unlike a traditional city, where new technology is added incrementally, the city will be developed with cutting edge technology embedded in the fabric of its building and data infrastructure from the beginning. Furthermore, the city is to be the first digitalized city running on cloud infrastructure enabled by blockchain. Smart buildings will be a central part of developing the city, and will require wide range of smart features to be built into them. With all buildings including such features, it will be possible to achieve scale and efficiency at the city level, that is not possible when only individual buildings have such technologies.

reporting by 28%.

Common challenges faced by smart city building technologies includes financing the large scale up-front investment costs as smart buildings are more expensive. While smart buildings are often profitable in the long run, equipping them with high-tech equipment increases the cost of construction, which is difficult to cover for many developers. Furthermore the Chinese legal environment has complicated renting and ownership structures, such as land being property of the state and most building ownerships set at 70 years.

2.2.3 E-payment

This technology uses digital verification of identity and financial details to carry out transactions in place of cash or other physical means of payment. This enables a series of efficiency improvements such as ease of access to payment methods, speed of processing, safety of transactions, and data collection such as for tax purposes. By these advantages the technology can contribute to SDG 5: Gender Equality (by enabling financial independence), SDG 9: Industry, Innovation, and Infrastructure, SDG 10: Reducing inequalities, and SDG 12: Responsible Consumption and Production. (Table 2.13)

Key applications of this technology include:

- Digital mobile phone payment: By integrating credit cards into third party platforms, consumers can directly make payments through smart phones by scanning or being scanned in physical shops or by verifying payments via platforms for online purchases. This has led to mobile payments being the primary payment method for 92% of people in Chinese cities today.

- Cash-less commuting: In particular since 2016, e-payment for transport has become mainstream in a number of Chinese cities, such as Beijing, Shanghai, Shenzhen, and Hangzhou. This in turn is based on the existence and widespread usage of WeChat and Alipay to which commuters payments are tied. Once rolled out in the above first tier cities, cash-less commuting is rapidly spreading throughout the rest of the country.

- Integrating sustainability: As e-payments allow for the collection of consumption data, it opens to the door to integrating sustainability solutions onto the platforms. This is what Ant Forest has done since 2016 by planting 122 million trees, as rewards for users adopting environmentally friendly consumption behavior. Based on such impact, Ant Forest won the UN Champions of the Earth Award in 2019.

A key challenges to further scaling up e-payment technologies is the spread of smartphone usage and internet access, which are both prerequisites for using the technology. While China has a range of low-end smart phones as well as comprehensive and cheap internet coverage, this is not the case in many developing countries. A second challenge is the cost of retrofitting public transport with screens, scanners, and NFC technology, which for example had to be done for the Beijing transport system.

Table 2.13
E-payment

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
JDD, Alibaba, Tencent	SDG 5: Gender Equality, SDG 9: Industry, Innovation, and Infrastructure, SDG 10: Reducing inequalities, SDG 12: Responsible Consumption and Production.	Hangzhou, Shanghai, Beijing,	Proliferation of smartphones and mobile internet, up-front costs of retrofitting commuter infrastructure

CASE STUDY: Alipay by Ant Financial (Alibaba): Alipay is a third-party online payment platform originating in Hangzhou in 2004, overtaking PayPal as the world's largest online payment platform in 2013 with 900 million users today. Together with WeChat of Tencent, Alipay was instrumental in driving China's cash-less payment revolution which saw a twentyfold increase from 2010 to 2019. The platform is today developing beyond third party payment services to becoming an aggregator of digital services such as wealth management, booking hotels, and food delivery. By increasing availability of financial solutions to low-income segments of society, the platform can further serve development goals of financial inclusion.

2.2.4 Smart Governance

Smart governance systems primarily use data collection and online platforms to engage with citizens and provide public services. This can greatly increase speed, accuracy, and range of public-private interactions by reducing transaction costs, and further improve governance throughout the process by better identifying social issues, improving policy making transparency, coordinating implementation, and gathering input as feedback. This can contribute to SDG 11: Sustainable Cities and Communities, SDG 16: Peace, Justice, and Strong Institutions, and SDG 17: Partnerships for the Goals. (Table 2.14)

Key applications include:

- Citizen engagement: Platforms for asking questions, requesting information, or filing complaints provides a direct way for the government to interact efficiently and effectively with citizens. There are many such cases in China being rolled out since 2010, such as the Chengdu Microblog Service Hall launched in 2013 which has more than a million followers and has addressed more than 16,000 appeals.

- Public service provision: A wide range of public services can be digitally provided without citizens needing to physically travel to government offices and preparing documentations. A number of Chinese government services have launched platforms over the last years, such as the Personal Income Tax app, which can seamlessly integrate citizen information from the employer, bank, and real estate companies.

- Community building platforms: Digital governance platforms can further work to promote and coordinate community building. A large number of cases with great variety have been implemented over the last years, such as the Shenzhen Communist Youth League's platform which facilitates volunteering activities. On the platform volunteers that register are provided with chip cards that giving them access to an online platform with information on volunteer opportunities.

In providing smart governance, a challenge is to provide access to the governance platform for all citizens. This is required both to provide the public services the government is mandated to, as well as to ensure representative participation from citizen consultations. Furthermore, a challenge is to put in place bot the physical and digital infrastructure needed to collect the data required to be used as basis for improved public services, in particular in terms of identifying social issues and collecting feedback in the process of implementation.

2.2.5 Energy

Smart energy systems increase efficiency by both coordinating supply and demand into a single system, as well as by making new sources of energy available to users such as through decentralization. This can reduce the amount of energy lost in the system, reduce the distances energy has to travel from producer to consumers, as well as open doors and reduce transaction cost for market entry for new energy sources. Ultimately, making the energy system more efficient and reducing transaction costs contributes in particular to SDG 7: Affordable and Clean Energy, SDG 11:

Table 2.14
Smart Governance

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
JDD, Founder, Alibaba	SDG 11: Sustainable Cities and Communities, SDG 16: Peace, Justice, and Strong Institutions, and SDG 17: Partnerships for the Goals	Shanghai, Hangzhou, Suqian, Changsha, Chengdu	Universal access to platforms, physical and digital infrastructure

CASE STUDY: JDD in Suqian city, Jiangsu province: Under the brand JD iCity, the company provides big data-powered services to give social credit scores to individuals, businesses, and potential investors for local governments in China, such as in Suqian City. By gathering, sorting and analyzing data originating from the 300 million active JD.com shoppers, from the company's logistic arm and from its fintech business, JD iCity's smart governance technologies aims to improve the daily lives of citizens by improving the efficiency of city governance. Suqian is the first place to roll out this system and serves as a model for implementation elsewhere. Apart from Suqian, JD.com also partners with governments in Chengdu and Changsha in social credit projects.

Sustainable Cities and Communities, and SDG 13: Climate Action. (Table 2.15). The most promising technologies include:

- Smart grid: Launched by Premier Li Keqiang in 2016, the Internet Plus Smart Energy launches Chinese national level efforts for developing smart grids. Furthermore, the 12th 5-year plan identified smart grid development as a national priority. The two companies managing China's grid, namely State Grid Corporation of China and China Southern Power, are currently implementing smart grids throughout the country.

- Electric vehicle charging infrastructure: With electric vehicles in China predicted to increase from four to 74 million between 2020 and 2030, Chinese cities are rapidly putting the support charging infrastructure into place. This installation requires a total investment of approximately 19 billion USD, which already today is supported by the Ministry of Finance providing subsidies to city governments.

- Blockchain energy facilitation: This technology has great potential to transform the energy system as it can directly tie producers to consumers, reducing mediation costs and electricity transportation costs as energy sources can be geographically closer to consumers. While no large scale blockchain schemes are running yet, a number of companies are already operating by providing decentralized electricity solutions.

The main challenges for developing smart energy grids stem from the staggering total value of the Chinese energy system as well as its role in underpinning the economy. Transforming the system does not only require software solutions but also massive investments in the energy grid and new ways of providing electricity such as for electric vehicles. Furthermore, implementation must be stable, gradual, and safe to avoid any power outages from shortage of supply or mismanagement which would severely hurt the economy.

2.2.6 Environment

Smart city technologies to protect and restore the natural environment has great potential in dealing with China's pollution of air, water, and soil. These technologies can be integrated through IoT systems and open databases to effectively involve all stakeholders, as this

Table 2.15
Energy

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
Wanxiang, AIpark, State Grid Corporation of China, China Southern Power	SDG 7: Affordable and Clean Energy, SDG 11: Sustainable Cities and Communities, and SDG 13: Climate Action	Shanghai, Guangzhou as well as numerous decentralized pilots	Physical infrastructure costs, risks from system transformation

Table 2.16
Environment

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
Wanxiang, Institute of Public and Environmental Affairs,	6: Clean Water and Sanitation, SDG 11: Sustainable Cities and Communities, SDG 15: Life on Land.	Qingdao, Wuhan, Beijing	Balancing environmental protection with economic development, commercializing new green technologies

CASE STUDY (Energy): Alpark in Beijing, Tianjin, and Zhangjiakou: The technology of AI Park combines camera and censor systems for monitoring with physical parking infrastructure into a single digital platform. Facilitating the construction of charging stations for electric vehicles on the platform, AI Park provides the prerequisite technology for transforming urban mobility by electrification. The technology allows for the future integration of car batteries with cities energy storage needs, by using car batteries as temporary storage of electricity required for cities to increasingly rely on renewable energy sources which are less stable than fossil fuels.

CASE STUDY (Environment): Blue Map pollution reporting: The online Blue Map platform run by the Institute of Public and Environmental Affairs provides comprehensive coverage of air, water, and soil pollution across China. The platform, which can be accessed by app and website, works as an aggregator of such information and makes the information available to the public. In addition to collecting reports from air quality monitors, the platform allows for any individual to report a pollution case with description, location, and picture. The local government Environmental Bureau is then directly notified of this case and can respond on the platform. The number of cases registered has grown from 6,000 in 2006 to 500,000 today.

is required to address environmental problems. This effort is targeted in particular towards SDG 6: Clean Water and Sanitation, SDG 11: Sustainable Cities and Communities, and SDG 15: Life on Land. (Table 2.16)
The most interesting technologies seen in China today include the following:

- Air quality measurement: While air quality has been improving in Chinese cities over the last year, pollution remains high and consequently a number of smart city technologies are being implemented to address the issue. Since 2013, air quality monitoring systems has been rolled out across China giving the public access to air pollution measurement and prediction over the next days, include recommendations on when to avoid certain activities.

- Water treatment: As China is suffering from water shortages, high pollution levels, and about 20% leakage of urban piping network, smart city technologies are currently being rolled out in a number of places. For example, based on Qingdao's smart city plan the city has implemented new water treatment systems developed by Tongji University.

- Water management: Similarly, a number of new technologies work to integrate water collection and usage, such as by rainwater collection, water re-usage, and drainage. An innovative example is seen in Wuhan Guangu Central Park to be completed in 2019, in which the park collects, stores, drains, and cleans water from surrounding areas, and simultaneously aims to provide an industrial hub of clean tech companies.

A common problem for implementing smart city technologies addressing environmental issues include the complication that protecting the environment may increase costs of production which in turn can have negative economic impacts. As municipal governments strive towards meeting both goals, it remains a delicate balance to prioritize both. Furthermore, while many promising technologies are being developed in labs and research centers, it is difficult to commercialize these due to the high perceived risk.

CASE STUDY: Blue Map pollution reporting: The online Blue Map platform run by the Institute of Public and Environmental Affairs provides comprehensive coverage of air, water, and soil pollution across China. The platform, which can be accessed by app and website, works as an aggregator of such information and makes the information available to the public. In addition to collecting reports from air quality monitors, the platform allows for any individual to report a pollution case with description, location, and picture. The local government Environmental Bureau is then directly notified of this case and can respond on the platform. The number of cases registered has grown from 6,000 in 2006 to 500,000 today.

2.2.7 Resilience

Smart city resilience technologies work to increase the ability of cities to withstand and respond effectively to various types of weather events and climatic changes. With such phenomenon becoming increasingly common as a product of climate change, resilience technologies are relevant both for developing new areas and for protection existing cities. Resilience technologies primarily address SDG 10: Reducing Inequality, SDG

Table 2.17
Resilience

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
Wanxiang, Xinchao	SDG 10: Reducing Inequality, SDG 11: Sustainable Cities and Communities, and SDG 13: Climate Action	Shanghai, Wuhan, Sanya, Beijing	Integrating sponge technology into city planning, short term expenses

CASE STUDY: Xinchao earthquake early warning system: As a smart media company Xinchao manages screens in elevators throughout China, which are being equipped with sensors to detect and warn passengers of emerging earthquakes. This further allows elevators to automatically respond by stopping or moving to the nearest floor before an earthquake hits which can pose a series danger, which is normally not possible to detect in advance.

11: Sustainable Cities and Communities, and SDG 13: Climate Action. (Table 2.17)

The most important technologies are the following:

- Weather prediction and action: Smart cities can become resilient to extreme weather events by first being better at predicting how weather will impact the city as well as integrating this information into the city's management system. This is currently being carried out under the Hangzhou City Brain initiative, where current and future weather data is integrated into the city traffic management system who's algorithm in turn optimizes travel flows.

- Smart warnings: Another way for smart cities to act based on improve weather data is to communicate directly with citizens. This can be done via designated platforms, text messages, and screens along roads. Such a system has been in place in Beijing for a number of years, by which the municipal government informs all resident of Beijing of potential hazards of floods, fire, air pollution, sand storms and more. With knowledge of the geographic location of each cellphone user, this information is being increasingly tailored.

- Sponge city technology: Since 2014 China has been implementing its Sponge City Plan which makes cities greener and more resilient by adapting and utilizing local natural environments, especially in terms of rivers and rainfall. Total investment has been measured to 1.5 trillion USD for the 657 cities in the plan. Wuhan is a success story of such technology as it paved over many rivers and lakes in its development process, until implementing sponge city technology to manage floods.

The primary challenge associated with smart city resilience technology is the difficulty of integrating all real estate development and urban planning with resilience principles. Using these principles in practice are also more expensive in the short term, even though it is profitable in the long run as cities avoid substantial costs from weather damage.

2.2.8 Waste management

Recently surpassing USA as the world's largest waste creator, smart city technologies can play an important role in dealing with this problem. Such technology includes sensors in bins, real-time databases on waste circumstances, and waste treatment technologies such as for the purpose of recycling. This technology addresses SDG 9: Industry, Innovation, and Infrastructure, SDG 11: Sustainable Cities and Communities, and SDG 12: Responsible Consumption and Production. (Table 2.18)

China is a world leading country across a number of technologies:

- Waste collection sensors: With mandatory waste sorting in the process of being implemented throughout China, this has been taken as a business opportunity by many waste management companies who have installed smart bins as pilots in a number of cities. One of the most innovative companies in the field is the Shanghai based AI trash bin company, Alpheus.

- Electronics collection and recycling: As electronics are both more valuable at discarding time as well as more harmful to the environment, such products need designated collection and recycling methods. An

Table 2.18 Waste management

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
Aihuishou, Xiaohuanggou, Dabashou, JDD	SDG 9: Industry, Innovation, and Infrastructure, SDG 11: Sustainable Cities and Communities, SDG 12: Responsible Consumption and Production.	Ningbo, Shanghai, Hangzhou	Collection and recycling standards, replacing informal waste collection

CASE STUDY: Dabashou in Ningbo: With recycling bins installed at more than 5.000 communities in Ningbo by the end of 2020, Dabashou is one of the largest and most mature recycling companies in China. The business model cover the entire was management ecosystem of waste separation, collection, as well as recycling itself. The bins accurately identify the garbage and pay customers by the amount given. In addition to image identification and real-time payment, the smart waste sorting bins also use big data, cloud computing, and accurate location, which enable users to trace their waste. This information is a central component to create an integrated system of waste management for a city as a whole.

innovative way of doing this is done by the company Aihuishou which sets up unmanned smart machines in malls and communities where consumers can sell their old electronics such as smart phones to the company, which may then sell the product to a designated recycling company.

- Waste information: As cities in China are transforming waste management systems, citizens need education in how to participate in this system. Towards this purpose JD AI has launched an open-source app that via voice and pictures can help citizens determine types of trash while providing them with concrete actions to dispose and recycle.

Common problems for applying the technology include the issue of standardizing definitions of waste. Today China has significant number of waste management companies that both collect and compensate based on their own processes, and while public standards exists for some waste type such as wet and dry waste, this is not detailed enough to cover the waste collected in practice. Furthermore, as waste collected for recycling was previously informally collected and managed, this industry is being replaced leaving an issue of integrating this workforce into the formal waste management industry.

2.2.9 Security and Safety

Smart city technology can play a central role in making cities safer by improving the ability to identify, analyze, and act upon actual and potential security threats. In China we are today seeing and a rapidly increasing number of cases of rolling out physical censoring infrastructure, implementing big data and AI solutions to this this data, and providing government departments and the public with software tools. These efforts contribute to realizing SDG 5: Gender Equality, SDG 11: Sustainable Cities and Communities, and SDG 16: Peace, Justice, and Strong Institutions. (Table 2.19)

A wide range of technologies exists, such as:

- Video surveillance systems: Video surveillance systems provide law enforcement officers with more eyes on the city, for example allowing police officers to better identify and react to crime. Such systems are being installed throughout China by companies such as HIK Vision, which provides both the surveillance camera equipment as well as software to manage and use such systems.

- Facial recognition: Using the data collected by video surveillance a number of Chinese companies are developing software for accurate facial recognition. This technology provides the ability to accurately identify the person carrying out a crime, without any law enforcement officers present. The company Intellifusion is amongst the leaders in this software which is for example used for identifying jaywalkers in Shenzhen.

- Security apps: Chinese cities are rolling out apps that allow citizens to report cases to security personnel either as individual apps or integrated into public service apps. Hangzhou further has one of the most advances smart security systems in China. For example, Hangzhou has the 110 Social Emergency Response Platform which has been effective in improving police performance by increase response time and information accessibility.

Table 2.19
Security and Safety

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
Huawei, HIK Vision, Intillifusion	SDG 5: Gender Equality, SDG 11: Sustainable Cities and Communities, and SDG 16: Peace, Justice, and Strong Institutions.	Hangzhou, Shenzhen	Data integration and availability, personal data security.

CASE STUDY: Huawei in Shenzhen: Huawai provides a complete package of security technology from hardware to software as well as data collection and data analysis, which has been used for facial recognition in Shenzhen. In 2014 Huawei and the Shenzhen Longgang Public Security Bureau established a facial recognition system, which after more than a year of testing and adjusting was fully operational. As an example of how the system works, the police localized a lost 3 year old boy after being lost for 15 hours, which would not have been possible without the system.

A central challenge to implementing smart city technology in the security field is integrating all information and analytical capacity into an integrated system. Such integration is necessary as many security issues need triangulation from data sources to be identified, like pairing facial recognition with mobile numbers or online purchases. Another challenge arising from such extensive data collection are issues of personal data security, since data leak and hacks may occur, exposing sensitive data such as credit card information.

2.2.10 Gender Equality

Within the wide range of objectives of smart cities, women empowerment and gender equality makes up an increasingly prioritized aspect. Technologies can support this objective by providing better access for women, increasing safety, or by providing greater independence. As such, these technologies contribute to SDG 5: Gender Equality, SDG 8: Decent Work and Economic Growth, SDG 16: Peace, Justice, and Strong Institutions. (Table 2.20)

The below technologies have shown a particular potential:

- Safety in transport: Technologies can improve women's' safety when commuting by identifying and reducing risks as well as by allowing simple reporting of cases. An example include the security measures on China's largest ride-hailing app Didi, which includes digital registration and background checks of all drivers, voice recording of rides, allowing other people to track the ride, as well as an in-app emergency alarm.

- Enabling financial independence: The freedom to make independent financial decisions has been shown to be a key way of promoting gender equality. As we see digital financial services being rapidly rolled out even to low-income segments, this enables women to access retail financial services through their smart phones, and even use this as basis for setting up shops online or access finance for small business start-ups. The services provided through Tencent's Wechat and Alibaba's Alipay are the two most widespread technologies of this category.

- Identifying gender problems: Collecting data on gender forms a prerequisite for identifying gender imbalances in different smart city areas such as workforce, transport, security issues, or tax payments. As China is developing smart cities, this pushed the awareness of gender issues and allows cities to analyze and act upon this information. For example, data on cases of inappropriate behavior towards women in transport has sparked a rollout of counter measures such as women-only carriages on trains in Guangzhou and Shenzhen.

A key challenge to using smart city technology to contribute to gender issues is including such issues into the overall planning of smart city development. Most policy documents outlining smart city development include social issues such as safety and gender, but do not provide a great enough level of detail to make sure that the issues are prioritized in practice. As gender equality is often a side effect of technologies rather than a central goal, it must be clearly specified in order to avoid the risk of being left out.

2.2.11 Employment

Smart city technologies can improve employment

Table 2.20
Gender Equality

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
Alibaba, Tencent, Didi	SDG 5: Gender Equality, SDG 8: Decent Work and Economic Growth, SDG 16: Peace, Justice, and Strong Institutions.	Hangzhou, Shenzhen, Guangzhou, Beijing	Including gender issues in smart city policy and planning

CASE STUDY: Alibaba creating job opportunities for women: As estimated by researchers at Renmin University, Alibaba created 36 million jobs via its online platforms composed of 14 million vendors and 22 million in upstream and downstream sectors. Approximately half of the vendors were women. As such, the platform provides a simple and direct ways for women to participate in the labor market. This working model works well for many women who do not have the flexibility to seek other types of employment, such as office jobs.

circumstances by improving to access to information for all stakeholders in order to ultimately better match supply of labor with demand from employees. Key ways of doing so is via online platforms as well as gathering employment and education history databases. These technologies can contribute to SDG 8: Decent Work and Economic Growth, SDG 9: Industry, Innovation, and Infrastructure, as well as SDG 10: Reducing Inequality. (Table 2.21)

The main technologies seen in China today include:

- Migrant worker opportunities: With approximately 300 million migrant workers in China, facilitating their employment once arriving in cities from the countryside is a massive task with great potential impact. Xi'an has put in place a system that tracks the flows of migrant works and collects data on their skills, in order to better match them with employers and better provide social services to them. For example, this allows migrants to take a job in advance of going to the city instead of after arriving.

- Online job portals: The possibility to instantly search between job openings and candidates online drastically reduces the transaction costs. A number of online platforms exist towards this purpose which are increasingly using big data and AI to match employers and employees. Zhaopin and 51job.com are successful national level examples of such portals.

- HR Management tools: From an employer perspective managing human resources can be a tiresome tasks for which a number of technologies exist. These platforms facilitate clocking in, filing overtime and holidays, and reimbursements, requiring simple approvals from supervisors while greatly reducing the amount of paperwork needed. Alibaba's DingDing is one of the largest software providers for this purpose in China.

Central challenges affiliated with smart city employment technologies includes the labor force adapting to new work opportunities. Such creative destruction may be good for society and workers in the long run but requires a transition which can be costly in terms of temporary unemployment, retraining, and social support. Another challenges is that of automation which may require fewer people to carry out the same task as previously. This frees up labor force to be used for other purposes, but again may encounter short term costs.

2.2.12 Household, Daily Life, and Utilities Management

Integrating smart city technology into each household

Table 2.21
Employment

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
51job.com, Zhaopin	SDG 8: Decent Work and Economic Growth, SDG 9: Industry, Innovation, and Infrastructure, SDG 10: Reducing Inequality.	Xi'an, Shanghai, Shenzhen	Labor force adaption, unemployment stemming from automation

Table 2.22
Household, Daily Life, and Utilities Management

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
JD, Huawei, Wanxiang, Tencent, Ele.me, Alibaba	SDG 10: Reducing inequality, SDG 11: Sustainable Cities and Communities, SDG: 12 Responsible Consumption and Production	Ningbo, Shenzhen, Shanghai, Guangzhou, Beijing,	Providing inclusive services to low-income sand less technically capable segments of society

CASE STUDY(Employment): 51job.com online job-marketplace: As one of China's largest online job platforms, and as listed on the Nasdaq exchange, 51job.com is a key example of how smart city technology can reduce transaction costs in the job markets. While platforms have existed for a number of years, 51.com applies big data analysis to identify job market trends, do head hunting, and better tailor suggestions for both employees and employers. As Chinese workers today change jobs more frequently than in the past, such platforms are critical to lower the transaction costs in the labor market. This is particularly relevant as technologies are disrupting the labor market from new skills requirements and automation. As many countries are undergoing similar trends of urbanization and labor market transformation such platforms using big data analytics have great potential across the globe.

CASE STUDY(Household, Daily Life, and Utilities Management): Alibaba and Ele.me medicine delivery: Through a partnership between Alibaba's healthcare branch, Alibaba Health, and the food delivery company Ele.me, citizens of Beijing, Guangzhou and Shenzhen can now have over-the-counter medicine delivered directly to their door within an hour, 24 hours a day. This service is gradually being rolled out in more cities across the country. Purchases are made directly on Alibaba's Taobao mobile platform within which a new feature of this partnership also allows customers to directly consult pharmacists online before making the purchase.

and seamlessly into the daily life of citizens is a complicated tasks requiring a number of technologies at different levels. These technologies both have to simultaneously provide citizens with a full range of services while reaching low end consumers to ensure inclusivity. This type of smart city technologies support SDG 10: Reducing inequality, SDG 11: Sustainable Cities and Communities, and SDG: 12 Responsible Consumption and Production. (Table 2.22)

The most mature technologies include:

- Smart communities: Making smart city technologies available at the household level is often realized via small scale smart communities. Most urban housing is also organized in gated communities, making this an important level of smart city development. Towards this purpose Tencent Youtu has integrated censors with a software system that allows for property managers to monitor people and car flows, while providing residents with better information, registration services, and direct communication channels. The same system can manage community utilities.

- Online grocery shopping: A central part of city layout is facilitating residents to move to commercial property to do shopping. Digitizing a part of this activity has the potential to save time and energy, while realizing economies of scale for both consumes, producers, and retailers. In addition to online shopping, we are seeing a number of Chinese companies integrating grocery shopping into apps including the big players such as JD, Alibaba, Meituan, Ele.me, and Tencent.

- Online review mechanisms: A smart city technology very successfully imbedded into daily life of Chinese citizens is online search and review apps. These apps allow users to conveniently find and see reviews of for example restaurants, hotels, art galleries, fitness centers and much more. The largest and most extensive of these platforms is Dazhongdianping, with more than 15 billion monthly views.

When implementing these technologies it is critical that the challenge of inclusivity is addressed. In this sense, in order to realize its potential, low-income segments of society as well as less technologically capable people such as senior citizens must be able to use the technologies. This can be done by ensuring apps can run on older phones, under circumstances of low speed connectivity, and on none-mobile platforms such as stationary computers.

2.2.13 Inclusive Finance and Crowd Funding

A number of smart city technologies can include otherwise excluded parts of the population from financial services such as loans, deposits, insurance, or participating in crowdfunding schemes. This is by offering digital financial services, by people having access to mobile phones and internet, as well as software tying together personal and credit information. This technology helps addressing SDG 5: Gender Equality, SDG 9: Industry, Innovation, and Infrastructure, and SDG 10: Reducing Inequality. (Table 2.23)

The most developed technologies include:

- Financial inclusion: Following the process of smart phone and internet expansion in China, digital financial services have proliferated across Chinese society. This allows for automation which reduces the costs of transactions for the financial services provider, providing

Table 2.23
Inclusive Finance and Crowd Funding

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
JD, Alibaba, Tencent, Demohour, ZhongChou, AngelCrunch	SDG 5: Gender Equality, SDG 9: Industry, Innovation, and Infrastructure, SDG 10: Reducing Inequality.	Hangzhou, Shenzhen, Beijing	Smartphone and internet access, information reliability and confirmation

CASE STUDY: JD Equity Crowdfunding Platform: Amongst the many types of crowdfunding, financing a startup by taking an equity stake is an important tool in China to spark entrepreneurship and innovation. The new platform also provides a number of training and support functions for companies throughout the startup lifecycle, intending to improve the chance of success. The platform is open to both professional and retail investors, and aim to financing companies across industries in China.

a business case for providing services at much smaller scale. The largest platform for such services is Alibaba's Alipay, which today is expanding into Africa in partnership with the United Nations.

- SME financing: Small- and medium sized enterprises are often left out of China's mainstream banking system, and digital platforms are therefore working to fill this gap through targeted online loans. Automatically collecting and analyzing data allows the companies to smoothly and accurately estimate credit risk upon which to price financial products. The services provided through Tencent's Wechat and Alibaba's Alipay are the two most widespread technologies of this category.

- Crowd funding: As with SMEs, many startups find it difficult to access financing from banks in China, and therefore digital platforms have been developed designated to raise money bottom-up from people directly. Such crowdfunding can finance projects, productions, or companies themselves in various forms. With more than 400 platforms in existence the largest include JD, DemoHour, ZhongChou, and AngelCrunch.

A central challenges to further scaling up inclusive finance and crowdsources is the spread of smartphone usage and internet coverage, with both necessary to scale up the technologies. Both of these have been rapidly expanding in China over the last years, including through government regulations forcing down data fees from China Mobile and China Unicom. An additional challenge is that of data reliability and clear regulation both for individual customers and companies to be financed. A recent case of this problem materializing is seen in the crackdown on P2P lending platforms in China in 2018.

2.2.14 5G

Increasing wireless data speed can vastly increase the possibilities possible within smart city technologies. Having not only phones but other objects in the IoT connected at higher speeds allow for much more complex and demanding tasks to be carried out, such as improving automated driving, drones, and mobile video services. Rolling out a 5G network can contribute to SDG 9: Industry, Innovation, and Infrastructure, SDG 11: Sustainable Cities and Communities, and SDG 12: Responsible Consumption and Production.(Table 2.24)
Key applications of the technology include:

- Augmented and virtual reality: As various types of video require high bandwidth speeds and complete reliability, these can only be rolled out wirelessly with 5G availability. China is a leader in developing both hardware and software in this field, as led by companies such as 7D Vision Tech and DPVR.

- Autonomous vehicles: 5G speeds are necessary for autonomous vehicles to communicate at adequate speed with their surroundings. The 5G network transmits data from car sensors, roadside sensors, and video cameras installed above the road to a local data center, which analyzes the information and sends it back to the vehicles to help them navigate. In Xiong'an the development of both 5G and autonomous vehicles

Table 2.24
5G

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
Huawei, China Mobile, China Unicom	SDG 9: Industry, Innovation, and Infrastructure, SDG 11: Sustainable Cities and Communities,, SDG 12: Responsible Consumption and Production.	Xiong'an, Beijing, Fangshan, Shanghai	Construction costs, national security concerns inhibiting efficient rollout

CASE STUDY: Huawei 5G rollout: As China's largest 5G network infrastructure supplier, Huawei is current in the process of constructing China's 5G network. For example, China Mobile as China's largest telecommunications provider is in the process of rolling out 5G in 40 cities and has awarded Huawei 50% of the 5G network construction contracts. This pace will lead to widespread commercialization of 5G in China already in 2020. Furthermore, as a technology company providing a long range of products outside 5G infrastructure, Huawei launched its first 5G compatible smart phone in August 2019.

therefore go hand in hand

- Internet of Things: As specifically included in China's 14th five-year plan, the government is promoting IoT developing, such as 5G infrastructure rollout. While many physical devices are already connected with and without wires in much smart city technology, 5G speed substantially increases the possibilities. While impacting all smart city technologies it will be particularly impactful on robotics, smart agriculture, an digital healthcare.

A key challenge of 5G is the costs of rolling it out. This includes 5G cell towers to be installed throughout cities and country and although 5G cell towers are smaller and have better range than predecessors this will be a vast up-front costs to be made, before reaping the benefits over time. A second challenge that has drawn the public's attention in recent years is the issue of foreign companies owning and operating 5G technologies, as this may pose a security threat. Technical and legal solutions need to be in place to avoid this threat materializing.

2.2.15 Health

As China continues to expand public and private health coverage and as its population ages, smart city health technologies is a central component in doing so successfully. These technologies can reduce costs and increase accuracy throughout the chain from diagnosis, treatment, and recovery, making high quality health services available to more people. In doing so it addresses SDG 3: Good Health and Well-being, SDG 10: Reducing Inequality, and SDG 11: Sustainable Cities and Communities. (Table 2.25)

Such technologies include:

- Cloud hospital services: Integrating hospital services into a single digital platform can improve efficiency for patients and hospitals. The Ningbo Cloud Hospital aggregates the resources of 100 medical institutions into a single network facilitating appointments, online doctors consultations, as well medicine prescriptions and deliveries as pharmacies are also integrated into the network. Similar platforms are being rolled out in Hangzhou, Guangzhou, and Wuhan.

- Big data diagnosis: Collecting medical details for large numbers of patients makes it possible to more accurately make a diagnosis based on big data analysis. In 2018 China laid the groundwork for this technology by setting up national health data network with a goal of developing a personalized health profile for each citizen, ranging from clinical records to dietary guidelines, as managed under the China Health Information and Big Data Association.

- Augmented and virtual reality operations: Another promising smart city health technology is doctors using AR and VR to perform trainings remotely, with the goal of carrying out surgery remotely as well in the future. Superb Medical Skills is the first company in China using this technology, as supported by more than 3,700 doctors in delivering clinical training to both doctors and trainees through VR headsets.

Two key challenges exist for scaling up this technology. First, this technology is vulnerable to the requirement of

Table 2.25
Health

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
Superb Medical Skills, Tencent, Alibaba	SDG 3: Good Health and Well-being, SDG 10: Reducing Inequality, SDG 11: Sustainable Cities and Communities	Ningbo, Guangzhou, Hangzhou, Wuhan, Shenzhen	Reaching low-income segments, health industry transformation

CASE STUDY: Tencent Trusted Doctors: Integrated into Wechat as a mini-program, the technology allows for online consultation with more than 440,000 doctors. The platform uses AI to find the best matches between patients and doctors. As a future extension of this technology, an Intelligent Health Terminal which can do simple health checkups and healthcare products at the workplace, will be able to provide a variety of self-testing products, such as urine testing, early pregnancy testing, ovulation testing and genetic testing, as well as health care products such as sanitary napkins and condoms.

patients having access to relative sophisticated mobile phones, as pictures and high speed connection is often required. This risks cutting off low-income segments of society, which in practice may be the group in the greatest need of getting access to healthcare. Secondly, it requires a substantial change in organization structure and management of hospitals to provide digital services, constituting a major costs of adjustment in the short term.

2.2.16 Education

Smart city education technology primarily uses online platforms to facilitate access to educational material and deal with practicalities on enrollment and exams. It contributes to ensuring education quality and access as well as allowing for tailored education to meet individual students needs. As other smart city technologies mature, this opens a window for education as well such as through VR and live discussions with teachers. This technology can support SDG 4: Quality Education, SDG 8: Decent Work and Economic Growth, as well as SDG 10: Reducing Inequality.(Table 2.26)

The main applications seen in China are the following:

- Cloud campus: This technology can integrate campus teaching, research, management, and practical information onto a single platform accessible by phone and computer. A successful example is the campus cloud set up by Guangdong Telecom providing this service to 78 schools and a total of 150,000 students. This includes a new integration of school libraries allowing for online book exchanges and ordering.

- E-learning: As also proliferating on a global scale such with Khan Academy and Coursera, China is home to a number of similar online education platforms. The main ones include Xuetangx and Wangyigongkaike which are also developing smart technologies to better tailor and test students. This technology has particular potential to streamline education quality across the country.

- School construction: By integrating data about number of current students, birthrates in different areas, as well as migration flows, it is possible to make better informed decisions on where to construct schools. This is currently taking place in Xi'an where the education department, health department, and public security bureau is sharing data to improve public education provision.

A key challenge of this technology is ensuring the quality of the education, as education can now be cheaply disseminated. The ability to cheaply provide access, should not be at the cost of improving education quality and tailoring, especially since education is changing rapidly today to meet the changing needs of the labor market. An additional challenge comes from integrating current manual education practices with new digital and online models especially in schools with a lack of physical technical equipment. If the government promotes the development of online teaching material, it is consequently critical that equipment to use it is supplied throughout the school system and not just in wealthier areas.

Table 2.26
Education

Key private sector companies	Primary SDGs addressed	Most advanced pilot cities	Challenges
Tencent, Xuetangx, Wangyigongkaike	SDG 4: Quality Education, SDG 8: Decent Work and Economic Growth, SDG 10: Reducing Inequality	Guangdong province, Hangzhou	Ensuring quality above dissemination, transforming education system

CASE STUDY: Tencent Education: As a new brand under the Tencent umbrella, the platform consists of 20 products across all six of the firm's business groups, providing online classes, personal development advice, as well as overseeing students in the classroom. This is based on Tencent existing education service experience having worked with 15,000 schools and 70,000 other educational institutes with a reach of more than 300 million users in the education sector.

CHAPTER 3

A WIDER USE OF CITY BRAINS

Hangzhou, China

Chapter 3 - A Wider Use of City Brains

3.1 Introduction

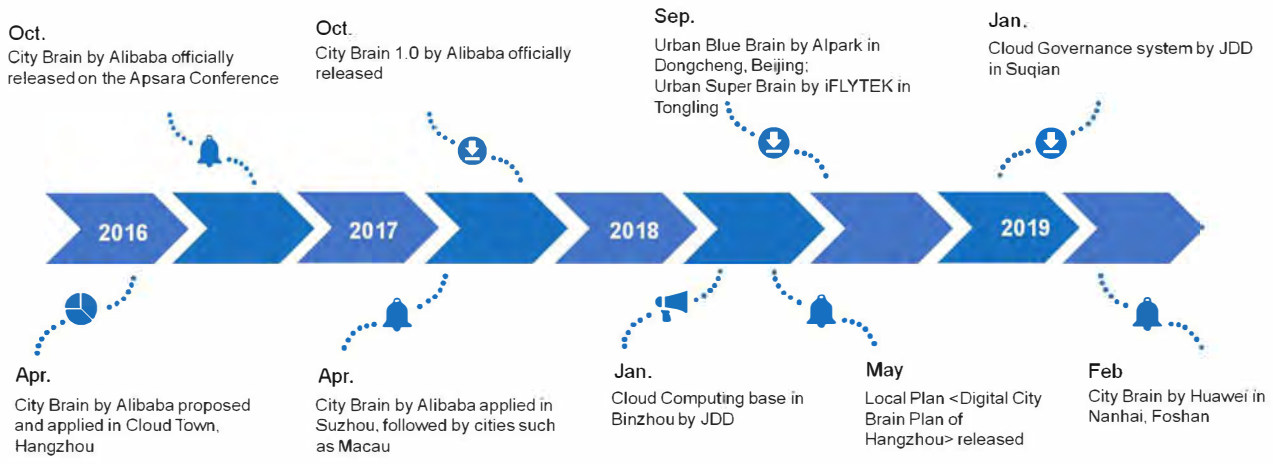
Since there are many technologies based on AI and Big Data (see Chapter 2), it is required to integrate the technologies and apply them to cities with the maximized benefits. The city brain, assembling several technological achievements in AI, Big Data and Cloud computing, might be the answer to how the technologies contribute to a city in real daily life.

The first city brain project was announced to be implemented in Hangzhou on the Apsara Conference in 2016 (Wang, S. 2016). It can make a real-time analysis of urban situations based on the urban operation data, such as the data of transport, energy, and water supply, to automatically distribute the public resources in a smart way. Since the first application of the city brain was released, there have been 23 cities all over the world that have introduced the City Brain by Ali (Liu 2019). In addition to the City Brain by Ali, similar concepts have also been suggested such as the "City Operating System" by JDD (JDD n.d.a) and the "Smart Parking Management platform" by Alpark (Anon. 2019a). Both are developed to offer some urban services, with increasing practical applications in different places.

There are definitions of city brain by some scholars. For instance, Gong (2018) defining it as "a smart city system" and Liu (2019) describing it as "a new architecture of smart city based on the internet brain". However, an accurate definition may be concluded from the common character of the practical systems above. In this case, a city brain is like a city-level AI system serving urban management in one or multiple scenes.

This chapter aims to have a comprehensive introduction of the city brain, including what it is, how it can serve a city, how it works in practice, and what experience it can offer for urban development in the future. Generally, a city brain can help in a variety of ways, including managing the transport, mitigating traffic congestion, keeping public security, motivating the local economy, managing environmental pollutions and offering parking management. Although it is criticized for some disadvantages, such as a lack of theoretic studies, risks of data safety, and exclusiveness in construction mode, it does benefit cities in many ways, particularly increasing traffic efficiency and accelerating administrative processes. City brain is not only innovation of urban governance, but also an inspiration on how data can benefit people. With stronger functions being developed and more cities applying it, city brains are being developed for wider use in future urban development.

Fig 3.1
Timeline of the key events in the development process of the city brain



3.2 What is a city brain

3.2.1 City Brain by Ali

3.2.1.1 What is a City Brain

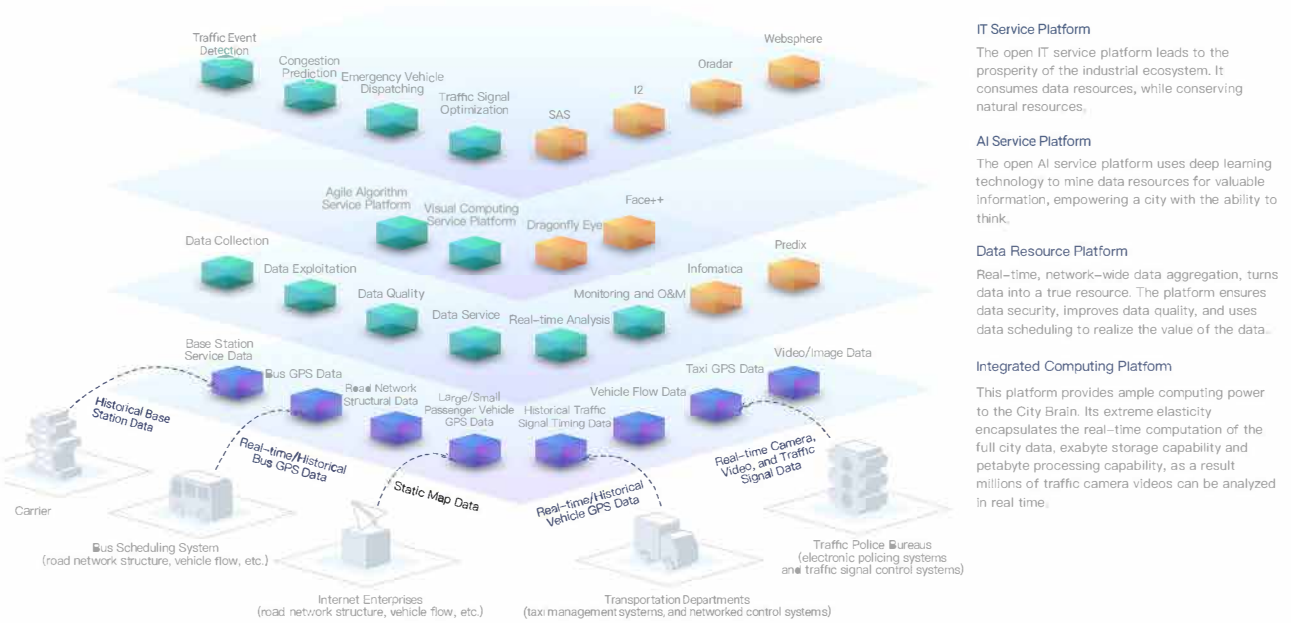
In the history of urban development, the infrastructure "roads" was developed in Rome in the time of horse-power while the infrastructure "electrical grid" was built in New York in the time of electricitypower. With the development of Internet of Things (IoT), Big Data and Cloud Computing, it is the time of computing-power and Jian Wang, the Chairman of Alibaba Technical Committee, regards the City Brain as the new urban infrastructure required for now (Wang, G. 2019).

According to Ali's website (Alibaba Cloud n.d.), the City Brain aims to equip cities with a data-driven governance system. There are four services a City Brain can provide: Event Detection and Reaction, Social Governance and Public Security, Traffic Congestion and Traffic Signal Control, and Public Transportation Management (Alibaba Cloud n.d.). It "holistically optimizes urban public resources by instantly correcting defects in urban operations by utilizing comprehensive real-time city data" (Alibaba Cloud n.d.).

Below is the structure of a City Brain to show it works (see Figure 3.2). The lowest level Integrated Computing Platform collects static and real-time data from multiple sources, such as Traffic Police Bureaus, Transportation Departments, and Bus Scheduling System, and provides ample computing power to the City Brain. Data processing steps such as Data Exploitation and Real-time Analysis are mainly at the second-lowest level Data Resource Platform, which ensures data security, improves data quality, and uses data scheduling to realize the value of data. At AI Service Platform, more valuable information is explored to empower a city with the ability to think by deep learning technology that is supported by various algorithms. The top-level is IT Service Platform. It offers functions such as traffic event detection and emergency vehicle dispatching and contributes to the prosperity of the industrial ecosystem.

In general, as Wang describes, the City Brain is an AI infrastructure serving cities (Wang, G. 2019). It is a city-level AI system offering urban management solutions, such as event detection, traffic signal control, and public transportation management, based on static and real-time data by technologies like Big Data computing, real-time video recognition, and deep neural network

Fig 3.2
The construction structure of City Brain



Source: (Alibaba Cloud n.d.)

physical architecture.

3.2.1.2 How a City Brain serves a city

-Event Detection and Reaction

By integrating and analysing the data from internet and alarm systems, a City Brain recognizes traffic accidents and congestion places from video footages in the city. It also integrates the commands from police, fire management and rescue departments and dispatches emergency vehicles by the smart vehicle dispatching technology. This technology coordinates the traffic lights to offer emergency vehicles traffic priorities.

According to the data in Hangzhou, there are 3,400 monitors checking the real-time situations on the roads in the whole city every two minutes. The City Brain, which can recognize 110 types of incidents, perceives more than 30,000 incidents every day with an accuracy over 95%. It also dispatches traffic policemen to the incident sites once it finds an incident. In addition, the City Brain has achieved a save of 50% of the time that emergency vehicles usually need to arrive at the accident places in Hangzhou (Sun et al. 2019).

-Social Governance and Public Security

- **Administrative cooperation system**

This cooperation system aims to automatically deal with on-site and online administrative issues by classifying problems and assigning tasks to solve the problems. There is a similar cooperation system "Three Maps in One", which is mainly responsible for supporting the police. It visualizes the real-time spatial distributions of police strength and security issues so that it can streamline the way to locate the police staffs (Sun et al. 2019).

Currently, the cooperation system can recognize and snapshot the illegal behaviours of retailers or individuals with an accuracy rate over 90% in Hangzhou (Sun et al. 2019).

- **Smart community**

Eight systems are supporting the City Brain when it is applied at a community level, including video monitoring, gate control, entry management, vehicle entry management, trespass alarm, electronic patrol, face snapshot, and fire management.

Since the City Brain was applied in the construction of smart community in Xiangshu Garden in Hangzhou, the number of security issues has decreased by 28% in total. In addition, no criminals or fires happened here in the first six months in 2018. Referring to the "8 + n" model of Xiangshu Garden, the government plans to complete the construction of about 500 smart communities by 2019, 1300 communities by 2020, and 800 more by 2021.

-Traffic Congestion and Traffic Signal Control

The City Brain integrates the data from AutoNavi, traffic police Weibo accounts, and video cameras to comprehensively assess the real-time traffic conditions on highways and street roads. It precisely analyses and figures out the causes of congestion and optimizes traffic lights throughout the city in real-time to reduce the congestion on the whole (Alibaba Cloud n.d.).

At present, this function of the City Brain has covered about 1300 crossings and connected about 4500 monitoring devices (Anon. 2018a). The streamlined traffic management has led to an increase of 11% in traffic speed on Shixin Rd (25km) and a decrease of 10% in the commuting time on Shangtang Rd (22km) (Luo 2016).

-Public Transportation Management

- **Public transport optimization**

The City Brain aims at an overall improvement of public transport efficiency. It can recognize the high-density areas and estimate how much public transport resources are required. Based on the real-time data collected,

it makes an analysis of potential passenger flows and streamlines the plan of bus routes, the relocation of bus stops, and the operation time. It also optimizes the taxi operation and consequently reduces the number of people staggering in one place.

There have been two bus routes optimized by the City Brain in Hangzhou, which increases the efficiency of public transportation (Sun et al. 2019).

- Intelligent parking service

The parking system operated by the City Brain presents the real-time number of parking automobiles, the number of available parking places, transfer rate[1] and a forecast of the parking situation in the coming time slot.

There is an intelligent parking system in Wulin operated by the City Brain, including an intelligent parking guidance system and an invisible payment system. This service aims to be installed in all the parking places in Wulin by the end of 2019 with a new function staggered payment[2] (Sun et al. 2019). (Figure 3.3)

3.2.1.3 How the City Brain by Ali will be developed

At present, City Brain developed by Ali has been applied in 23 cities in the world, such as Quzhou, Macau and Kuala Lumpur (DZWWW, 2019). With more cities equipped with City Brains, there will be an increase in the services offered by the City Brain. The comprehensive version of City Brain has been released in December 2018. In addition to the current systems transport, police and urban management, the new version supports the medical system and tourism system. It will offer nine public services in addition to the current ones, for example sharing parking places, monitoring the particular types of automobiles and offering electronic tourism card for suburban travelling (Sun et al. 2019).

The ambition of Ali in the development of City Brain is not limited in popularizing it in more cities or enabling more functions. According to Wang (Luo 2016), Ali aims to develop the City Brain as a city-level AI platform to offer comprehensive services to benefit citizens. It will involve in partners offering services in different industries,

Fig 3.3
The screen to present the real-time transport situations using maps, index and figures in Hangzhou

Source: (http://www.sohu.com/a/116546074_232663)

1.Transfer rate: It is determined by dividing the number of available parking spaces into the number of vehicles parked in those spaces in a stated time period. It reflects the serving capability of a parking lot.
2.Staggered payment: drivers are free to make a remote payment anytime within 15 minutes (a set time period) before the automobile is sensed to leave. By making staggered payment available, the queueing time for payment can be greatly reduced.

such as infrastructure construction Foxconn and logistics service Green Hand, and create an "IoT ecology" (Luo 2016). This means Ali does value the City Brain and build it as a new urban infrastructure in the time of data (Wang, G. 2019). Ali intends to lead a revolution of urban management by building up the city-level AI systems, "just like Apple led a revolution of mobile phones" (Luo 2016).

3.2.2 City Operating System by JDD

3.2.2.1 What is City Operating System

The concept of intelligent city (iCity) is proposed in the report by CCID Consulting (2019), which is a sound combination of technology innovation and urban development. In a sustainable way, an intelligent city can offer numerous conveniences to daily life, with increased efficiency of public administrative issues, developed industrial economy, a green and liveable environment, and smart urban infrastructure. Marking a fresh start for the company's urban computing business, iCity is the company's intelligent city brand providing comprehensive intelligent solutions for urban development, which is serving 15 cities in China (M Li, 2020, personal communication, 18 January). These solutions are for several areas, including e-government services, environmental protection, and energy (JDD n.d.a). During a personal communication on 18 January 2020, Director of Industry & Finance Research Center of JDD, Dr. Li stated that iCity also serves traffic and parking management.

Regarded as "the brain" of iCity, the City Operating System helps solve the key challenges faced in intelligent urban development. The City Operating System aims to empower cities and their public services to go online and become both intelligent and highly digitized. It is featured with standardized data, digital gateway, modulated algorithms, and lifestyle platform (JDD n.d.a). (Figure 3.4)

3.2.2.2 How the City Operating System serves a city

–Digitalization of urban governance

Fig 3.4
The structure of City Operating System (JDD n.d.a). The integrated solutions (upper level), for example, AI + Industry Development, are serving the sector fields (lower level), for example, Intelligent Transport.

- Sharing data and improving the cooperation

It is very common to see that the data saved by different local authorities are in diverse forms, which makes it very difficult to share information among the local authorities. Cloud Governance system, as a part of the City Operating System, is particularly helpful as it processes the data collected from different local authorities and enable the data to be exchanged and shared among them (JDD n.d.b).

For example, JDD supported Suqian Government to build up the Cloud Governance system to offer information services. Data resources from 61 local authorities are assembled and standardized on 186 cloud platforms so that about 1.3 billion pieces of administrative data can be shared online. JDD also built up a cloud computing platform where the local authorities can communicate and cooperate together. It changes the initial situation where the data from different local authorities were separated and the authorities were like "individual information islands" (JDD n.d.b; Global Times 2019). (Figure 3.5)

- Increasing the efficiency of administrative processes

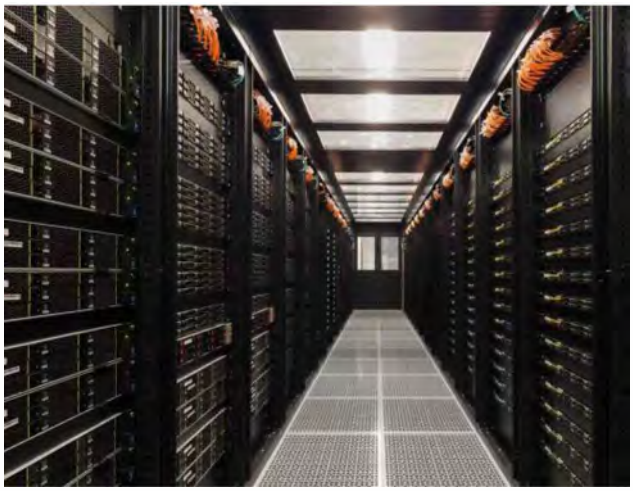
Since the administrative information is assembled and shared by the Cloud Governance system online, the efficiency of processing administrative issues is highly increased with lower operating costs.

In Suqian, there is an online governance system of the Provident Fund. Data from a source other than the Provident Fund system can be referred and used on this system, which means that the information that is already collected by another administrative system is no longer required to submit again. This simplifies the processes for administrative approvals. To be specific, an applicant can make a request for approval on the Provident Fund system by simply submitting electronic documents via the mobile app and the approval will usually be completed within three workdays (JDD n.d.b). In addition, there is a new processing model "no face-to-face", which means that the applicants and the administrative staffs no longer have to meet and deal with the applications for approvals face to face in the Provident Fund lounge (JDD n.d.b). Such innovation benefits the applicants a lot because it enables them to submit an application anytime they are free instead of in the fixed time slot when the administrative staffs are on work.

–Business management

According to Zheng, the vice CEO of JDD, a visualized analysis of customer numbers, increasing rate of customers, consumption habits and preferences is able to be offered by the iCity, which is supported by the City Operating System (Publicity Department of Suqian

Fig 3.5
Data processing center supporting City Operating System in Suqian



government 2019).

In Suqian, the business management programme of the project "iCity" has been put into practice in March 2019. It benefits in understanding consumption behaviours and social commonwealth mechanism (Publicity Department of Suqian government 2019).

-Environmental management

Environmental management is one of the services offered by the project iCity. For example, real-time air pollution data are monitored and analysed (by the City Operating System). Historical pollution data are also available to be checked and processed with this system.

The construction of iCity in Suqian enables the decision-makers to realize the problems and reasons by analysing and presenting the pollution data. In this way, it makes it possible to offer pollution prediction and reaction plans so as to assist with environmental management (Publicity Department of Suqian government 2019).

3.2.2.3 How the City Operating System will be developed

The City Operating System is expected to solve the key challenges faced in intelligent urban development, which requires solutions in seven major areas, including planning, transportation, energy, environmental protection, urban credit, public safety and e-government services (JDD n.d.a). According to Yu Zhen, the City Operating System is a technical foundation based on Cloud technologies, offering an ecology to involve partners to build up intelligent cities together (Anon. 2019b). It is very similar to the ambition of the City Brain by Alibaba, which aims at a city-level platform to offer a variety of urban services and expect the partnerships from different industries.

Though the City Operating System targets at a platform offering multiple solutions serving iCities, the key areas that will be emphasized in priority in the next stage should be e-government services and the digital economy. This prediction is based on the current construction situations in the cities such as Suqian, Xiong'an, and Chengdu (JDD n.d.b;). The city-level application of the system in Suqian mainly offers the local authorities an online system to manage administrative issues. On the other hand, the City Operating systems in Xiong'an and Chengdu mainly targets at local economy by managing consumption data and logistics data (JDD n.d.c; Anon. 2018d).

In November 2019, the updated version City Operating System 2.0 was officially released with faster processing speed, higher efficiency of algorithms, improved data safety, and better-visualized technologies (Anon. 2019b, Anon. 2019c). Compared with the City Brain by Ali, the City Operating System is increasingly presenting its competitiveness.

3.2.3 Smart Parking Management platform by Alpark

3.2.3.1 What is the Smart Parking Management platform

According to the Alpark CEO Jun Yan (Anon. 2018b), parking, which involves a great number of real-time data of human activities and automobile movements, particularly requires intelligent management. He also indicated that there are two reasons for the parking problems – one is the lack of parking places and the other low utilization rate resulted by information bias. The key solution is to use AI technology to improve parking management.

In this case, Alpark created an AI parking management platform, which is a part of the city level parking solution Alpark City, to manage the parking problems. Generally, it can monitor the parking behaviours and operate an electronic charging system in cooperation with the front-end device "Alpark Eye", a series of innovative algorithms "All Blue Brain", and Alpark app

Fig 3.6
The framework of Alpark City – Smart Parking Management Platform as a part of the solution (Alpark 2019)

Source: Alpark 2019)

Fig 3.7
Alpark Eye, a video camera as the front device serving Smart Parking Management platform to collect image data (https://baijiahao.baidu.com/s?id=1632217017906067827&wfr=spider&for=pc)

Source: https://baijiahao.baidu.com/s?id=1632217017906067827&wfr=spider&for=pc)

(Alpark 2019). The platform analyses the image data collected by the video cameras Alpark Eyes using the algorithms All Blue Brain and serves users via the app. The Smart Parking Management platform, Alpark Eyes, the algorithms, and the app make up the solution of parking management offered by Alpark (Alpark 2019). (Figure 3.6), (Figure 3.7)

3.2.3.2 How Smart Parking Management platform serves a city

–Parking management

Smart Parking Management platform, with the help of Alpark Eye, can recognize the illegal parking behaviours in the real-time monitoring videos and enable real-time management strategies. The key value is that Smart Parking Management platform can offer a chain of evidence on the illegal parking behaviours. In China, it usually requires four photos to accuse of illegal parking, one taken in a short distance, one in a long distance, and the other two taken when the car enters and leaves the place. Smart Parking Management platform is capable to sense the movements of a car by the cameras "Alpark Eye" and capture the photos required for the chain of evidence (Li 2019).

–Charging system

Smart Parking Management platform also offers charging services. Using image recognition technology and algorithms developed for different situations, Smart Parking Management platform can sense a car when it is entering a parking place. The parking will be automatically judged whether it is legal (see the content above). If so, once the car is properly parked, "electronic fences" will be virtually created around it and the charging will be started. Once the car is sensed to move out of the electronic fences, the charging will automatically end and a payment request will be sent out (Li 2019). The charging service is also available for renewable automobiles. With "Alpark Eyes" equipped on the charging piles, making a payment, scheduling parking places, and charging the car can all be simply done via a smartphone. Using a similar method and context-based algorithms, Smart Parking Management platform can also deal with traffic accidents.

In April 2019, Alpark won the competition for the project to build up the Dynamic Monitoring and Electric charging system for the parking management in Fengtai District in Beijing. In December, Alpark confirmed that it obtained the opportunity for building up the city-level parking system for Beijing. Currently, there are about 41,000 parking places managed by Smart Parking Management platform (Li 2019). Moving into the next stage, Alpark plans to apply the solution to Alpark City

Table 3.1
Summary of city brains' developers and their functions, example cities, and the number of cities with a city brain (Please note: During a personal communication on 18 January 2020, Director of Industry & Finance Research Center of JDD, Dr. Li confirmed that there are 15 cities where the City Operating system by JDD has been put into practice. This number may be different from that can be found in public resources. The possible reason could be that some projects have not been officially released.)

Developer	Name of City Brain	Main functions	No. of cities with the city brain	Applied places - examples
Alibaba	City Brain	Transport management, Parking management, Public security control	23	Hangzhou, Quzhou, Suzhou
JDD	City Operating System	Public administration	3	Suqian
Huawei	City Brain	Public administration, Environmental monitoring	2	Nanhai
iFLYTEK	Urban Super Brain	Public administration	1	Tongling
Alpark	Smart Parking Management platform	Parking management	3	Beijing

in more cities, such as Shijiazhuang and Shanghai (Li 2019).

3.2.3.3 How Smart Parking Management platform will be developed

Yan, the founder of Alpark, said that the group targets at the innovation of a new model of transport management and urban services. In addition to parking management, Alpark plans to develop more applications such as a service system for drivers, a car-financial service system, renewable energy management and emergency reactions (Anon. 2019d). In summary, Alpark's ambition in AI technology is far more than parking management and involves in a lot of urban governance issues. In this case, Smart Parking Management platform will not only be developed to offer parking or traffic solutions but also to support urban management.

3.2.4 Summary

In conclusion, the city brain is an AI system serving urban management at the city level. It works in a variety of ways. Based on the information of the city brains developed by Ali, JDD, and Alpark, the functions of a city brain include assisting social governance, detecting events, managing the public transport, mitigating congestion, guaranteeing public security, suggesting to business management, managing environmental pollution and offering parking management. Moreover, there are increasing developers building up their city brains. Huawei and iFLYTEK are developing their city brain products and trying to popularize them (Anon. 2019j; Tongling Government Office 2018; Gu 2018). A city brain serving Xuhui district in Shanghai is also being developed, which is already put into use in monitoring food quality, traffic congestion, water quality, and living situation of low-income families (Shu 2020).

Though there is some overlap among the functions of city brains developed by different developers, in general, all the developers have a similar ambition to develop their city brain as an open platform connecting to omni-bearing urban data resources and offering comprehensive urban services.

To be specific, for example, the City Brain in Hangzhou offers a range of services varying from traffic management to community services. JDD also targets at a comprehensive solution to create intelligent cities, with an emphasis on streamlining administrative governance and assisting the digital industry. Alpark focuses on parking management and its Smart Parking Management platform mainly works on this single application, yet it targets wider uses in urban services such as renewable energy management and emergency reactions. A summary table is listed below to make a comparison between the city brains by different developers. The examples of how these city brains work will be offered in the next section.(Table 3.1)

3.3 What a city brain can bring to a city

3.3.1 Services of city brains

3.3.1.1 Transport management

Currently, city brain has contributed to transport management in many ways, for example offering parking guidance, intelligent control of traffic signals, video inspections and many other ways mentioned above (Luo 2016; Sun et al. 2019; Alibaba Cloud n.d.). It increases traffic efficiency by reducing the time cost of looking for parking places, increasing passing speed, and streamlining the distribution of public transport resources.

For instance, there have been 476,000 parking places connected to the parking network of the City Brain by Ali in Hangzhou, which enables intelligent guidance on where to park in real-time (Anon. 2019e). A similar system has also been put into use in Beijing (Anon. 2018b; Anon. 2019a). On Shixin Rd in Hangzhou, it shows that the passing speed has increased by 11% since the City Brain was applied here, networking video

cameras and traffic signals together and analysing the real-time monitoring videos (Luo 2016). It also assists with distributing public transport resources in a smart way by calculating how much public transport resources are required and how the bus routes can be optimized (Sun et al. 2019).

3.3.1.2 Public security

A city brain can benefit public security by enhancing video monitoring in public space and building up a people-locating system (Sun et al. 2019). It also has a positive effect by monitoring pedestrian volumes and their changes of spatial distribution (Luo 2016). In this way, the city brain can organize the police force based on real-time monitored situations. In addition, based on real-time face recognition technology, abducting criminals and abducted victims can be found out more quickly (Luo 2016).

3.3.1.3 Urban governance

It is indicated that a city brain can optimize urban governance (JDD n.d.b). A city brain offers a platform that assembles, processes, and shares the data collected from different local authorities. It also reduces the time cost of administrative issues by avoiding physical commuting among the authorities (Anon. 2019f). It not only benefits the citizens who request approvals from different authorities but also government staffs. All of these effects of city brain can improve governance efficiency.

3.3.1.4 Industry transformation

A city brain motivates the development of information industry because it requires a variety of technologies to build up and improve it. To be specific, processing traffic videos in real-time relies on Cloud computing; data collection and upload from different devices require the IoT; a universe system to inform citizens of public information has to be achieved with the technology of mobile Internet (Luo 2016). All of these technologies involved in the development of a city brain are initiated to make more breakthroughs when there is a new city brain project.

The application of City Brain also contributes to upgrading the traditional industries, initiating them to explore new business models. For instance, the province-level trade platform of local special agriculture products supported by cloud computing, which will be developed as a part of city operating system in Binzhou, can offer an online platform to trade the products remotely (Anon. 2017; Ma 2019).

3.3.1.5 Energy-saving

A city brain can save energy by optimizing the energy distribution. For example, the city brain developed by Ali has improved the electricity distribution plan via real-time data share, automatic management, and incident warning. It has increased the benefits of photovoltaic power stations by 3-7% annually (Luo 2016). In addition, the City Operating System by JDD can also benefit in energy-saving as it is able to analyse the historical data of thermal power stations and advise how to minimize the energy costs (JDD n.d.c).

By reducing congestion and commuting time, a city brain also decreases energy consumption. As mentioned above, there have been many applications of city brain in traffic management and urban governance, which mitigates congestion and decreases energy consumption (Chen 2019).

In addition, a city brain is capable of monitoring the electricity consumptions and minimizing the linkages (Anon. 2019f). Therefore, it also benefits energy-saving by sensing and monitoring the resource supply.

3.3.1.6 Pollution mitigation

The city brains, as a part of the information industry, produce less pollution compared with traditional

industries (Chen 2019). Moreover, they decrease environmental pollutions by mitigating congestion, reducing commuting activities, and avoiding greenhouse gas emissions (Luo 2016, JDD n.d.b).

In addition, city brains can mitigate the negative impacts of pollutions by forecasting environmental qualities. For example, the monitoring systems of water quality, noises, and air pollution operated by a city brain can monitor the harmful pollution and offer environmental warnings (Gu and Zhang 2019). A city brain can also suggest the waste transportation route to maximize transportation efficiency and reduce the environmental impacts (Anon. 2019f).

3.3.1.7 Public health

A city brain is able to offer a health information platform where the personal health data and digital health records can be assembled and checked (with approval). It is convenient for doctors to have a comprehensive awareness of the patients' disease history and offer efficient prescriptions (Gu and Zhang 2019). It also benefits the home-based care services for the old, who are easy to forget their medical history or facing difficulties to exactly describe their illness.

In addition, a digital payment system supported by a city brain also contributes to public health by avoiding the queueing time to make a payment (Chen 2019). It is a particularly important application in hospitals because the sooner patients get treatment, the sooner their symptoms are relieved.

3.3.1.8 Other benefits

A city brain also benefits a city in other ways. For example, the living status of the old people who live alone can be monitored by a city brain. The city brain can observe and analyze the daily use of utilities such as electricity and gas consumption (Chen 2019). Once the consumption of utilities stops, the city brain will automatically inform the police in case the old people having a solitary life are in some trouble. A city brain also enables an online system of dealing with legal issues (Anon. 2019g), which saves the time cost of submitting legal files in person and that of travelling to distant departments or courts. In general, city brain offers

Fig 3.8
A screen to show how City Brain manages data in Quzhou

Source: http://www.sohu.com/a/246443323_100188373

a more convenient life for citizens.

3.3.2 Examples of city brains

3.3.2.1 City brain of Deqing – applications in small scales and awareness of innovations in governance processes

Different from those applied in megacities like Hangzhou and Suzhou, the City Brain in Deqing is mainly used for the applications in "micro-scenes". To be specific, for example, the City Brain is applied in the construction sites to monitor whether the workers are entering the sites with safety helmets. There are video cameras installed on the sites, monitoring the workers and checking whether they are with helmets by AI technologies. Once there is a worker recognized as a one without a helmet, the City Brain starts to locate the construction site where the worker works and find the responsible institution as well as the responsible safety manager. With more real-time safety information data from different sites reported and assembled, the City Brain is fully aware of how the real-time safety situation is in each site and is able to decide how to enhance it. In this case, the City Brain in Deqing, targeted at applications in small scales, improves the local security.

Moreover, the City Brain in Deqing initiates the idea that the City Brain is not only a capable tool to deal with data, but also an opportunity for everyone to realize and explore the value of data (Yu 2019). The vice Director of Big Data Office in Deqing Xianguo Tang regards the city brain something more than a platform offering data services and emphasizes the two tasks of the city brain construction. Tang indicates that a one is to collect, accumulate and analyse data while the other is to streamline the initial governance processes and innovate new solutions. It is positive to see that there is an awareness of the value of a city brain beside the functions it offers.

3.3.2.2 City brain in Quzhou – applications in identity verification, peasants' construction, and appointments in hospitals

In Quzhou, in order to solve the problem of proving "I am myself" when a one's identity card is lost, the technology of facial recognition is applied at governance counters as well as Apps on mobile phones. The only thing people need to do when they come to a local authority is to offer their ID numbers or to scan their faces via their phones. The submitted figure or facial data will be compared to the recorded information in the system and judged whether they are matched so that the verification process can be completed in a simple and fast way. In addition, the identity card and other legal licenses can be encrypted as QR codes. In this case, such information can be verified by scanning the codes, instead of examing paper materials (Anon. 2019h).

The City brain offers smart management for the construction work by peasants. Based on the GIS system, the app Ding offers services including construction approval, online construction monitor, and quality examination. There is also an online channel to report illegal construction. Currently, there have been 5,960,000 peasant households connected to this management network with an accuracy approximately at 96% (Anon. 2019h).

"Future Hospitals by Dingtalk" is a program of the City Brain in Quzhou. The program aims to rebuild the diagnosis process via the intelligent applications "Hospital Dingtalk" for hospitals and their staffs, the app "Healthy Qvzhou Ding" for administrative staffs, and the app "online hospital" for the public. There are 13 medical institutions using the program, four of which have completely transferred the initial manual service to online appointment service (Anon. 2019h).

The City brain also serves as the information infrastructure to interest digital companies to locate in the city. For example, the model district of AI industry

has interested companies from the groups such as Ali, Netease, and ZTE Corporation (Anon. 2019h).

3.3.2.3 City brain in Haidian Dis trict in Beijing – applications in emergency reaction and public safety

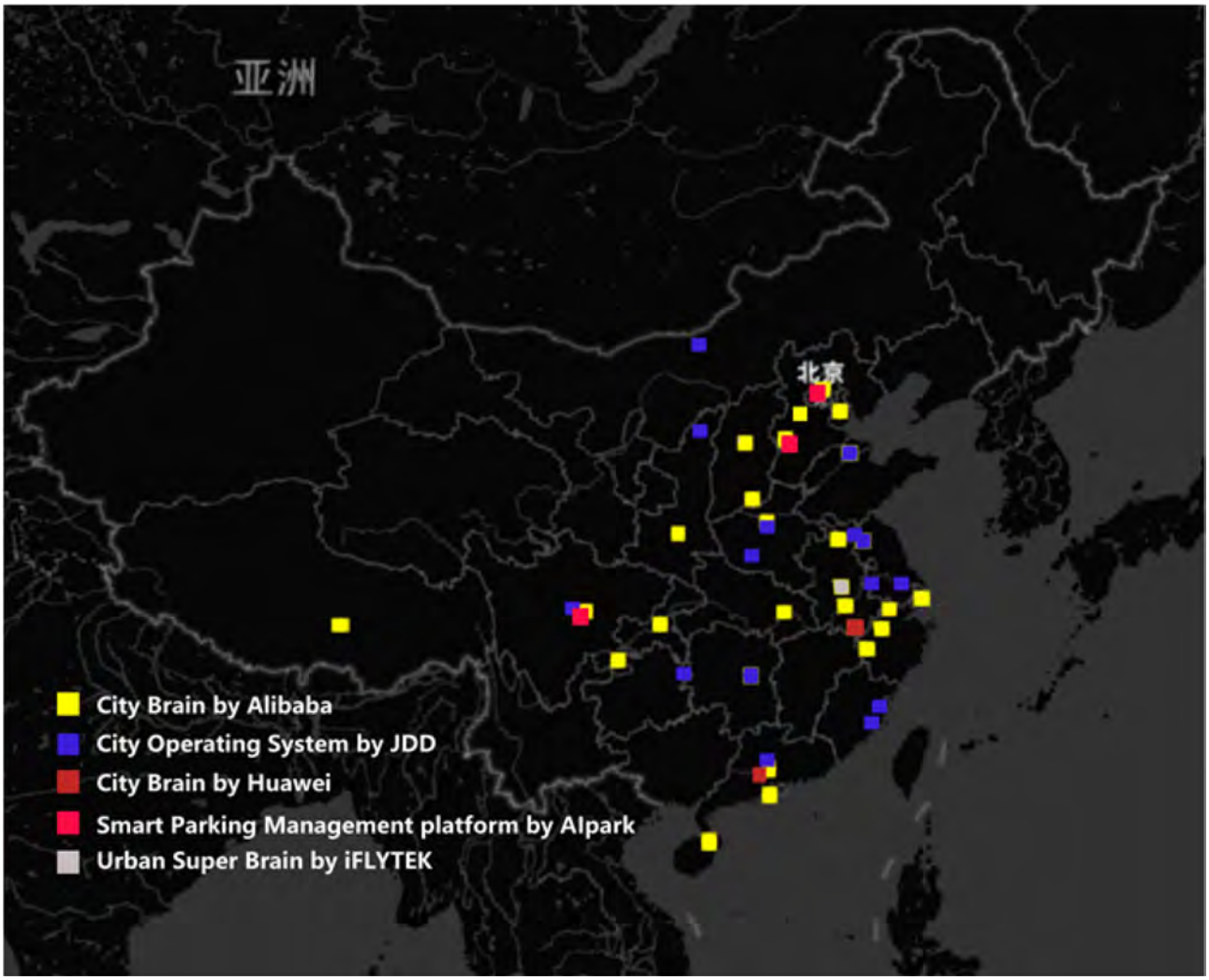
In Haidian, Beijing, there is an emergency guidance platform operated by the City Brain by Baidu. It only takes 60 seconds to react to the reported emergency and three minutes to contact the responsible institution. To be specific, once there is a call reporting drainage block, the platform will transfer the oral reporting to literal content and locate the block location in the system in one minute. Within three minutes, the responsible person in the area where the block is located will be contacted and informed to process the problem.

There are about 520 sensors installed on manhole covers and underground pipes, which monitor the potential safety problems such as cover displacement and gas leakage. It highly enhances the ability to guarantee public safety (Li 2019).

3.3.2.4 City brain in Suzhou – applications in transport management and civil administration

The City Brain in Suzhou was first put into practice in the Industrial District for an experiment. It mainly serves transport management. For example, the City Brain analyses the number of commuting people in each time slot and how they transfer, calculate the differences in the traffic efficiency by different transportations, analyses the ratio of how much traffic flows are shares by the public transport. Based on the calculation results by the City Brain, there have been two bus routes optimized. In addition, an event forecast system is also in operation in Hudong area in the Industrial District. It offers event

Fig 3.9
Distribution of cities with a city brain in China



forecast for the specific roads, which are about 1-2% of the total road length in this area, every two hours and suggests on how to arrange the police strength.

The City Brain also benefits urban management. For example, missing people can be found and identified by facial recognition. Since 2018, there have been 60 people in aid stations identified and 127 missing people recognized, which means that approximately 100 people were able to be sent home and reunite with their families (Shi 2019). It also supports administrative issues as well as waste management, which also contribute to an intelligent way to manage the city.

3.4 Experience for other cities

Since the first application of city brain in Hangzhou in 2016, there has been an increasing number of city brain projects in China, such as in Suzhou, Shanghai, Quzhou, Macau, Xiamen, Shenzhen, Foshan, Chongqing, and Xiong'an District (Yan 2018, Anon. 2019f).

City brain has also been put into practice out of China. It is reported that Malaysia is the first country to import the City Brain by Ali in 2018 (Anon. 2018c). There will be 281 crossings connected to the transport network at the first stage of this project in Kuala Lumpur. The City Brain will dominate in the transport management, speeding up the passing speed, detecting accidents, and offering priority for the ambulances (Anon. 2018c).

With the popularization of the city brain projects, there are accumulating experience of the current construction for the new projects. The popularization also makes the city brain interesting to more and more scholars so that and there are increasing studies on this topic. Below is a summary of the current discussions and opinions on the city brain, which may offer suggestions for the cities that are considering whether to build up a city brain.

3.4.1 Benefits

A city brain brings three innovations for urban development in the future. First of all, a city brain innovates a new way to manage a city. There have been great impacts of the development of IoT, cloud computing, mobile internet and Big Data on urban governance, business modes, and the urban daily life. A city brain is particularly important when coordinating digitalization, urbanization, and technology development. It is a necessary method of making reasonable suggestions on urbanization. (Anon. 2019i, Yun 2019)

A city brain is an innovation of urban services. It is an important infrastructure offering delicacy management of the city and precise services for people and companies. (Anon. 2019i)

A city brain is also an innovation of industrial development and a necessary method to develop the urban economy. It changes the factors of production, which replaces the factors such as land, labour and energy capitals. In this case, the construction of city brain contributes to a reduction in resource consumption, environmental pollution, financial costs and social issues of expropriation. It also strengthens the competition of service and information industries, acting as new economic growth engines (Anon. 2019i, Yun 2019). Furthermore, a city brain is an important foundation of internationalization. A city's competition in the world is highly strengthened by the application of city brain in upgrading industry development, streamlining urban governance, and improving the business environment. (Yun 2019)

3.4.2 Criticisms

3.4.2.1 A lack of theoretic studies

Currently, there is a gap between the practice of city brain and its theoretical studies. There has not been a solid foundation of academic studies on the city brain

for its practical applications (Yun 2019, Yan 2018). Consequently, it happens that there are city brain projects that simply repeat the previous work, without any innovations or progress. Some projects were started in a hurry and they were not endorsed with sufficient scientific evaluations at the beginning (Yun 2019).

3.4.2.2 Little involvement of professional experts

It is argued by Lu, Xiao, and Yang (2018) that there is a lack of the involvement of experts as well as a consideration on professional transport theories in the application of city brains. Lu, Xiao, and Yang (2018) indicate that there might be significant errors in the modelling results given that there was limited involvement of professional experts.

3.4.2.3 Risks of data safety

Lu, Xiao, and Yang (2018) argue that the transport data are highly relative to national security, public security, and personal security. There will be amazingly negative impacts if unauthorized data disclosure happens. Lu, Xiao, and Yang (2018) also emphasize that the safety of the modelling parameters of the city brains is the same important because the parameters decide the efficiency of the urban activities and even people's life.

3.4.2.4 A gap between innovations by companies and demands by governments

On one hand, technology companies only have a limited realization of the governance activities. They are still far to offer solutions precisely focusing on the government's demands based on their current technical achievements. On the other hand, it is common that local governments barely understand how cutting-edge technology innovations can benefit urban governance. There is a huge gap between the technical innovations and practical demands from the local authorities (Yan 2018).

3.4.2.5 Disadvantage of infrastructure to support city brain

It is common to see a lack of the network of infrastructure devices, for example, no connections between video cameras and traffic signals. The construction of City Brain requires an infrastructure revolution, which contains a digitalized network with the data of transport, energy and water supply. It is not only facing technical difficulties but also funding and human-resource shortages (Luo 2016).

3.4.2.6 Exclusiveness in the construction of city brains

The current construction of a city brain is usually based on the cooperation between the local government and one company. It usually works in this way: a local government is interested in city brains and publish an invitation for bidding competition; the company wins the bidding dominates the construction of the city brain. Such cooperation mode that only involving in one single company is helpful to limit the legal responsibilities of the developer and reduce the risk of data security. However, it also results in a situation where there is usually only one developer dominating in the construction of the city brain. Consequently, the advantages of other developers in serving the functions, which the dominating company cannot do well, are not very easy to be involved.

Though it is better to have cooperation with other developers to build up a city brain, it cannot be easily achieved given that the current cooperation mode is not changed.

3.4.3 Suggestions

1. Theoretic studies are required to offer guidance for the future development of the city brain. The scholars Lu, Xiao, and Yang (2018) have made their suggestions on a systematic process to evaluate and monitor a city brain project. Since there are still limited studies on city brain compared to the relative topics such as smart city, more efforts should be made in this field considering its

great impacts on the urban governance as well as its popularization.

2. It is suggested to take the current data, statistic local policies, transport theories, and relative study results into consideration when building up the calculation models for transport management (Lu, Xiao, and Yang 2018).

3. Safety regulations that are particularly for the operation of city brains should be drafted and released as soon as possible. It is not only because the data are highly relative to citizens' daily life, but also because the number of data is so large that there is a great difficulty to guarantee its confidentiality.

4. A city brain should not be regarded as an individual technical innovation, but 'an innovative thought' affecting the entire processes of urban governance. It should be a motivation to update and streamline the urban management system (Yan 2018). The construction of a city brain is highly depended on the supports from the local government because a city brain requires not only data resources but also cooperation from different local authorities (Luo 2016). In order to meet the gap between the innovations by companies and the demands by governments, Liu (2019) suggests a strategy to offer solutions targeting at practical demands. The strategy is scene-oriented. It firstly precisely obtains the demands in different application scenes and then prepares a technology pool. The matched demands and technologies will then be encapsulated to offer practical solutions.

5. The development and the construction of city brains require cooperation from diverse partners as it needs a number of technologies to sustainably develop. For example, the real-time processing of traffic videos relies on Cloud computing; data collection and upload from different devices require the IoT; a universe system to inform citizens of public information has to be achieved with the technology of the mobile Internet. There should be effective communications and cooperation among the city brain developers and partners from other industries (Luo 2016).

6. It is suggested to improve the way to start a city brain project with higher openness to multiple developers. Once the exclusiveness in the construction of city brains is reduced, there will be more than one developer working on the local brain. This means that the advantages of other city brain products can also be adopted and put into use for one city.

3.5 Conclusion – City brain in development

A city brain is a city-level AI system serving a number of scenes of urban governance, which make use of a variety of technologies supported by AI, Big Data, IoT, Cloud computing. The effects of a city brain are mainly seen in transport management, public security, urban governance, industry upgrading, energy-saving, pollution mitigation, public health, and other benefits to make daily life more convenient.

Many group companies, such as Ali, JDD, and Alpark, are developing their own city brains. The City Brain by Ali is considered the one put into the widest use with the most comprehensive functions. Currently, each city brain emphasizes particular functions with disadvantages in some way and is still in development.

More attention on the city brains is being paid by scholars, with increasing city brains are in construction across the world. Some scholars regard city brains as an innovative and intelligent method of urban management. On the other hand, some think city brains incapable to offer guidance on urban activities. No matter city brains are positively or negatively commented, its development is benefited from these discussions. This is because there are increasing experts studying on them and the city brains can be further streamlined based on their studies.

Currently, City Brain in Hangzhou has been upgraded as version 3.0. It has already been put into use in more new scenes, such as health management and tourism. The city brains are being developed for more applications and stronger functions with increasing academic studies, for wider use in the coming future.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

Guangzhou, China

Chapter 4 Conclusions and Recommendations

The previous chapters of the Outlook have shown that we are facing great urban and sustainable development challenges, but technologies can and have already provided new solutions. Some cities are capable in dealing with technologies, but many of them are left behind. A transition to future cities offers an immense opportunity to secure national economic prosperity and improve quality of life while tackling the existential threats posed by sustainable challenges. The smart revolution of cities must serve the many and not just the few. Based on our analysis and consultations, we made the recommendation as follows (Fig 4.1):

1 Place smart technology at the heart of urban innovation, high-quality transformation and prosperous future

R1.1 We recommend that fully evaluate and depict the potential of urban technology to urban innovation, governance and socio-economic growth;

R1.2 We recommend that carefully study the change to urban forms, types and completeness being brought by smart urban technologies;

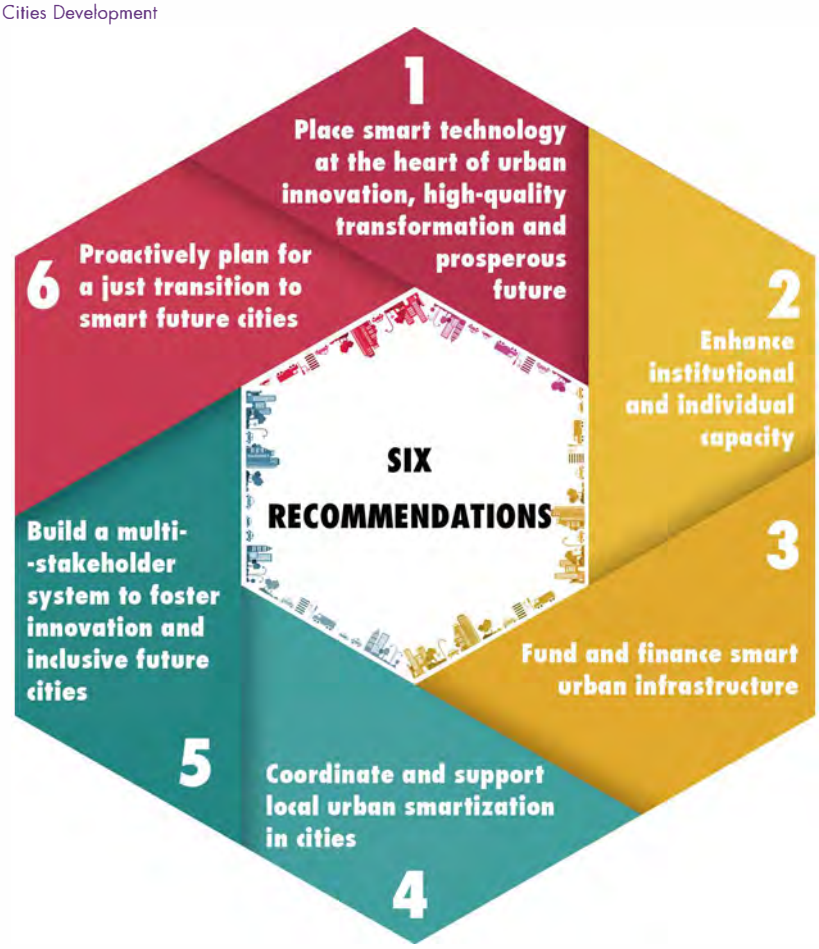
R1.3 We recommend that establish a standard for security and maintenance of smart urban system.

2 Enhance institutional and individual capacity

R2.1 We recommend that establish different tiers of smart urban technology facilitators from regional to country and city level to help governments, civil society, and private sector to get better understanding of urban technologies;

R2.2 We recommend that monitor technological developments, identify trends, inform policy makers and the public of emerging risks and opportunities and provide data for decision making;

Fig 4.1
Recommendations for Future Cities Development



R2.3 We recommend that strengthen capacity development for small and medium cities or towns and marginalised people to create an inclusive smart future of no one and no place left behind.

3 Fund and finance smart urban infrastructure

R3.1 We recommend that work with city governments to establish integrated spatial and smart infrastructure plans that can underpin a pipeline of proper business models and bankable smart city projects,

R3.2 We recommend that scale diverse financing instruments to fund smart urban infrastructure, including help cities to access international finance for smart city development,

R 3.3 We recommend that establish incentive financing and taxation mechanism to smart urban infrastructure

4 Coordinate and support local urban smartization in cities

R4.1 We recommend that establish smart city leaders working team in cities to coordinate the overall formulation of smart city plan and deployment of smart urban facilities;

R 4.2 We recommend that the capacities of local urban professionals, including urban planners, transport planners, architects etc need to be equipped with updated knowledge on smart infrastructures,

R 4.3 We recommend that create better integration of spatial planning and smart infrastructure and make best land use in smart age.

5 Build a multi-stakeholder system to foster innovation and inclusive future cities

R5.1 We recommend that ensure a collaborative smartinisation action in cities among local governments, urban tech providers, smart city operators and citizens;

R5.2 We recommend that encourage diverse models of smart city construction and operation to create a multi-participation, including local governments, private companies, social capitals, research institutes, citizens etc;

R5.3 We recommend that sustainable investing and operational models of smart cities need urgently to be considered and prevent the financing and operational risks.

6 Proactively plan for a just transition to smart future cities

R6.1 We recommend that enhance age and gender equality in smartinisation process by educating all people since only the people get smart then a city can be smart;

R6.2 We recommend that do not create smart technology gentrification to urban poor;

R6.3 We recommend that undertake international pilot projects and cities and provide best practice cases for reference.

We believe in future cities which are safe, inclusive, resilient and sustainable, in which smart urban technologies are applied to enhance safety, reduce inequalities, improve efficiency, promote economic prosperity and environmental sustainability as well as create innovation.

Our recommendations toward future cities will require leadership and political will, clarity about roles and responsibilities of diverse stakeholders, inclusive partnerships with capacity development, creative incentives, greater coherence of fragmented efforts, and building common trust.

We hope this report has shown the urban technologies in Chinese cities and can contribute to a reference to other cities in the world.

ACKNOWLEDGMENTS

Acknowledgments

Future Cities Advisory Outlook is the result of a new collaboration of UN-Habitat China with Chinese technology companies with an interest in promoting urban technologies in sustainable urbanization, in the UN-Habitat China Future Cities Council (CFCC)

UN-Habitat wishes to thank the Chair of CFCC, Mr. Lu Weiding, Chairman and CEO of Wanxiang Group, for his support for the initiative from the first day and his genuine encouragement of the team and participating members. His Wanxiang Group also hosted the final report review meeting on 13 January 2020 at the company headquarters in Hangzhou. UN-Habitat also thanks Mr. Chen Jun, Vice President of Wanxiang Group, for his support of the CFCC proceedings on behalf of Wanxiang.

Furthermore, UN-Habitat wishes to thank the Vice-Chair of CFCC, Mr. Pang Shengdong, Co-Chairman of Xinchao Media in Chengdu, and Mr. Zhang Li, Vice President of Xinchao Media for their strong collaboration and hospitality in Chengdu.

The CFCC activities through 2019 were joined by JDD and Alpark. The team appreciated JDD for hosting the inception review meeting on 30 October 2019 and Alpark for hosting the interim review meeting on 10 December 2019. We are glad that Alpark, BOE and KE.com joined towards the end of year 1 and delegated senior representatives to CFCC meetings.

The CFCC project and report team was headed by Mr. Sheng Ying, National Officer of UN-Habitat China. The chapter authors were Mr. Mathias Lund Larson and Mrs. Wang Yining. UN-Habitat thanks the chapter authors for their excellent collaboration.

The CFCC project is overseen by Mr. Bruno Dercon, Senior Human Settlements Officer of the UN-Habitat Regional Office for Asia and the Pacific (Fukuoka, Japan) and Mr. Zhenshan Zhang, UN-Habitat Habitat Programme Manager for China.

REFERENCES

References

EU SME Center & China Britain Business Council (2015). Sector Report: Smart Cities in China

International Telecommunications Union & China Academy for Information and Communications Technology (2017). Presentation: Development and Practice of Smart City in China

Chen (2017). China Smart City Pilot and Financing. GP-ORF Series: Smart Cities in the BRICS. With reference to MOHURD statistics

China Center for Urban Development (2019). Smart City Initiatives in China Overview & Outlook.

Deloitte (2018). Super Smart Cities: Happier Society with Higher Quality

Airui (2019). China Smart Cities Development Report

EO Intelligence (2019). 2019 China Smart Cities Development Research Report

Deloitte (2018). Super Smart Cities: Happier Society with Higher Quality

OAV (2019). China's Urban Future: Opportunities Through Smart Cities.

Deloitte (2018). Super Smart Cities: Happier Society with Higher Quality

Govinsider (2019). Five Chinese smart cities leading the way. Retrieved from: https://govinsider.asia/security/five-chinese-smart-cities-leading-way/

OAV (2019). China's Urban Future: Opportunities Through Smart Cities.

The Paper (2019). 上海成立智慧城市建设领导小组，应勇任组长. Retrieved from: https://www.thepaper.cn/newsDetail_forward_4032285

Govinsider (2019). Five Chinese smart cities leading the way. Retrieved from: https://govinsider.asia/security/five-chinese-smart-cities-leading-way/

South China Morning Post (2019). Didi by the numbers: ride-hailing firm covered more miles in 2018 than 5 Earth-to-Neptune round-trips. Retrieved from: https://www.scmp.com/tech/start-ups/article/2181542/didi-numbers-ride-hailing-firm-covered-more-miles-2018-5-earth

Ibold, S., (2018). Shared mobility services and car-sharing in China, C. GIZ, Editor.

Huawei (2018). How big data and AI will transform Shenzhen Airport. Retrieved from: https://www.huawei.com/us/about-huawei/publications/winwin-magazine/32/shenzhen-airport-digital-platform-and-ai

Ideas for Development (2018). The Fight Against Pollution and China's Great Leap Forward. Retrieved from: https://ideas4development.org/en/fight-pollution-green-buildings-china/

Liu, Bingsheng & Wang, Min & Zhang, Yutao & Liu, Rui & Wang, Anmin. (2017). Review and Prospect of BIM Policy in China. IOP Conference Series: Materials Science and Engineering. 245. 022021.

EO Intelligence (2019). 2019 China Smart Cities Development Research Report

ICities4greengrowth (2019). Wanxiang Innova City, Hangzhou China. Retrieved from: http://icities4greengrowth.in/casestudy/wanxiang-innova-city-hangzhou-china

Daxue Consulting (2019). Payment Methods in China: How China became a mobile-first nation. Retrieved from: https://www.intheblack.com/articles/2018/05/01/wechat-super-app

South China Morning Post (2018). China moves further towards cashless society as payment giants Alipay, WeChat Pay gain ground. Retrived from https://www.scmp.com/business/companies/article/2130400/china-moves-further-towards-cashless-society-payment-giants

UN Environment (2019). Chinese initiative Ant Forest wins UN Champions of the Earth award. Retrieved from: https://www.unenvironment.org/news-and-stories/press-release/chinese-initiative-ant-forest-wins-un-champions-earth-award

Alipay (2019). Alipay. Retrieved from: https://intl.alipay.com

United Nations Development Program (2015). Rethinking Smart Cities: ICT for New-type Urbanization and Public Participation at the City and Community Level in China.

State Taxation Administration (2019). Zhejiang: Easy Submission through Person Income Tax APP. Retrieved from: http://www.chinatax.gov.cn/chinatax/n810219/n810744/n3752930/n3997266/c3998573/content.html

United Nations Development Program (2015). Rethinking Smart Cities: ICT for New-type Urbanization and Public Participation at the City and Community Level in China.

South China Morning Post (2019). JD.com pushes further into smart cities, offering social credit and AI-powered tools to local governments in China. Retried from: https://www.scmp.com/tech/science-research/article/3002691/jd-pushes-further-smart-cities-offering-social-credit-and-ai

China Daily (2016). New 'internet plus' strategy for energy puts emphasis on innovative development and industry integration. Retrieved from: https://www.chinadaily.com.cn/china/2016-06/28/content_25881036.htm

OAV (2019). China's Urban Future: Opportunities Through Smart Cities.

Technode (2018). Blockchain could help China's push for decentralized energy. Retrieved from: https://technode.com/2018/09/03/decentralized-energy-blockchain/

China National Environmental Monitoring Centre (2019). CNEMC. Retrieved from: http://www.cnemc.cn

OAV (2019). China's Urban Future: Opportunities Through Smart Cities.

OAV (2019). China's Urban Future: Opportunities Through Smart Cities.

Forbes (2017). How An App Is Stopping Pollution In China. Retrieved from: https://www.forbes.com/sites/jeffmcmahon/2017/11/17/how-an-app-is-stopping-pollution-in-china/#52f4d65288c8

Xinhuanet (2018). AI-driven technology reshaping city traffic in China. Retrieved from: http://www.xinhuanet.com/english/2018-03/10/c_137029827.htm

New York Times (2015). Beijing Issues a Second 'Red Alert' on Pollution. Retrieved from: https://www.nytimes.com/2015/12/18/world/asia/beijing-issues-a-

second-red-alert-on-pollution.html

Jia, Haifeng & Wang, Zheng & Zhen, Xiaoyue & Clar, Mike & Yu, Shaw. (2017). China's sponge city construction: A discussion on technical approaches. Frontiers of Environmental Science & Engineering. 11. 10.1007

The Guardian (2019). Inside China's leading 'sponge city': Wuhan's war with water. https://www.theguardian.com/cities/2019/jan/23/inside-chinas-leading-sponge-city-wuhans-war-with-water

Equal Ocean (2019). Shanghai Launches AI Trash Bins: AI + Waste Management is Getting Popular in China. Retrieved from: https://equalocean.com/ai/20190817-shanghai-launches-ai-transh-bins-ai-waste-management-is-getting-popular

China Daily (2018). Electronics recycling platform Aihuishou eyes overseas growth. Retrieved from: http://www.chinadaily.com.cn/a/201806/22/WS5b2c8821a3103349141ddcbc.html

JD.com Corporat Blog (2019). Trash Sorting: It's a piece of cake with JD AI. Retrieved from: https://jdcorporateblog.com/trash-sorting-its-a-piece-of-cake-with-jd-ai/

Ningbo Government (2019). "Dabashou" waste recycling cabinets well received in Ningbo. Retrieved from: http://english.ningbo.gov.cn/art/2019/8/22/art_931_1017884.html

EO Intelligence (2019). 2019 China Smart Cities Development Research Report

EO Intelligence (2019). 2019 China Smart Cities Development Research Report

Deloitte (2018). Super Smart Cities: Happier Society with Higher Quality

Huanqiu (2017). 云天励飞动态人像识别技术再次助力警方寻人. Retrieved from: https://finance.huanqiu.com/article/9CaKrnK68Uj

South China Morning Post (2019). One year after two deaths plunged Didi into a safety crisis, what's changed at China's ride-hailing giant?. Retrieved from: https://www.scmp.com/tech/start-ups/article/3013071/one-year-after-two-deaths-plunged-didi-safety-crisis-whats-changed

PYMNTS (2018). Alipay Ramps Up Supply Chain, Lending Services To SMBs. Retrieved from: https://www.pymnts.com/news/b2b-payments/2018/alipay-small-business-loans-supply-chain/

South China Morning Post (2019). China's women still waiting for an end to getting groped on public transport. Retrieved from: https://www.scmp.com/news/china/society/article/3027186/chinas-women-still-waiting-end-getting-groped-public-transport

Alibaba (2018). Alibaba Group ESG Report 2018.

Govinsider (2019). Five Chinese smart cities leading the way. Retrieved from: https://govinsider.asia/security/five-chinese-smart-cities-leading-way/

Zhaopin (2019). Main page. Retrieved from: https://www.zhaopin.com

TechAsia (2015). Alibaba goes social with enterprise chat app Ding Ding. Retrieved from: https://www.techinasia.com/alibaba-goes-social-with-enterprise-chat-app-ding-talk-ding-ding

51job.com (2019) Front page. Retrieved from:

https://www.51job.com/

EO Intelligence (2019). 2019 China Smart Cities Development Research Report

Techcrunch (2019). China's grocery delivery battle heats up with Meituan's entry. https://techcrunch.com/2019/03/31/meituan-grocery-delivery/

QZ (2018). China's payments giant is ready to boost financial inclusion in Africa. https://qz.com/africa/1354548/ant-financial-plans-for-digital-financial-inclusion-in-africa/

PYMNTS (2018). Alipay Ramps Up Supply Chain, Lending Services To SMBs. Retrieved from: https://www.pymnts.com/news/b2b-payments/2018/alipay-small-business-loans-supply-chain/

Floship (2019). Crowdfunding in China: Practices and Trends You Need to Know. Retrieved from: https://www.floship.com/crowdfunding-in-china-practices-and-trends/

JD.com (2015). JD.com Launches Equity Crowdfunding Platform to Promote Entrepreneurship in China. Retrieved from: https://ir.jd.com/news-releases/news-release-details/jdcom-launches-equity-crowdfunding-platform-promote

Forbes (2017). These Chinese Companies Are Quietly Revolutionizing The VR Industry. Retrieved from: https://www.forbes.com/sites/lionelchok/2017/07/17/these-chinese-com'panies-are-quietly-revolutionizing-the-vr-industry/#28b251a7768b

CGTN (2019). Xiong'an New Area to take the lead in deploying 5G technology. Retreived from: https://news.cgtn.com/news/3d3d514e3241444f31457a6333566d54/share_p.html

EY (2018). China is poised to win the global 5G race.

South China Morning Post (2019). Huawei wins half of China Mobile's 5G network contracts while Ericsson picks up a third. Retrieved from: https://www.scmp.com/tech/big-tech/article/3014766/china-mobile-awards-half-its-5g-network-contracts-huawei-while

International Telecommunications Union & China Academy for Information and Communications Technology (2017). Presentation: Development and Practice of Smart City in China

South China Morning Post (2018). China moves a step closer to national health care network with Guizhou data centre. Retrieved from: https://www.scmp.com/tech/start-ups/article/2148834/china-moves-step-closer-national-health-care-network-guizhou-data

Forbes (2017). These Chinese Companies Are Quietly Revolutionizing The VR Industry. Retrieved from: https://www.forbes.com/sites/lionelchok/2017/07/17/these-chinese-companies-are-quietly-revolutionizing-the-vr-industry/#6092d449768b

International Telecommunications Union & China Academy for Information and Communications Technology (2017). Presentation: Development and Practice of Smart City in China

Wangyiongkaike (2019). Shouye. Retrieved from: https://open.163.com

International Telecommunications Union & China Academy for Information and Communications Technology (2017). Presentation: Development and Practice of Smart City in China

TechCrunch (2019). Tencent's latest education push is a nod to new collaborative structure. Retrieved from:

https://techcrunch.com/2019/05/23/tencent-education/

Wang, S (2016). 2016 阿里云栖大会：杭州城市大脑正式发布 [2016 Aspara Conference: the official release of City Brain in Hangzhou] [online] available from <https://www.ithome.com/html/it/264198.htm> [31 December 2019]

Liu, F (2019). IEEE 论文：城市大脑，基于互联网大脑模型的智慧城市建设 [IEEE article: City brain, the construction of smart city based on a brain model of internet] [online] available from <http://www.sohu.com/a/289744949_297710> [31 December 2019] JDD (n.d.a) Building Intelligent Cities with AI and Big Data [online] available from <http://icity.jd.com/english> [31 December 2019]

Anon (2019). 爱泊车丰台区再中标 蓝色大脑助力北京静态交通管理全面升级 [Alpark won the bidding competition in Fengtai District- A "Blue Brain" assists with upgrading static traffic management in Beijing] [online] available from <http://www.sohu.com/a/311149873_396923> [31 December 2019]

Gong, T (2018). 什么是 " 城市大脑 "，城市大脑对整座城市的作用 [What is "city brain" and a city brain's effects to a city] [online] available from <http://m.elecfans.com/article/650061.html> [31 December 2019]

Wang, G (2019). 3 年心路总结 王坚揭秘 " 城市大脑 " 产生的背后逻辑 [A summary of three-year thinking – the logic behind the birth of City Brain by Jian Wang] [online] available from <https://www.leiphone.com/news/201904/tCcitAGmLZahf8gP.html> [31 December 2019]

Alibaba Cloud (n.d.) City Brain – Empowering cities to think with data-driven governance [online] available from <https://www.alibabacloud.com/et/city> [31 December 2019]

Sun, P., Yan, P., Bo, C. & You, T. (2019). 2019 年中国智慧城市发展研究报告 [Report on Chinese smart city development 2019] [online] available from <https://www.iyiou.com/intelligence/insight100847.html > [31 December 2019]

Anon. (2018a). 阿里云推杭州城市大脑 2.0：覆盖面积相当于 65 个西湖 [Alibaba Cloud released City Brain 2.0: serving an area as wide as 65 West Lake] [online] available from <https://baijiahao.baidu.com/s?id=1612010647667053750&wfr=spider&for=pc> [31 December 2019]

Luo, C. (2016). 城市大脑：杭州代表中国为世界探索，影响不亚 AlphaGo [City Brain: Hangzhou on behalf of China to make an exploration-the importance of effects is more or less than AlphaGo] [online] available from <https://cloud.tencent.com/developer/article/1111441> [31 December 2019]

DZWWW (2019). 直击云栖大会 | 全球 23 个城市引入阿里云城市大脑 [Spotted on Cloud Aspara: 23 cities across the world are equipping with City Brain by Alibaba] [online] available from <http://baijiahao.baidu.com/s?id=1645712342750502331&wfr=spider&for=pc> [31 December 2019]

CCID Consulting (2019). 中国智能城市发展战略与策略研究 (2019) [A report on the development strategies and policies of Chinese smart city] [online] available from < http://www.cbdio.com/BigData/2019-11/29/content_6153131.htm> [31 December 2019]

JDD (n.d.b) Suqian Municipal People's Government [online] available from <https://www.jdcloud.com/en/case/detail/1 > [31 December 2019]

Global Times (2019). 构建智能城市开放生态 京东提出打造城市操作系统 [Building up an open ecology for intelligent city – JDD proposed City Operating System] [online] available from <http://baijiahao.baidu.com/s?id=1643197927732580023&wfr=spider&for=pc> [31 December 2019]

Publicity Department of Suqian government (2019). '牵手京东 宿迁将打造一体化智能新城' [Cooperating with JDD – Suqian is developing as an intelligent new city] Xinhuanet [online] 1 March. available from <http://www.js.xinhuanet.com/2019-03/01/c_1124181338.htm> [31 December 2019]

Anon. (2019b). 京东城市正式发布"城市操作系统"为智能城市装上 Windows ['City Operating System' equipping intelligent cities with Windows is officially released by JDD] [online] available from <http://news.sina.com.cn/2019-03-22/doc-ihsxncvh4655596.shtml> [31 December 2019]

Anon. (2018b). Alpark（爱泊车）闫军：以AI停车技术助力智慧城市建设 [Alpark CEO Jun Yan: contributing to the development of smart city using AI parking technologies] [online] available from < https://baijiahao.baidu.com/s?id=1606497567803138196&wfr=spider&for=pc > [31 December 2019]

Anon. (2019d). 爱泊车丰台区再中标 蓝色大脑助力北京静态交通管理全面升级 [Alpark won the bidding competition in Fengtai District- A "Blue Brain" assists with upgrading static traffic management in Beijing] [online] available from <https://news.hexun.com/2019-04-30/197028001.html> [31 December 2019]

Anon. (2019e). '城市大脑破解"停车难"' [City Brain solving parking problems]. Hangzhou Daily [online] 8 March. available from <http://www.hangzhou.gov.cn/art/2019/3/8/art_812262_30914490.html> [31 December 2019]

Anon. (2019f). 复盘阿里城市大脑这3年 [A review of the three-year development of City Brain by Alibaba] [online] available from <http://www.sohu.com/a/291492653_114877.2019-01-25> [31 December 2019]

Ma, G. (2019). '京东云助力滨州打造新型数字城市样板' [JDD helping Binzhou develop as a new model of digital city]. International Business Daily [online] 13 November. available from <http://epaper.comnews.cn/xpaper/appnews/203/2718/13579-1.shtml> [31 December 2019]

Anon. (2017). 滨州市政府与京东签约 京东云落户滨州经济开发区 [Signing a contract with Binzhou government – JD Cloud locating in Economic Development District in Binzhou] [online] available from <http://sd.ifeng.com/a/20171019/6079370_0.shtml> [31 December 2019]

Chen, W. (2019). '杭州城市大脑的实践与思考' [Practice and review of City Brain in Hangzhou]. Hangzhou Daily [online] 9 September. available from < http://kns.cnki.net//KXReader/Detail?TIMESTAMP=637134763477158750&DBCODE=CCND&TABLEName=CCNDLAST2019&FileName=HZRB201909090141&RESULT=1&SIGN=ZH2aWpJbnHRfJPtrpo8apXYMH%2fE%3d > [31 December 2019]

Gu, Y. & Zhang, X. (2019). '面向智慧城市的城市交通大脑建设体系与应用研究' [Construction and practical study of urban traffic brain system for a smart city] Telecom World [online] 26 (07), 361-362. available from < https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2019&filename=TXSJ201907225&uid=WEEvREcwSlJHSldTTEYzVDhUSFJPYWxSeXNvcUEweFJKOVprZ2MyVzk5ST0=$9A4hF_YAuvQ5obgVAqNKPCYcEjKensW4IQMovwHtwkF4VYPoHbKxJw!!&v=MDc3ODhadVp1RnlqaFc3N1BNVFhZWkxHNEg5ak1xSTFIWVlSOGVYMUx1eFlTN

ORoMVQzcVRyV00xRnJDVVI3cWY= > [31 December 2019]

Anon. (2019g). '城市大脑引领智慧治理' [City Brain leading smart management] Hangzhou (Weekly) [online] Z2, 39. available from < https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2019&filename=HZDZ2019Z2028&uid=WEEvREcwSlJHSldTTEYzVDhUSFJPYWxSeXNvcUEweFJKOVprZ2MyVzk5ST0=$9A4hF_YAuvQ5obgVAqNKPCYcEjKensW4IQMovwHtwkF4VYPoHbKxJw!!&v=MTUwODR1eFlTN0RoMVQzcVRyV00xRnJDVVI3cWZadVp1Rnl2bFVMM05MVGZQZExHNEg5aW1yWTllYklSOGVYMUw= > [31 December 2019]

Yu, Y. (2019). '德清"城市大脑"建设"接地气"' [City Brain in Deqing feet on the ground] Informatization Construction [online] 7, 36-37. available from < https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2019&filename=XXJS201907018&uid=WEEvREcwSlJHSldTTEYzVDhUSFJPYWxSeXNvcUEweFJKOVprZ2MyVzk5ST0=$9A4hF_YAuvQ5obgVAqNKPCYcEjKensW4IQMovwHtwkF4VYPoHbKxJw!!&v=MjQ5NjNCZmJHNEg5ak1xSTlFYklSOGVYMUx1eFlTN0RoMVQzcVRyV00xRnJDVVI3cWZadVp1Rnl2bFc3L0lQVFg=> [31 December 2019]

Anon. (2019h). '衢州：基于"城市大脑"的"雪亮工程"全国样板' [Quzhou: a national model of "Bright Project" based on City Brain] Informatization Construction [online] 7, 30-32. available from < https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2019&filename=XXJS201907016&uid=WEEvREcwSlJHSldTTEYzVDhUSFJPYWxSeXNvcUEweFJKOVprZ2MyVzk5ST0=$9A4hF_YAuvQ5obgVAqNKPCYcEjKensW4IQMovwHtwkF4VYPoHbKxJw!!&v=MTcyOTFNcUk5RVlvUjhIWDFMdXhZUzdEaDFUM3FUcldNMUZyQ1VSN3FmWnVadUZ5dm1VYnZQUFRYQmZiRzRlOWo=> [31 December 2019]

Li, Y. (2019). '海淀"城市大脑"2020建成' [A city brain for Haidian district will be completed in 2020] Investment Beijing [online] 6, 61-62. available from < https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2019&filename=SDJA201906024&uid=WEEvREcwSlJHSldTTEYzVDhUSFJPYWxSeXNvcUEweFJKOVprZ2MyVzk5ST0=$9A4hF_YAuvQ5obgVAqNKPCYcEjKensW4IQMovwHtwkF4VYPoHbKxJw!!&v=MTY0MjBGckNVUjdxZlp1WnVGeXZtV3I3S05pbkJiN0c0SDlqTXFZOUhZSVI4ZVgxTHV4WVM3RGgxVDNxVHJXTTE=> [31 December 2019]

Shi, Q. (2019). '"城市大脑"建设的苏州实验' [The experimental practice of city brain in Suzhou] People [online] 08, 57-58 available from <https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2019&filename=QUNZ201908033&uid=WEEvREcwSlJHSldTTEYzVDhUSFJPYWxSeXNvcUEweFJKOVprZ2MyVzk5ST0=$9A4hF_YAuvQ5obgVAqNKPCYcEjKensW4IQMovwHtwkF4VYPoHbKxJw!!&v=Mjc0NjhadVp1Rnl2blU3M0FORGpGZExHNEg5ak1wNDlHWjRSOGVYMUx1eFlTN0RoMVQzcVRyV00xRnJDVVI3cWY= > [31 December 2019]

Yan, T. (2018). '北京市海淀区"城市大脑"思维确立与实践研究' [The consideration and practical research on the city brain of Haidian district in Beijing] Urban Management and Technology [online] 20 (06), 38-41. available from < https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2019&filename=CSGL201806009&uid=WEEvREcwSlJHSldTTEYzVDhUSFJPYWxSeXNvcUEweFJKOVprZ2MyVzk5ST0=$9A4hF_YAuvQ5obgVAqNKPCYcEjKensW4IQMovwHtwkF4VYPoHbKxJw!!&v=MjUzMjI3TVlyRzRlOW5NcVk5RmJZUjhIWDFMdXhZUzdEaDFUM3FUcldNMUZyQ1VSN3FmWnVadUZ5dm5VN3JQSmo= > [31 December 2019]

Anon. (2018c) 中国城市级AI首出海：马来西亚引入阿里云ET城市大脑 [City-level AI on sailing abroad:

Malaysia introducing City Brain by Alibaba] [online] available from < http://tech.sina.com.cn/it/2018-01-29/doc-ifyqyuhy7393435.shtml> [31 December 2019]

Anon. (2019i). '城市大脑：探索未来的智慧之城' [City brain: exploring the smart city in the future] China Chief Financial Officer [online] 08, 137. available from < https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2019&filename=ZKJS201908098&v=MjEyNzExVDNxVHJXTTFGckNVUjdxZlp1WnVGeXJrVjcvSlB5YkJmYkc0SDlqTXA0OU1iSVI4ZVgxTHV4WVM3RGg= > [31 December 2019]

Yun, F. (2019). '为什么要建城市大脑' [Why to build up city brains?] Informatization Construction [online] 7, 1. available from < https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2019&filename=XXJS201907001&v=MjU0MjI1WnVGeXJrVmJ2TVBUWEJmYkc0SDlqTXFJOUZaWVI4ZVgxTHV4WVM3RGgxVDNxVHJXTTFGckNVUjdxZlo=> [31 December 2019]

Lu, H., Xiao, T. & Yang, M. (2018). '建设城市交通大脑的若干思考' [Thoughts about building up an urban traffic brain] Urban Transport of China [online] 16 (06), 1-6. available from < https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2019&filename=CSJT201806002&v=MTcyNTdXTTFGckNVUjdxZlp1WnVGeXJsVzd6QUpqN0JIckc0SDluTXFZOUZab1I4ZVgxTHV4WVM3RGgxVDNxVHI= > [31 December 2019]

Liu, J. (2019). '"城市大脑"浪潮下的产业高端人才培育机制创新' [The mechanism of cultivating talents for the industries in the wave of city brain] Zhong Guan Cun Magazine [online] 06, 69. available from < https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2019&filename=ZGCI201906023&v=MTY2MDZxZlp1WnVGeXJtVTdyQlB5cklaN0c0SDlqTXFZOUhaNFI4ZVgxTHV4WVM3RGgxVDNxVHJXTTFGckNVUjc= > [31 December 2019]

Alpark (2019). Alpark 爱泊车 - 全球城市级智慧停车领导者 [Alpark-Leader of city-level smart parking] Unpublished booklet. Beijing: Intelligent Interconnection Technology Co., Ltd

Li, J. (2019). 'Alpark 中国最大的智慧停车平台' [Alpark-the greatest smart parking platform in China]. Meeting of Future Cities Advisory Outlook (FCAO) of UN-Habitat China Future Cities Council. held 10 December at Alpark company Beijing

Anon. (2019j). PK 阿里腾讯，华为首个"城市大脑"将落地广东（附项目清单）[Competing with Alibaba and Tecent, the first City Brain by Huawei will be built in Guangdong (Attached with the project list)] [online] available from < http://www.sohu.com/a/294824550_654086> [31 December 2019]

Tongling Government Office (2018). 市政府与科大讯飞合作交流座谈会举行 [Communication meeting with iFLYTEK was held by the local government] [online] available from <http://zwgk.tl.gov.cn/openness/detail/content/5c1f371aec7f8c6963596712.html> [31 December 2019]

Gu, J. (2018). 铜陵"牵手"科大讯飞创建智慧城市 [Tongling developing as smart city in cooperation with iFLYTEK] [online] available from <http://www.sohu.com/a/238767456_114967> [31 December 2019]

Shu, S. (2020). 徐汇智慧网格 2.0 启动，城市运行"稳不稳"，要看"大脑"灵不灵 [Smart Grid 2.0 is started in Xuhui district – city operation depends on the city brain] [online] available <https://web.shobserver.com/wx/detail.do?id=198405&time=1577966224689&from=timeline&isappinstalled=0> [2 January 2020]

JDD (n.d.c) 城市计算平台白皮书 [A whitepaper of city computing system] Unpublished booklet. Beijing: JDD

Anon. (2018d) 京东城市全球研发中心落地成都 助力天府新区智能城市建设 [JDD's Global Research Center located in Chengdu, assisting with the construction of intelligent city in Tianfu New District] [online] available from <http://news.chengdu.cn/2018/1128/2017319.shtml> [20 January 2020]

UN-Habitat China Office

6-1-83, Jianguomenwai Diplomatic Residence Compound
1 Xiushui Street, Chaoyang District
Beijing, China

Printed on environmentally responsible paper

UN-HABITAT
FOR A BETTER URBAN FUTURE