Future Cities Advisory Outlook 2022

Building New Urban Resilience

UN-Habitat China Future Cities Council Annual Report 2022

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

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Future Cities Advisory Outlook 2022: Building New Urban Resilience

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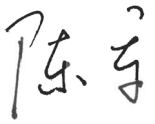
Preface



Jun Chen
Special Representative of Chair of
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The year 2022 marks the third year since the outbreak of COVID-19. It is also the third year of the United Nations Sustainable Development Goals' "Decade of Action". Our world continues to face enormous challenges. More than ever, humans are looking for better ways to "heal up". The world has witnessed a persistent and unchecked pandemic, which has swept across the world like a hurricane, affecting our lives and work, triggering massive health crises, destroying economies, and even claiming more than 5.3 million precious lives. No part of the world can cope with this challenge alone, and no part of the world can insulate itself from this global challenge. This demonstrates our vulnerability as individuals and the importance of increasing solidarity. Cities are at the forefront of this crisis. Facing the unprecedented challenges, no one is immune to worry, but instead of worrying, we need to take actions. Our cities urgently need to strengthen the capacities for emergency response and control in the face of such public health events.

Fortunately, our cities can be more resilient. Looking back on the nearly three years of fighting the pandemic, cities in China have worked closely with governments, businesses and societies to actively explore the development and application of technologies in response to the new pandemic. This has accelerated and deepened our focus and development of urban resilience, as well as expanded our understanding and expectations of the public services and infrastructure on which urban operations and governance depend - smart technology is evolving our cities, which is another opportunity of the times for the human habitat to seek symbiosis and win-win with our nature, and smart technologies will become our core ability to develop people-centred cities with new resilience qualities.

In order to better discuss and share our experience in using smart technologies to respond to the pandemic, my CFCC colleagues and I proposed to build New Urban Resilience. With the help of smart technologies, future cities will be equipped with abilities to cope with more uncertain external shocks under the pressure of

environmental changes; to more finely manage the costs and benefits of urban operations under limited resources; and to pay more attention to the value of social equity and humanistic qualities under the development trend led by technologies. The new urban resilience of the future must have a more agile response speed, more accurate monitoring capability, more efficient collaboration mechanism and more intelligent urban decision-making.

Cities are engines of vitality and innovation, and they are the primary homes of human life. Each of us has a responsibility to protect our homes. This report provides recommendations and detailed examples of how cities around the world can build new urban resilience. We look forward to the positive implications of these recommendations for overcoming the pandemic and building a better urban future.

October 2022

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The UN-Habitat China Future Cities Council project is supervised by Mr. Bruno Deacon, Senior Habitat Officer, UN-Habitat Regional Office for Asia and the Pacific, Mr. Zhenshan Zhang, Habitat Programme Manager for China, UN-Habitat China Office, and Mr. Pontus Westerberg, Programme Management Officer, Innovation Unit, External Relations, Strategy and Innovation Division, UN-Habitat, and Head of People-Centered Smart Cities Global Flagship Programme; Mr. Sheng Ying, National Officer of the UN-Habitat China Office, was responsible for leading the implementation.

UN-Habitat is particularly grateful to the key members of the report writing team: Mr. Hungchih Liu (Senior Vice President of AECOM Asia, Head of Strategy and Development and Head of Urban Strategy Consulting for China), Ms. Xueli Zhang (Deputy Secretary General of China Communications Standardization Association) and Dr. Wenjun Ma (Vice Director of Design Practice Institute of Shanghai Jiaotong University).

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Special thanks also go to the members of the report review panel, who are: Mr. Pontus Westerberg, Programme Management Officer of the Innovation Sector, External Relations, Strategy and Innovation Division of UN-Habitat, and Head of the People-Centered Smart Cities Global Flagship Programme, Mr. Salvatore Fundaro, Senior Urban Planning Specialist of UN-Habitat, Mr. Jian Wang, Academician

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Executive Summary

The year 2022 marks the third year since the outbreak of COVID-19 pandemic which has posed real challenges to economies worldwide and to the global realization of the Sustainable Development Goals, reversing the long-standing efforts in eradicating poverty and hunger, solving the problems of education, health and social protection, promoting economic growth, creating employment opportunities, and other aspects. The economic contraction is therefore jeopardizing the efforts concentrated in the "Decade of Action". More than ever, humans, governments, businesses and cities are looking with hope at the future aiming for a speedy recovery from the pandemic. Cities have been since the beginning the "epicentre" of the pandemic, and while this is not over, they are looking at how to heal back stronger than before, to be able to respond strongly to any future shock.

This report is the second annual report of the UN-Habitat China Future Cities Council, made of Chinese technology entrepreneurs committed to promote sustainable urban development and urban technologies helping the implementation of the United Nations 2030 Sustainable Development Goals. It provides an overview of the impact of COVID-19 pandemic on Chinese cities and offers reflections on the role of Chinese urban technologies in enhancing new urban resilience to respond to the different waves of the COVID-19 pandemic. By presenting various digital solutions developed and implemented in Chinese cities, the report provides pathways on how to build the new urban resilience in China while presenting solutions that can be replicated elsewhere. The report stresses the importance of developing and using digital technologies not only as a way to respond and mitigate the effects of the pandemic but also to create resilient cities. The report argues that, with the growing importance of intelligent infrastructure in urban governance, operation and maintenance, the traditional infrastructure resilience theory is not applicable anymore. The unexpected and borderless spread of the COVID-19 pandemic and the continuously mutating shape have posed new challenges to existing urban infrastructure and public services. However, intelligent infrastructure is not the antithesis of traditional infrastructure. Empowered by new frontier technologies, intelligent infrastructure can help transform and upgrade traditional infrastructure to achieve a New Urban Resilience in cities.

The report highlights some of the key elements to consider by city planners and policy-makers to develop a new Urban Resilience in cities, namely:

(1) Integration of intelligent technologies with traditional ones. The New Urban Resilience will depend on the development of new infrastructures and the integration with traditional ones, with the first building on the front-end collection of material carriers, the mid-office system of data processing, and the terminal platform of information collection and transmission. The stability of the physical infrastructure structure, the adaptability, flexibility and compatibility of its management and operational procedures and platforms make these technologies resilient and meeting the goal of creating an "urban immune system".

(2) data-driven intelligent technological

resilience. In the post-pandemic era, intelligent infrastructures based on data will be the key to the resilience of cities for prevention, planning, response to emergency shocks. By setting up the city comprehensive and interoperable data management platform, the potential urban risks can be more efficiently and promptly identified, mitigation measures be deployed based on multi-scenario simulation emergency plans, increased monitoring capability and real data-based decisions, generating efficiency gains and cutting costs of reconstruction in case of emergencies.

(3) More efficient cooperation mechanism. Digital infrastructure can realise uninterrupted feedback and adjustment mechanisms so to continuously match the allocation of materials, personnel and technology to new needs in the daily operation and in emergency scenarios. Resource efficiency can be therefore achieved not only in cities, but also in cross-regional and cross-cutting service supply, ultimately generating more efficient regional cooperation mechanism.

(4) privacy protection, inclusivity and sustainability of the technologies are essential principles to ensure that no one and no place is left behind. While cities should make sure their citizens specific needs are reflected into the urban resilience plans, global collaborative action initiatives are needed to build New Urban Resilience that offers equal opportunities to residents and communities of any place globally.

(5) intelligent urban resilience is realised combining digital infrastructure, digital economy and digital technology. In the post-pandemic era, new urban resilience will become the core capacity for sustainable urban development, enabling the new vitality of cities with digital infrastructure, prospering the new driving force of the digital economy era and innovating through a new governance model empowered with digital technologies.

As further discussed in this report, the construction of digital infrastructure can help accelerating green development and better lifestyle, address global warming, and build an ecological civilization for a healthy planet, overall supporting the achievement of the 2030 Agenda's goals. Through promoting new urban resilience and proactively engaging digital technologies, high energy consumption and carbon emission in the construction process of large-scale conventional infrastructure could be avoided, leveraging effective use of energy in the construction and operation of mega infrastructure, shun from further aggravating the "urban heat island" effect and empowering cities to respond to any upcoming new challenge.

Building on China's experience on infrastructural upgrading, collaboration and engagement models, new economic opportunities and administrative changes, the experience of building a new urban resilience model, the cases presented throughout this report can serve as an example for other countries and cities to plan a New Urban Resilience model to not only respond to ongoing challenges but also to build back stronger.

Chapter 1 COVID-19 Shaping a New Urban Resilience Concept

The Arcade Commercial Street under the Influence of the Pandemic Source: 58pic.com

Chapter 1

1.1 COVID-19 Poses New Challenges to Chinese Rapid Urbanization

For a long time, the outbreaks of pandemic diseases always exert significant impacts on the development of cities. Outbreaks of plague, cholera and other diseases in the history prompted people to re-examine the relationship between urban environment and public health, effectively promoted the revolution of urban planning concept, and directly led to the iterative updating of urban management and construction related bills. Today, China is one of the countries with the fastest urbanization process and of the largest scale in the world. According to the data of the 7th national population census released by China's National Bureau of Statistics, China's urbanization rate has reached 63.89% and migrant population has reached 376 million .

China is characterized by very rapid urbanization, yet with uneven regional economic development. The rural-urban migration trend, triggered by more job opportunities and higher quality of life and services, has further intensified the spike of urban population density and challenged cities to adapt promptly and respond to the increased services' demand of urban migrant population, posing a more daunting task to the already stretched public service supply in Chinese cities.

The pandemic has seriously threatened the sound operation and growth of cities, posed a grave challenge to any city's safety and efficiency, and also produced a deeper understanding and more dire needs for the city's resilience. The outbreak has brought acute impact and pressure to the city over the long run, threatening the life, health and safety of every urban resident, and uncovering many deficiencies and inadequacies of urban resilience development in modern urban planning and governance. In the long-run, the spreading of the virus increases the operating costs for the sustainable development of the city. In this pandemic, urban transportation, tourism, physical retail, accommodation and catering, cultural entertainment and other service industries have suffered the most, with many small and medium-sized enterprises barely survive. As a result, debt default, business bankruptcy, unemployment and other challenges have affected the city's social and economic development, with economic activities stagnating.

To limit the spread of the virus, as it has been the case in the rest of the world, also Chinese cities have implemented a series of restrictive measures, such as prohibiting gatherings, switching education online, suspending public entertainment facilities. While these measures have effectively reduced the spread of pandemic in the city, they have also caused periodic interference and shutdown to the normal city's functions such as in people's work, lifestyle, transportation and recreation activities. Due to the high demand of specific services, especially healthcare, local governments were overloaded and short in resources to respond to the demand.

After an initial chaotic phase, local governments have quickly adjusted their policies and protocols to respond positively to the new circumstances.

Field hospitals were established to treat many patients with mild symptoms, which helped in cutting medical costs and curbing the spread of the virus. Strict lockdowns were also imposed.

Chinese citizens and enterprises have played a key role in supporting governments' emergency measures. While the first have been promoters of solidarity actions, for instance private car owners and drivers organized their own convoy to transport medical staff, private enterprises and organizations also voluntarily came forward to contribute. For example, data technology companies, represented by Metrodata, used big data to monitor the resumption index of cities reopening according to four levels, namely, land scale, city scale, regional scale, neighbourhood. They also provided the government with data to support evidence-based decision-making and provided an information platform for community grass-roots services. Moreover, various digital tools and computing power support services were developed to fight against the pandemic, as discussed further in the report, accelerating the development of new online technology platforms and new social ecology in various fields (including pandemic prevention and control management, virus sequencing and vaccine research and development, intelligent material distribution, telemedicine services, online office and teaching, etc.). To name some examples :

• health and travel records collection have helped pandemic prevention and control management;

• e-health solutions have solved the issue of difficult access to medical care and drug distribution for some patients with chronic diseases and slowed down unnecessary crowd gathering in medical and health institutions;

• the spreading of apps such as Ding Dong Fresh and FreshHema have ensured people could fill their "household shopping basket";

• teleworking and teaching apps such as Tencent Conference, Teams, Zoom and DingTalk have helped enterprises and schools to carry out daily work and ensure continuity in learning.

Support and expressions of solidarity from the international community, included medical teams, medical and pandemic prevention materials, and donation of materials. China has also contributed to knowledge exchange to helped other countries globally to tackle the various waves of the pandemic. By May 31 2020, China had sent 29 medical expert teams to 27 countries, providing aid to 150 countries and 4 international organizations. Among the aids, two batches of cash support totalling US $50 million were donated to the World Health Organization (WHO), to help purchasing personal protective equipment and establishing a material reserve centre in China, as well as establishing the "COVID-19 Solidarity Response Fund" to raise funds in China. China has also participated in the WHO's campaign of "accelerated access to COVID-19 tools", which aims to speed up the development, production and equitable distribution of new tools.

1.2 Urban Resilience

1.2.1 New Urban Resilience and Agenda 2030

In the time of the so called "Decade of Action" aimed to accelerate on the goals of the Agenda 2030 , the COVID-19 is having a very negative impact on the global scale, not only threatening the lives and health of people in all countries and hindering the sound development of social economy, but also posing a grave test and challenge to the realization of the global Sustainable Development Goals (SDGs). Progresses over goals such as poverty reduction, zero hunger, access to basic services, inequalities reduction and many more have been drastically challenged and slowed down and in certain cases even experiencing a regression. For example, social, political and economic inequalities have further exacerbated the

negative impact of the pandemic. An increasing number of issues have arisen out of the rapid urbanization around the globe, such as the mismanaged expansion of cities caused by rapid growth and high population density, air pollution, traffic congestion and the unbearable cost of increasing public service demands. This time, densely populated cities have also provided a hot-bed for the spread of the virus. The impact of the pandemic has been most severe in poor and densely populated urban areas, with one billion people living in non-standard settlements and slums around the world bearing the brunt first. Overcrowding of cities has made it difficult to observe social distancing and adopt pandemic prevention measures such as self-quarantine. The Food and Agriculture Organization of the United Nations (FAO) has warned that the number of people suffering from hunger and deaths in urban areas could increase significantly, if measures are not taken to ensure food supplies for poor and vulnerable populations . All this poses a huge obstacle to the achievement of the goal of "sustainable cities and communities."

While SDGs achievement is a de facto challenge, China has managed to limit the spill over effects on the economy. In June 2021, the International Monetary Fund predicted that the global economy would shrink by 4.9% in 2020, while China would be the only large economy in the world to register positive growth, with a conservative estimate of 1% of growth. While China's previous economic growth benefited in part from the export of pandemic-related products, the country developed an economic recovery plan which included a large component of revenues from the acceleration of digital transformation in the country. The pandemic has triggered a substantial reshuffling of the city's industrial layout, digital economy has become an important powerhouse to pull economic growth, so industries closely related to digitalization have ushered in an explosive growth. Against the context of global economic stagnation, China has been upgrading infrastructure to enhance the new resilience of cities. While creating more capacity reserves for cities to adapt to external shocks, to engage in more accurate and rapid interpretation of shocks and threats, emergency response to maximize the well-being of normal and abnormal human settlements. China has also explored new administration methods and new economic growth points, successfully promoting China's economic recovery in the post-pandemic era, and improving social employment rate by creating new jobs and opportunities. It is committed by China to minimizing the negative social and economic impact caused by the pandemic, laying a solid foundation for its further development and making important contributions to the country's goal of eradicating poverty this year, keeping 1.4 billion people away from the threat of poverty and hunger.

The pandemic gave great significance of intelligent infrastructure to empower the new resilience of cities, accelerating the development of China's digital economy but ultimately accelerating the achievement of the SDGs. In addition, in the post-pandemic era, the information technology scenario integrating the application in the real economy will also continue to fundamentally change the economic and social operation modes such as consumption and production. In spite of great impact of this pandemic, many enterprises seized the tide and turned the crisis into an opportunity and started combining the application of digital technologies such as 5G, Internet of Things, big data, artificial intelligence, etc., and regarded the pressure of pandemic as a trigger for transformation and a new driving force for business model. Digital transformation has the power of mitigating the negative effects of pandemic on the market and economy and strive for the sustainable growth of enterprises in the future. In the first half of 2020, the added value of China's high-tech manufacturing industry increased by 4.5%, and the investment amount in e-commerce service industry increased by 30%. At the same time, emerging products and service industries witnessed rapid development, with the growth of 3D printing equipment, integrated circuit wafers

and charging stations all exceeding 70%. On top of all that, with the popularization and application of digital technology, this pandemic has helped curbing unemployment. According to relevant data statistics, at present, the scale of flexible employment in China has reached about 200 million .

Efforts have been made to offer good health and well-being for the Chinese people through various measures such as adopting digital technology to fight against the pandemic and speeding up vaccine research and development. In addition, measures to enhance the new urban resilience by strengthening the construction of intelligent infrastructure made China a good example to accelerate the realization of the United Nations SDG11 aimed at developing sustainable cities and communities.

1.2.2 Urban Resilience During the Pandemic

While urban resilience studies and research have usually focused on natural disasters and climate change, the sudden outbreak of the pandemic has showcased weakness in the connection between modern urban planning and governance. It has been an incentive and opportunity for urban changes, prompting the innovation of urban planning philosophies and methods and driving the iteration of urban administration and construction acts.

The massive impact of the pandemic made China, and other countries globally, re-examine the concept of smart city and of "urban resilience" and urged the need to strengthen emergency response and control capabilities in the face of such public health shocks, looking at prevention, response and recovery aspects. In fact, in the immediate, the outbreak has posed grave challenges to urban infrastructures and public service capacity, questioning the city's ability to operate and respond to citizens needs in a safe and healthy way when ravaged by a pandemic. Still in the medium-run, cities have wondered how can they be more prepared to adapt to the uncertain external impact and resist pressures in the future. These have become key reflections in building resilience of cities in the future. If compared to an organism, ideally a city should have a perfect "immune system" capable of healing by itself. Building on engineering technology and information technology, the city would have the all-round ability of independent insight, independent recovery and independent construction. It would proactively respond to the occurrence of unpredicted turbulences and external shocks, and finally, be able to turn challenges into opportunities.

In such a context, what kind of continuous transformation and development do our cities need to better cope with the acute impact of such large-scale public health shocks and the long-term pressure on the global society and economy? What new features should pandemic-resilient cities have?

In China, the use of big data has become the basis for strategic planning and decision-making. Digital technology reaches into all aspects of social life and is continuously integrated and closely related to urban social and economic development. Taking e-commerce as an example, the delivery trajectories of couriers can be tracked through data positioning, thus generating an enormous amount of space-time data. For example, during the COVID19 outbreak, the pandemic situation awareness system for high-risk groups, developed by JD City, has helped to screen suspected groups of people through the system via efficient space-time data management, provided that data security is ensured, so as to reduce the blind spots of supervision and the associated risks caused by information asymmetry. The system can screen the population stationary for more than 2 hours in a specific area in a limited period of time, while identifying potentially risky people contacts by tracking the movement routes of the population, applying strategies for investigation, testing and control formulated by relevant departments so to prevent and control the virus.

Based on the experience in China, the following five key points could support the development of new resilience in cities:

(1) more agile response speed: data-driven technological resilience will further shorten the time-consuming process from information acquisition and analysis for decision-making. Using comprehensive and interoperable urban data management platforms, any urban-related risk can be more promptly identified with real time warning system and intelligence tools, ultimately supporting more agile response and risk mitigation.

(2) more accurate monitoring capability: interoperable devices and platforms empowered by new technologies, such as 5G, Internet of Things (IoT), artificial intelligence allows to effectively process, cross-validate data and information, proactively detect and evaluate urban risks with more accurate monitoring capability, and establish multi-scenario simulation emergency plans, so as to reduce the economic loss and reconstruction costs caused by emergencies

(3) more efficient cooperation mechanism: cross-cutting collaboration models existing among technical personnel in urban management schemes are replicated in the data sharing platforms, improving efficiency of cooperation, enabling more coordinated responses and reflecting the complex relations between modern urban clusters (such as industrial chain layout, ecological collaborative governance etc.) and flows of people, traffic, material, capital and information. The urban resilience system based on digital infrastructure can realize uninterrupted feedback and adjustment mechanism through relevant digital technology, to achieve optimal emergency resource allocation, realize online and cross-regional service supply as well as integrated emergency scenarios and responses.

(4) privacy protection, inclusivity and sustainability of the technologies are essential principles to ensure that no one and no place is left behind. While cities should make sure their citizens specific needs are reflected into the urban resilience plans, global collaborative action initiatives are needed to build New Urban Resilience that offers equal opportunities to residents and communities of any place globally.

(5) more intelligent urban decision-making: data availability, access and reuse through the use of data platforms, big data, data analytics and interoperable systems are key to ensure timely and evidence-based responses to risks as well as to better plan for future challenges, making use of historical data to assess risks and make predictions.

1.2.3 Long-lasting Urban Resilience - Future-ready Cities

In response to the above five key resilience building blocks, the evolution and upgrading of infrastructure is a must-take action. The traditional definition of infrastructure resilience is mainly based on the awareness of disaster resilience engineering. The context of resilience mainly occurs in external natural disasters (including earthquakes, tsunamis, fires, etc.). Infrastructure resilience mainly refers to the response and recovery ability of urban infrastructure in the face of disasters, or the mitigation of the vulnerability of built structures and facilities and covers the smooth flow of lifeline projects and the emergency response capacity of urban communities. However, with the change of urban operation logic and scenarios caused by the Industrial Revolution 4.0, infrastructure has ushered in the reconstruction of industrial system and institutional culture, where the traditional set-up can no longer accommodate the new social production and life mode. The characteristics of the unpredictable, borderless spread of COVID-19 and other variants have not only unveiled many weaknesses in our urban governance, but also posed brand new challenges to our urban infrastructure construction and public service capacity, further

catalysing and accelerating the extension of infrastructure applications scenarios.

With the growing importance of intelligent infrastructure in urban governance and operation and maintenance, the traditional infrastructure resilience theory can no longer comprehensively summarize the new resilience of cities built on intelligent infrastructure. In the future urban development, the intelligent infrastructure (such as 5G, the Internet of Things, Industrial Internet and satellite internet, artificial intelligence, cloud computing and blockchain, and the computing power infrastructure represented by data center and Intelligent Computing Center) and the traditional infrastructure will have to link up, complement, integrate and reinforce each other, thus jointly empowering the construction of new resilience of the city. Among them, integrated infrastructure will help cities realize digital, data-oriented and intelligent transformation as soon as possible through the transformation and upgrading of traditional infrastructure.

To sum up, the new resilience of cities in the future will depend on the profound development of new infrastructure and the integration with traditional infrastructure. Future ready cities build on the information flow storage, made of the front-end collection, the mid-office system of data processing, and the terminal platform of information collection and transmission. The components of its resilience include the stability of the physical infrastructure, as well as the adaptability, flexibility, integration and compatibility of its management and operational procedures and platforms. The first carries over the resilience of traditional infrastructure, while the latter mainly relates to the emergency plans of the operating procedures and the editable space in the back-end. The new resilience of cities has the advantage of material flow and information flow coexistence and values the operation and maintenance of normalization and universality, with strong adaptability, iteration ability, and ecological regulation mechanism that, altogether, makes the urban immune system.

To summarize, the below principles characterize a future-ready city:

(1) Coexistence of Material Flow and Information Flow

(2) Normalization and Universality

(3) Adaptability and Iteration Ability

Chapter2
Smart Urban Technologies in the Phases of COVID-19 Outbreak

Disinfection robot at Shanghai Hongqiao International Airport Source: Sheng Ying, UN-Habitat

Chapter2

To improve urban resilience, different information and communication technologies, products and services were used to empower cities' operations and governance during different stages of the pandemic response. In the early stage, it was necessary to quickly obtain an overview of the spread of the pandemic. New media applications that distribute health advice and alleviate public pressure played an important role in this phase. With number of new cases tapering off and work and production activities gradually resumed, the task of pandemic monitoring and control shifted to normality. The technology products that emerged during this phase were mainly used to monitor the pandemic, track the movement of people, as well as the living and working needs of the population. The telecommunication big data travel history card and other population movement monitoring technologies, first solved the problem of cross-provincial and municipal personnel movement, providing the prerequisites for resuming work and production; Intelligent logistics, intelligent delivery, online conferences, online education and other technological achievements have ensured services' continuity to the public. On the other hand, the community electronic exit and entry system and the remote diagnostic application have led to a further reduction in the risk of infection.

The figure below illustrates two technologies developed in the early stage of the pandemic. Additionally, online communication through new media channels and social media highly intensified during the pandemic to provide timely updates and share reliable information with Chinese citizens. Communication included key governmental decisions, measures deployed by the Joint Prevention and Control Mechanism of the State Council, figures related to cases, public health guidance and research results on the virus. For example, the "Rumor Pulverizer" used big data analytics, to identify and report misinformation about COVID-19. Citizen participation and contribution to news spreading was particularly high. In fact, the use of the hashtag #Help for Pneumonia Patients# for hospitalization on Weibo helped not COVID-19 affected patients to obtain treatment.

When infection rate started declining, the main objective was to support normal activities resumption, such as production, movements, work and education. Intelligent logistics, unmanned delivery, online conference and remote education have offered convenient services. On the other hand, infection risks have been further decreased by smart control system of community exits and remote diagnosis apps.

Although the technology products developed in this phase were different, they relied on the same technologies such as big data, artificial intelligence, cloud technology and 5G networks are at the heart of urban technology in this pandemic prevention battle. Examples of technologies deployed are the "Travel History Card Application" developed by China Academy of Information and Communications Technology (CAICT) and three Chinese telecom operators, that by using mobile data GPS could control people movements in high-risk areas in the past 14 days as well as alert on potential risky contacts with the infected people. During

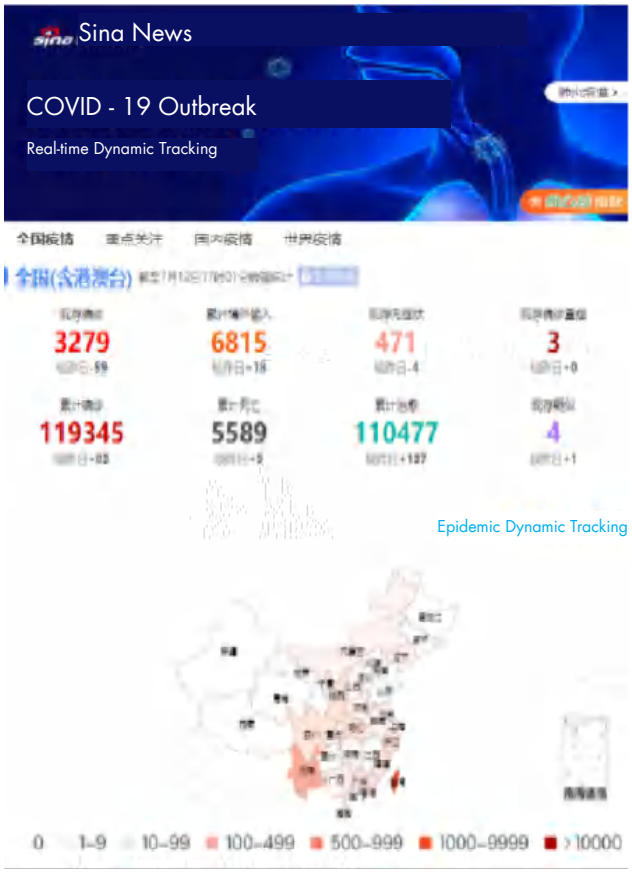

Figure 1: Real-time COVID-19 Surveillance Platform

Sina launched a pandemic monitoring system based on technologies of big data and artificial intelligence. With the data and visualizing tools, the platform is able to report the total number of COVID-19 cases including confirmed, suspected, deaths, recovered, and imported cases. Data is disaggregated at district and county and national levels.

the analysis and use of data, security and personal information protection policies were strictly implemented. Also, the "Migration Big-data Platform for Pandemic Prevention and Control", based on the SEIR pandemic model, used the cell phone signal and data and social relation data to stimulate for government officials the post transmission chains and to estimate infectious reproductive number. The below figure showcases some of the technologies developed during this stage. Worth mentioning, the spread of online learning with the launch of a national e-learning platform, allowing the end to end learning process, including notes taking and exams.

The electronic access card launched by Tencent Haina provided a contactless community access management solution using the WeChat account to obtain services such as e-passes, key personal access controls, pneumonia self-examination, resident health registration, and home observation body temperature reporting. Users' privacy is guaranteed through security control and encryption protection at any use stage, from the personal information collection to the storage systems and platforms.

Figure 2: Urban Epidemic Prevention and Control Big Data Platform

Developed and built based on high-definition mapping, GIS and data processing technologies, focusing on the entry and exit of people in transportation hubs and the quarantine situations of the people arriving in the city.

Five dashboards Pandemic Overview, Transportation Hub, Highway, City Control, and Transferred People Tracking through visualization tools and visible on the platform.

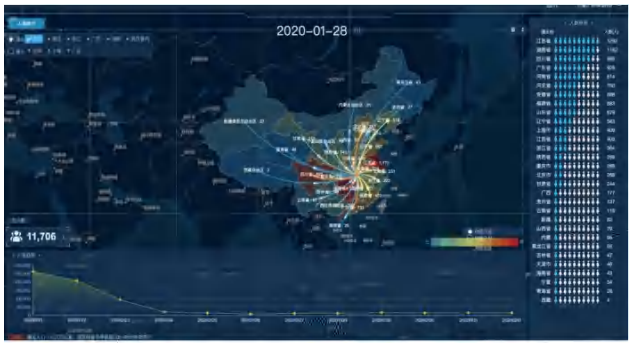

Figure 4: Population Big Data Platform of Pandemic Prevention and Control

Figure 5: National Key Medical Material Support Scheduling Platform

Figure 3: Travel Big Data Itinerary Card

Figure 6: National Primary and Secondary School Network Cloud Platform

Figure 7: Residential Compound Access Management Platform

For example, when collecting and transmitting data and information, the devices, platforms and transmission channels of both parties were equipped with encryption measures, such as domestic cryptographic algorithms, to effectively prevent the leakage of personal information. This phase has experienced the proliferation of e-health solutions, such as an 5G remote ultrasonic robot allowing remote diagnosis and treatment of patients (currently used also in many hospitals in China such as Leishenshan Hospital, Jiang'an Cabin Hospital, and Huangpi Cabin Hospital, monitoring most severe patients), COVID19 Fast Testing based on knowledge mapping and semantic retrieval techniques and empowered with AI technologies learning from historical data and trends.

Last, to mitigate the pressure on transportation in affected areas, logistics companies such as SF Group and Jingdong Group applied drones to help with the transportation. Three technologies including unmanned aerial vehicle data link system, unmanned aerial vehicle flight control

navigation system, and unmanned aerial vehicle autonomous control were the key of developing the drones.

Other technologies were developed to support the return to work, such as employee's management system to advise on differentiated strategies for resuming working modalities based on the real-time pandemic situation, digital certificate approval platforms for contactless validation of negative tests etc. New digital infrastructures were developed at the country level to resume economic operations, such as heat map for shopping centers and business spaces, customer flows estimation platforms, business operations data platforms, pricing monitoring platforms etc.

In the last stage, solutions were developed in collaboration with the international community and mainly to support the global tracking of cases and convergence of measures. Information and data sharing have supported the deployment of the 2019 Novel Corona-virus resource database providing open access to resources, translating big data into big discoveries and support worldwide activities in both academia and industry and the COVID-19 Academic research communication platform.

The below table provides a summary of the various technology solutions developed to respond and manage the pandemic in China.

Data-driven anti-pandemic technologies greatly improved the digital aggregation by sharing public data, bridging the digital divide within society and among countries. While there has been convenience and benefits brought by smart urban and anti-pandemic technologies, personal privacy and data protection has been a topic of attention. On the one hand, privacy protection can be enhanced through technological advances.

For example, the use of encryption algorithms can prevent privacy leakage in data collection and transmission (e.g. community access management system); the use of blockchain technology combined with big data can provide encryption protection for information uploaded by individuals. On the other hand, the improvement of laws and regulations is also strengthening privacy protection. Bridging the digital divide and protecting data privacy is a long-term and systematic goal that cannot be achieved without the efforts and cooperation of policy-makers, individuals, businesses and any data user. However, as technologies continue to advance and regulations continue to be updated, we expect that these two will be even better supported in future means of fighting the pandemic.

Table 1: overview of technology solutions to respond to COVID19 outbreak in the various phases

Scenarios	Products/Tools	Key Technologies	Functions
Early Stage			
Urban pandemic monitoring	Real-time COVID-19 Tracking Platform	Data analysis	Monitoring and visualizing the COVID-19 expansion trend
	Big-data Platform for Pandemic Prevention and Control	GIS, mapping, data processing	Monitoring and visualizing population movements
New media propaganda	Short video applications	Data mining, data analysis, natural language processing	Reporting: key measures for prevention and control, patient numbers, fake news
	Online news application		
	Social media		
Interim Stage			
Migration detecting	Travel History Card Application	Acquisition, transmission processing of signalling data	Checking if a user has been to high-risk areas in the past 14 days
	Migration Big-data Platform for Pandemic Prevention and Control	Dynamic databases, independent search algorithms, adjoint algorithm, SEIR modelling	Monitoring population movements into mega-cities, stimulating the post transmission chains, estimating infectious reproductive number
Intelligent logistics	National Key Medical Supplies Planning Platform	Multi-source data analysis	Monitoring the production and supply of key medical materials
	Unmanned delivery vehicles	Level 4 self-driving	Unmanned vehicle delivery
	Delivery drones	Unmanned Aerial Vehicle (UAV) data link, UAV flight control, UAV self-control, drone navigation	Unmanned delivery
Intelligent delivery	Contactless delivery	Instant communication technology	Contactless delivery and pick-up
	Smart cabinet	QR code and instant communication technology	Contactless delivery and pick-up
Online conference	Online Conference App	Cloud technology, instant communication	Video conference, online meeting, etc.
	Online cooperative document editing	Cloud technology, instant communication	Online collaboration of file editing, saving, sharing, presenting, etc.
Online education	National E-learning Platform for Primary and Secondary Schools	Cloud storage, cloud platform	Offering online lessons for elementary and secondary schools
	Online Course Platforms	Cloud platform	Offering online lessons, setting up online courses for teachers, recording engagement for students
Community grid management	Electronic exit and entry system	Data collection and analysis	Managing community-level people flow-in and flow-out
Remote diagnosis	5G-assisted remote ultrasound diagnosis	Robot and AI, real-time remote controlling, 5G network	Remote ultrasound diagnosis and treatment
	COVID-19 Fast Testing and COVID-19 Intelligent Q&A	Semantic recognition	Remote medical diagnosis and advice

Scenarios	Products/Tools	Key Technologies	Functions
Late Stage			
Information sharing with international communities	2019 Novel Corona-virus Resource	Database, data platform	Updating genome sequence data, collecting and monitoring academic literature on COVID-19, updating real-time prevention and control policies
	COVID-19 Academic Research Communication Platform	Database, data platform	Updating the latest scientific findings and knowledge on COVID-19
Technologies supporting go back to work	A management system of people going back to work	Multi-source data analysis	Recognizing the distribution of risky people, making differentiated strategies for resuming, estimating case numbers and spreading trend projection
	Digital certificate approval platform	Verification technologies, such as biometrics, electronic signature, and electronic seal	Making online signature, signing self-health statement
Urban recovery	A Big data platform of business operation, information sharing for business resuming	Multi-source data processing, big data collection and analysis, cloud computing	Projecting customer flows, plotting heat map, analyzing customer movements, offering customer portraits
	Misinformation and pricing monitoring platform	Natural language processing, image analysis technologies, machine learning	Monitoring unreasonable market pricing and exposing misinformation

Chapter 3 The Digital Construction of New Urban Resilience

Concept of 5G Wireless Digital Connectivity and IoT in Smart Cities Source: 58pic.com

Chapter 3

While the outbreak of the COVID-19 has posed new challenges for every city globally, the impact is being higher especially in vulnerable cities. Digital solutions such as artificial intelligence, the Internet of Things and 5G are rapidly creating opportunities for cities to develop and fight against the pandemic. They also play roles in pandemic surveillance and analysis, virus traceability, prevention, control and treatment, resource deployment and other areas, as was discussed in Chapter 2.

The digital construction of the new resilient city uses big data, artificial intelligence, city information model (CIM), decision-making model and other digital technologies to achieve the combination of both "peacetime and battle time" for city operation and management. It makes the city management more intelligent and the emergency decision-making more scientific and can increase the city's resilience to better respond against disaster and stocks of any kind. In normal times, various types of sensing devices and intelligent infrastructure of the smart city can realistically mirror the city status. When emergencies occur, it can provide the real-time image of the disaster, suggest remote emergency command, and rapid dispatch of resources; last, in the aftermath of the disaster, it can help in design a rapid recovery plan.

3.1 New Resilient Cities Under the COVID-19

In the context of COVID-19, the traditional urban disaster prevention and recovery system does not obtain accurate and on-time information, lowering organizations' ability to quickly respond to or adopt preventive measures. The new resilience emphasises a city's ability to remain resilient, surviving, adapt and remain sustainable in the event of emergencies by relying on its dynamic balance and self-recovery characteristics powered by digital technologies. The following are some of the features making a city resilient:

• A general digital framework for a new resilient city in the context of the pandemic response has been developed. Through the collection of real-time big data on the pandemic, knowledge association and fusion analysis, the direction and location of population movement can be tracked, the trajectory of suspected virus contagion identified, and "high-risk groups" and super-spreaders promptly spotted. It supports the prevention and control departments to accurately identify critical nodes and chains that need to be focused on and can generate content-rich visual analysis reports to support the coordination of various pandemic prevention and control departments across different regions.

• Data, platforms and applications are key to support the new resilient city digital scheme. First, data collection through IoT devices allows multi-source information gathering. During the pandemic, geospatial data, other data such as the medical data were obtained by the National Health Commission, population data by the Public Security, traffic data by civil

aviation and railroads, internet big data by cloud platforms, communication data by the three major operators, and industrial data by the Industrial Internet information. By cross-checking multi-sources data, it is possible to draw evidence and take decisions on the pandemic response. Secondly, data has to be stored into a data sharing and exchange platform which is open and accessible. The primary goal of building such a platform is to be integrated and interoperable, breaking silos and administrative compartmentalization to reach a unified planning and construction.

• To guarantee the successful implementation of the digital scheme of the new resilient city, a series of safeguard measures are needed, such as: full-cycle management, sector-wide coordination, community-wide participation, standardized regulatory system, digital security protection, addressing the digital divide, objective evaluation and periodic assessment, etc.. Digital framework is the foundation to promote the construction of new "people-centered" resilience cities. A community living circle with good quality services and healthy life standards is the foundation of the new resilient city. We can finely measure communities' life in terms of services needs and health resilience, continuously optimize the layout of various public service facilities, and improve the quality of urban life and living. The continuous "build and evaluate" process will help us learn from our experience and lay a good foundation for urban regeneration and new construction.

• To establish an integrated, ubiquitous monitoring network, cities should have an air-space-ground integrated system of remote sensing and meteorological satellites, drones, detection instruments and sensors, Internet and other monitoring terminal systems to acquire full-time, full-area and city operation-related data. The unified planning and construction of satellite networks, 5G communication networks, IoT and the Internet are used to provide a network foundation for data collection. The Cloud, network and terminal construction; with its comprehensive coverage, intensive sharing, and instant intelligence characteristics, provides a base for the set up of a urban digital ecosystem and data that support governments in the decision-making. The system can, by analysing the collected data, predict and warn potential risks of various urban public activities, as illustrated in the image below.

• Building the cloud can is a process to be

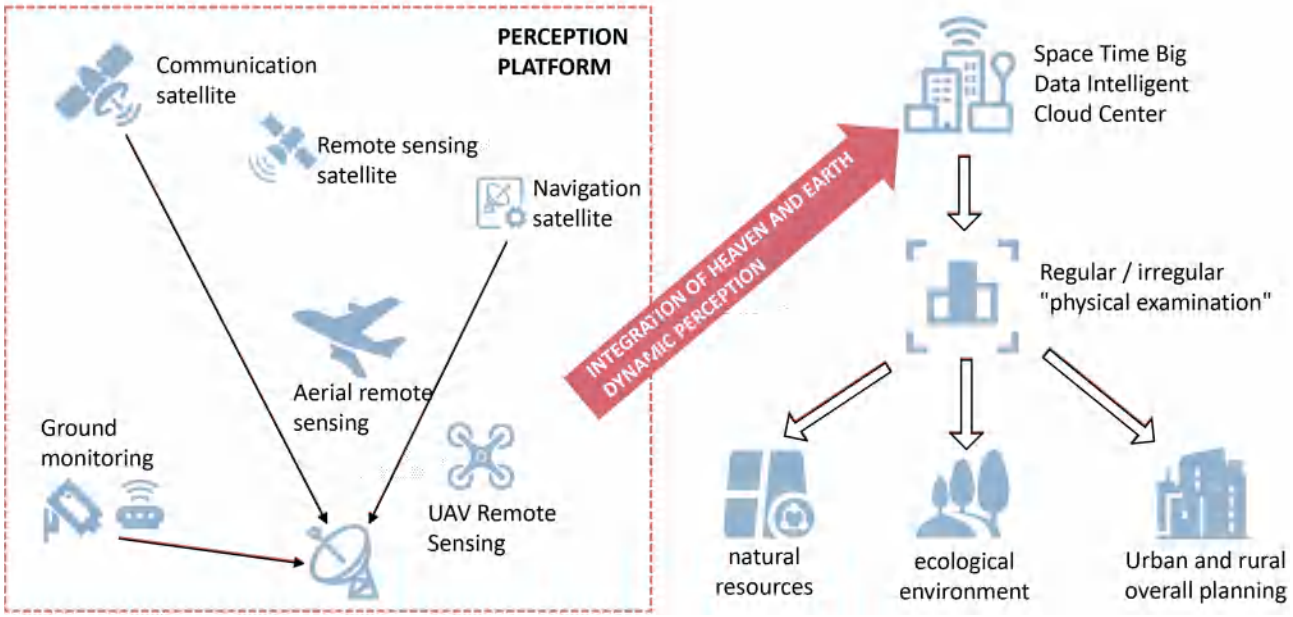

Figure 8: Ubiquitous Perception Monitoring Network for Urban Integration, Source: Collect and draw by author

done progressively. The main advantages of the cloud are the ability to share resources, improve the ability to solve critical tasks and reduce the difficulties of operations and maintenance. Currently, most cities in China have completed the construction of multiple types of clouds, with the government cloud playing an increasingly important role in the city's digital governance system.

• When creating the network, it is necessary to allow future upgrades of the system. The network is built gradually with the city's development and then retrofitted and upgraded based on demand and on business capacity. The construction of urban terminal networks provides basic support for community management. When the urban residents become the real users of urban digital systems, the city can truly enhance its resilience.

• Counting on a platform is a strong asset for city intelligence. Integrate the construction needs of application fields of the smart city; form a public database of unified collection and storage; build an interoperable platform support system covering the integration of data/ technology/ facilities and applications; promote sharing of infrastructures; provide integrated services

Table 2: Example of Safeguard Measures to be Adopted for New Resilient Cities

SAFEGUARD MEASURE	DESCRIPTION
Full-cycle management	The full cycle of pandemic prevention and control includes four stages: prevention and preparation, monitoring and early warning, response and implementation, recovery and reconstruction. **The full scene of pandemic prevention and control** can monitor the overall situation of the pandemic from a macroscopic perspective, and also present the details of community pandemic prevention, trajectory tracking, resumption of work and production, and focused relief from a microscopic perspective, achieving the effect of multi-dimensional visualisation of pandemic prevention and control scenarios. [5]
Sector-wide coordination	The digital construction of the new resilient city is not simply the digitization of urban government departments and business lines, but to coordinate the "viscera" of urban governance through interconnection, vertical and horizontal linkage, to turn the past "steady" and compartmentalised information system, into a full time, full mode and full response intelligent system , which can improve the city's responsiveness to emergencies and enhance urban resilience. The end product of sector-wide coordination is reflected in the construction of platforms such as "integrated online platform" and "Integrated management platform".
Community-wide participation	**Build a multi-centered, composite pandemic prevention and collaborative control system** , to realise a widely connected, interactive and collaborative pandemic prevention and control network, and realise a decentralised, real-time and interactive big data intelligence network. As a result, it can quickly understand and gather the real situation, wisdom and demands of the people under the pandemic prevention and control, and facilitate the pandemic prevention and control system to better realise the people-centred concept. [1] Actively promote the shift of the centre of social governance and build a government-led grass-roots governance pattern of common construction, sharing and governance. [6] The key is the continuous enrichment and improvement of social organisations to form an effective synergy with the emergency response capabilities of individual citizens, so that the city can become smarter at the social level. [7]

Standardisation of the regulatory system	**Improve the relevant regulatory system and promote the construction of standards.** A large number of new technologies are applied in the pandemic prevention and control stage, and in order to guarantee the standardisation of the technologies in the process of use, China has launched a series of national standards. **Implementing refined prevention and control mechanisms and forming a safety work operation manual.** Take "risk prevention and control without dead ends, emergency response to be efficient" as the requirements, improve the risk detection, assessment standards, management and control measures, information transmission, response and other aspects of the mechanism, to solve the issue of "action" and "management" of city risk prevention and control and emergency activities. [8]
Digital Security Protection	Since the launch of the "Health QR Code" and "Passing Code", there have been several network crashes, affecting citizens' daily travel. The digital infrastructure carries a large amount of access, therefore, it needs to maintain its own security and stability, especially to prepare for sudden emergencies and cope with instantaneous overload situations.
Data Masking	When the basic information of new cases and action tracks are published, the specific names and detailed addresses of patients are removed so that the public cannot identify specific individuals through such information and avoid incidents of leakage of sensitive personal information.
Data security	Standing on the side of the overall security concept, a comprehensive three-dimensional defense system for big data security should be built. To do so, firstly, the resilience of digital infrastructure should be enhanced to prevent possible power and network outages. Secondly, different security measures are applied to each stage in the full life cycle of the data. Thirdly, we should achieve the transformation from passive defense to active detection.
Address digital divide	**Improve digital infrastructure construction and narrow the digital gap between urban and rural areas.** During the pandemic, education was fully shifted from offline to online, and remote areas could not get good education resources because of insufficient infrastructure construction and poor broadband network signal. In the face of the dilemma of rural online classes, some public welfare organisations launched campaigns to donate smart devices respectively. **Create a combination of traditional services and intelligent services to prevent and control the pandemic on a regular basis.** During the pandemic, the widespread promotion of electronic passes such as “health QR code” and “travel code” caused some inconvenience to the elderly during their travels. In November 2020, the “Implementation Plan on Effectively Solving the Difficulties Faced by the Elderly in Using Intelligent Technology” was deployed to promote the solution of the difficulties faced by the elderly in using intelligent technology, which insists on the parallel of traditional service methods and intelligent service innovation.
Improve risk research and early warning capability	The new smart city integrates information technology and physical space creation to achieve a scientific, timely and effective response in the face of disasters.

for various intelligent application systems, and effectively avoid multiple investments. The platform should be people oriented, meaning aimed at solving people's livelihood problems and responding to city operation and social development needs.

• Smart terminals can help build multi-application systems. The rapid growth of various digital application demands has given rise to the emergence of countless digital terminals. Based on an interoperable data pool and platform support system, through the real-time and dynamic transmission of data multilaterally, the smart applications of spatial and social governance can improve the overall urban governance capacity.

• It is advisable to adopt distributed digital architecture. The majority of data is generated in the city, the value of which is mainly reflected in local applications, and it should be realised as far as possible to obtain data in the vicinity, store it in the vicinity, and apply it in the localised operation mode, so as to reduce the amount of data that needs to 'run', and let the data that needs to run to run more smoothly.

• To guarantee the successful implementation of the digital scheme of the new resilient city, a series of safeguards mechanisms are needed, these safeguards include: full-cycle management, sector-wide coordination, community-wide participation, standardised regulatory system, digital security protection, and elimination of the digital divide, etc.. The below table summarized the possible safeguard measures to adopt.

3.2 Solutions for the Impact Caused by Specific Scenarios

Several digital/smart solutions have helped in addressing pandemic-related impacts. Firstly, Information interaction and sharing based on digital technologies such as big data, allows the key data to be circulated among regions, presented in a holistic panoramic view; it realised the use big data for pandemic identification and analysis of the trend of the pandemic around the world, to determine the impact of the pandemic on the economy, and more practical applications.

The image below illustrates a transmission chain developed across Chinese cities to analyse the pandemic spreading.

Secondly, advanced technologies including artificial intelligence applied to the healthcare sector have made assistance to medical diagnosis and healthcare more efficient and faster. For example, AI applications aiding experts in identification of the coronavirus and shorten the genome-wide secondary structure prediction time have been developed during COVID19 in China.

Thirdly, both emergency and development, public and individual needs are to be satisfied by integrating institutionalised and fragmented pandemic prevention and control resources and forces, etc..

Fourthly, in the process of pandemic prevention and control, the spreading of fake news around the public is very common, so the media has to be the source of truth, strengthen positive guidance and curb false information with effectiveness. Open and transparent information allows the public to participate in the social governance monitoring process in a diversified way, deepening trust in the government, enterprises and social organisations. Since the outbreak of the pandemic, relevant departments and institutions have released timely data and digital statistics of confirmed, suspected, cured and deceased patients. Some internet companies' services have effectively met the public's demand for pandemic-related information and played an important role in effectively guiding the whole community to fight against the pandemic

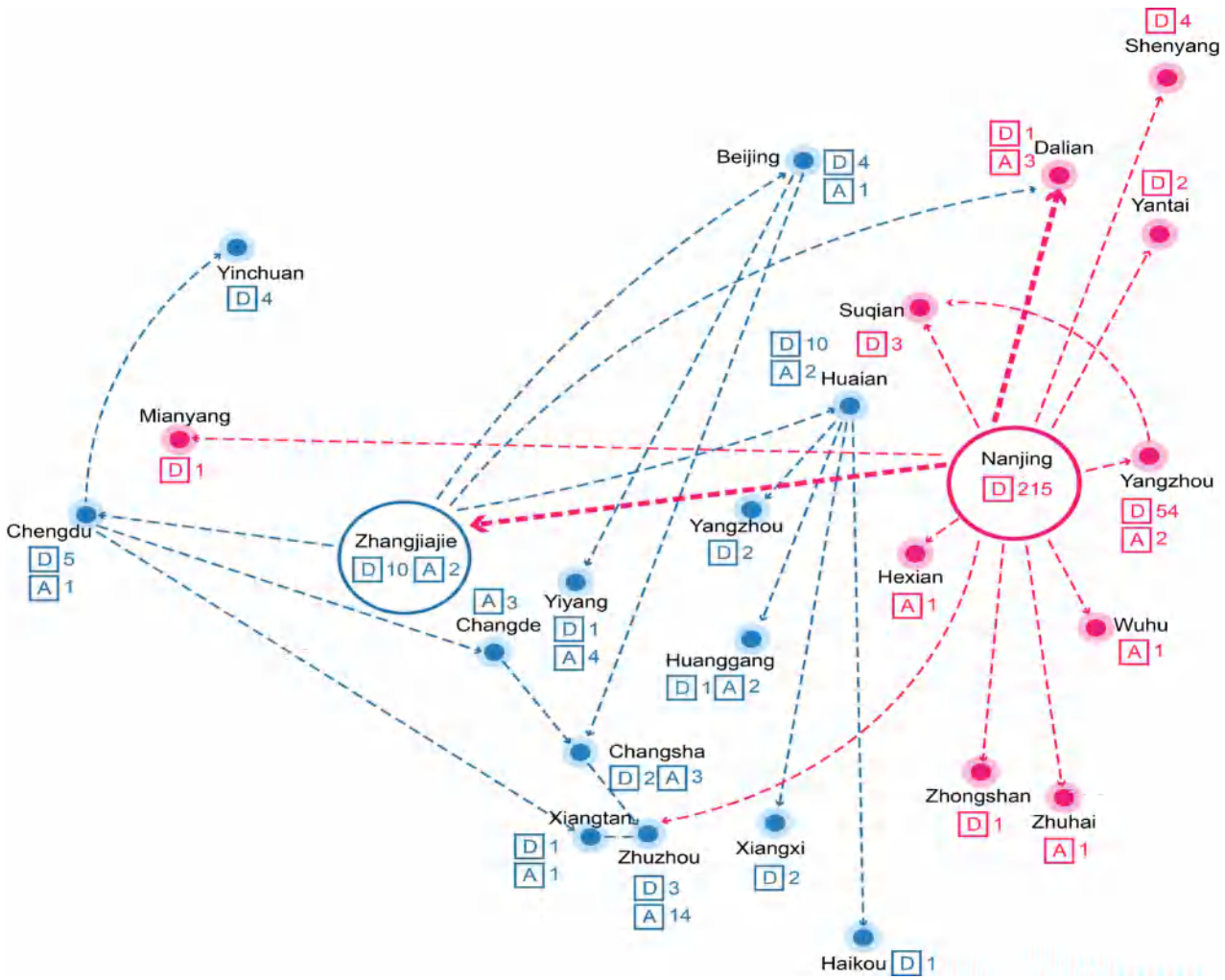

Figure 9: Transmission Chain of the Pandemic in Nanjing in July 2021, Source: Ge, Bai & Cun, Zhang, Beijing Daily (2021), redrawn by author

effectively and rationally. Furthermore, many medical and psychological counselling platforms not only provide psychological guidance to people in the disease affected areas, but also popularise the knowledge of the pandemic to the public and help people get out of the shadow brought by the pandemic as soon as possible.

3.3 The Case of New Resilient Communities

Resilient governance is a systemic project with multiple elements intertwined, which is mainly reflected in the system's ability to sense risks in time, inhibit the expansion of sudden shocks, and have a functional structure that is resilient and survives to recover. As the cornerstone of social security, communities play the role of "first responder" in emergencies. By using new generation information technologies such as the Internet of Things, cloud computing, big data and artificial intelligence, community resilience can be enhanced.

3.3.1 Specific Scenarios for Community Prevention and Control

There are various methodologies for enhancing prevention and control at a community level. The system can collect and manage comprehensive information on people in the community without contacting them, which facilitates the

comprehensive management and early warning of the pandemic within the community. The strict control of movements and visitor management through the monitoring of exits and entry points by using sensors and other smart technologies is a prevention measure. Moreover, the personnel tracking system collects and summarises all aspects of health information through information reporting, health check-in, and performs relevant statistics and analysis to provide comprehensive assistance to community management during the pandemic.

Other mechanisms include the easy-to-install, user-friendly, "Pandemic Prevention Caretaker", equipped with the artificial intelligence image device chip, which can identify violations of norms. There are also face recognition applications to identify persons not wearing the mask and issue warnings.

Additionally, there are innovations to manage key population groups such as remote monitoring, to facilitate the no-contact management. Through voice calls, two-way video calls to keep track of isolated persons at any time. Through video flash memory, video of isolated personnel leaving home will be retained.

Finally, the ability to effectively organise communication and command decisions is the key when an emergency occurs. Using the 4/5G private network, we can quickly build regional emergency private network command communication.

3.3.2 Case: Zhenru Community, Putuo District, Shanghai

Zhenru Community, Putuo District, Shanghai deepens the construction of "Integrated Online Platform" and "Integrated Management Platform", accelerates the pace of digital transformation of the economy, life and governance, focuses on urban operation, public safety, grid management, ecological environment, emergency management and other key areas, and realises "one screen to view the panorama, one network to manage the whole region", to improve the resilience of the community.

In order to effectively control the entry and exit of the people under home isolation, Zhenru town street took the lead in trying to install door sensors on the doors of the home

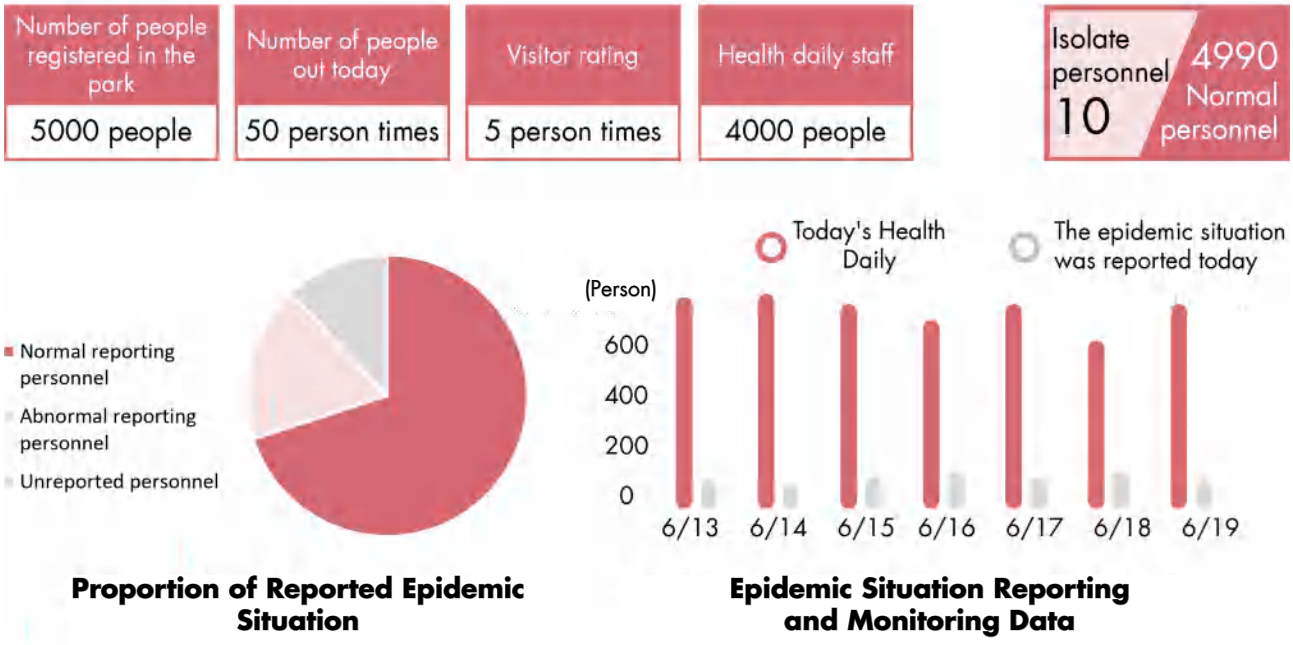

Figure 10: Statistical Chart of Community Personnel Data, Source: Schiele Intelligence

isolation households, to monitor the entry/ exit of community members and minimise their movement. Additionally, a community intelligent access control system has been developed, to record data when residents are entering or exiting the community. Different methods such as face recognition and electronic cards are developed to address the "digital divide" problem for elderly and disabled people. For some of the key populations, with their consent, measurement and control devices are installed in their homes to ensure that their health statuses are known at all times. Furthermore, Zhenru town street pioneered the "one code management" system, which empowers each line to send orders to the property companies and provide comments, so that the street assessment of the property companies becomes objective, transparent and fair.

Other technologies include the “Little red hat” grid members equipped with a 5G mobile network to conduct grid-based management, solving various practical problems such as pipe ruptures and flood control. This way is not only effective in saving manpower and financial resources, but also effective in dealing with various emergencies. Another issue addressed was that electric vehicles' access into the residential floor may cause detonation and other safety hazards. This was achieved by using elevator ladder control sensors. Furthermore, Monitoring systems were developed to enhance the safety of the people; to make sure there are no major production safety liability accidents and major fire safety liability accidents.

3.3.3 Assessment of Healthy Resilient Living Community

By integrating the concepts of health and resilience into community planning, configuring and optimising daily health and emergency facilities, the community life circles can also become prevention circles of urban disaster and epidemic. Therefore, it is possible to make refined measurements of community life from daily life services and health resilience and build a healthy resilient 15-minute community based on multi-source big data.

50 experts from Shanghai, Wuhan, Quanzhou, and Ningbo ranked and weighted the importance of various living service facilities and divided the evaluation objects into 16 basic living services in 7 categories, such as education, culture, sports, administration, commerce, pension, and medical care. The health resilience assessment

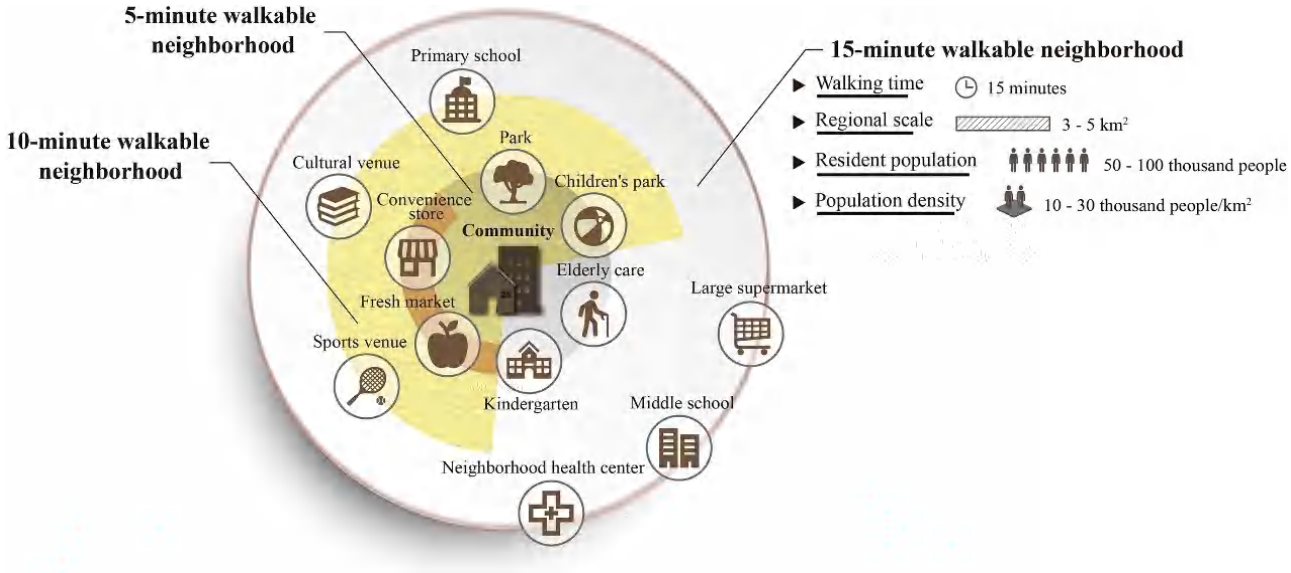

Figure 11: Schematic Diagram of a 15-minute Walking Life Circle, Source: Weng et al., 2019

of the community mainly focuses on technical resilience and conducts multi-faceted analysis and evaluation of the construction of related facilities such as disaster prevention, medical care, transportation, and open space.

3.3.4 Evaluation of Community Resilience Based on Multi-Source Big Data

The four cities, Beijing, Shanghai, Shenzhen, and Wuhan, all have a resident population of more than 10 million, representing the highest level of development in the Beijing-Tianjin-Hebei region, the Yangtze River Delta, the Guangdong-Hong Kong-Macao Greater Bay Area and the central China hub region. They were selected in the assessment of their services for a healthy resilient community, to compare the differences in the planning and construction of their communities. From the boxplot shown in Figure 6, it can be seen that Shenzhen has the best performance in disaster prevention and epidemic prevention, with the highest value and the overall median value among the four cities.

The image is the assessment of transportation resilience, which is compared by the median of the transportation resilience index of all residential areas to represent the overall level of each city. From the results, on the whole, the traffic resilience index of residential areas in the four cities shows a trend of decreasing gradually from the central urban area to the

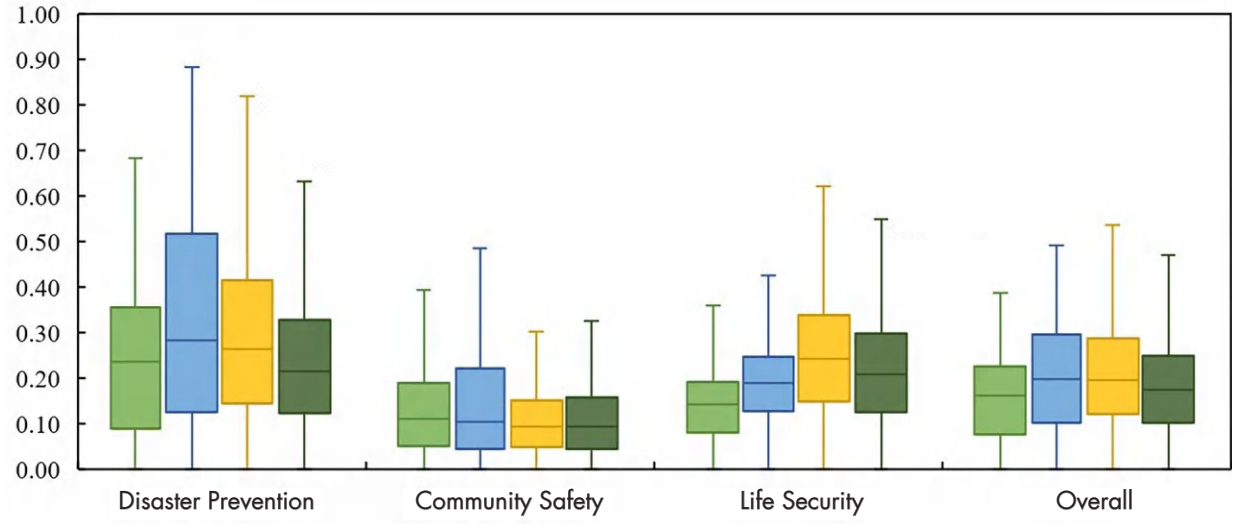

Figure 12: Disaster and Epidemic Prevention Index by Facility Category in Beijing, Shanghai, Shenzhen and Wuhan, Source: Author

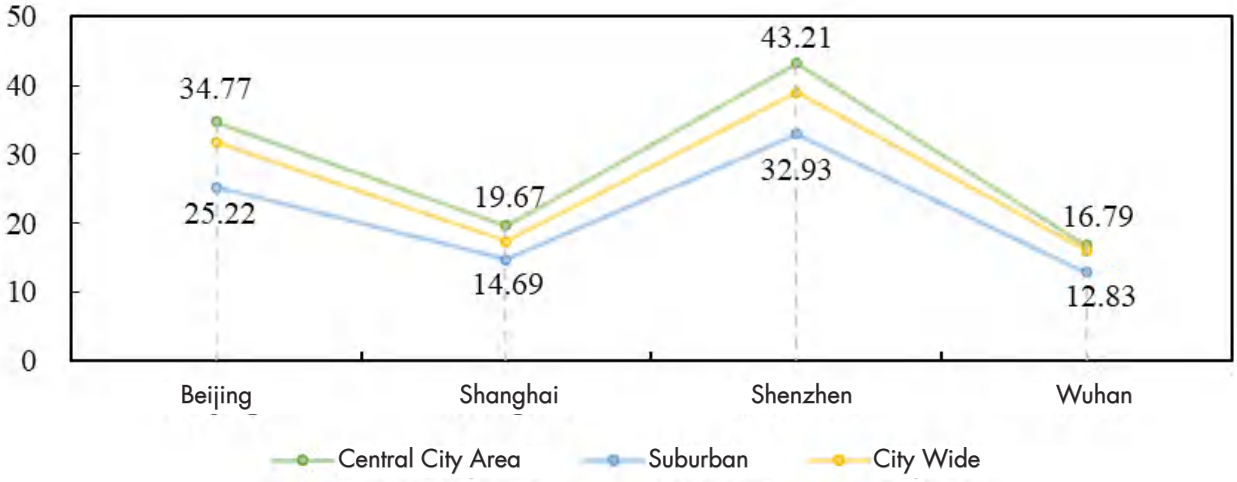

Figure 13: Beijing-Shanghai-Shenzhen-Wuhan Environmental Resilience Index, Source: Author

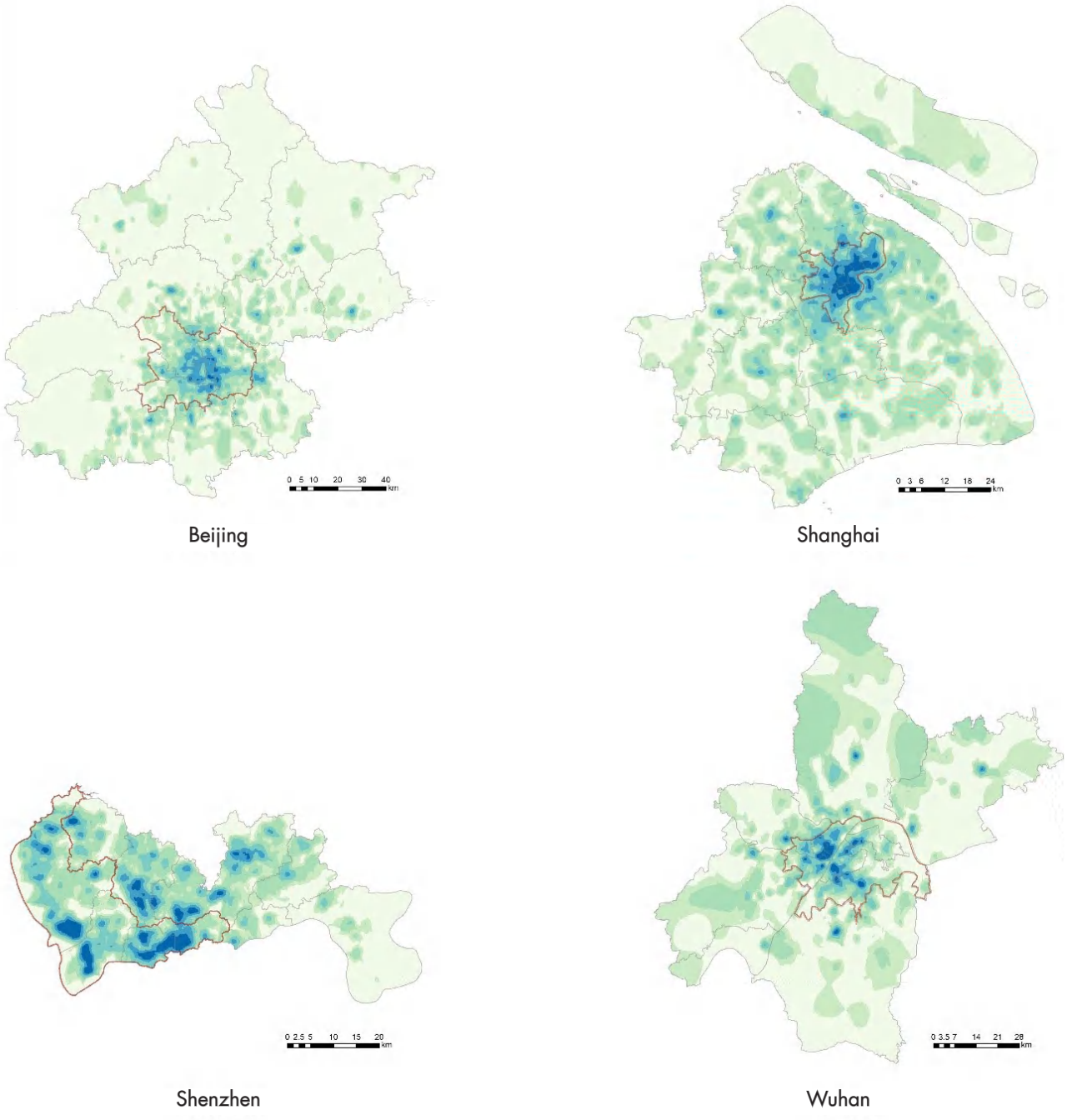

Figure 14: Spatial evaluation of the Beijing-Shanghai-Shenzhen-Wuhan disaster prevention and pandemic prevention index, Source: Author

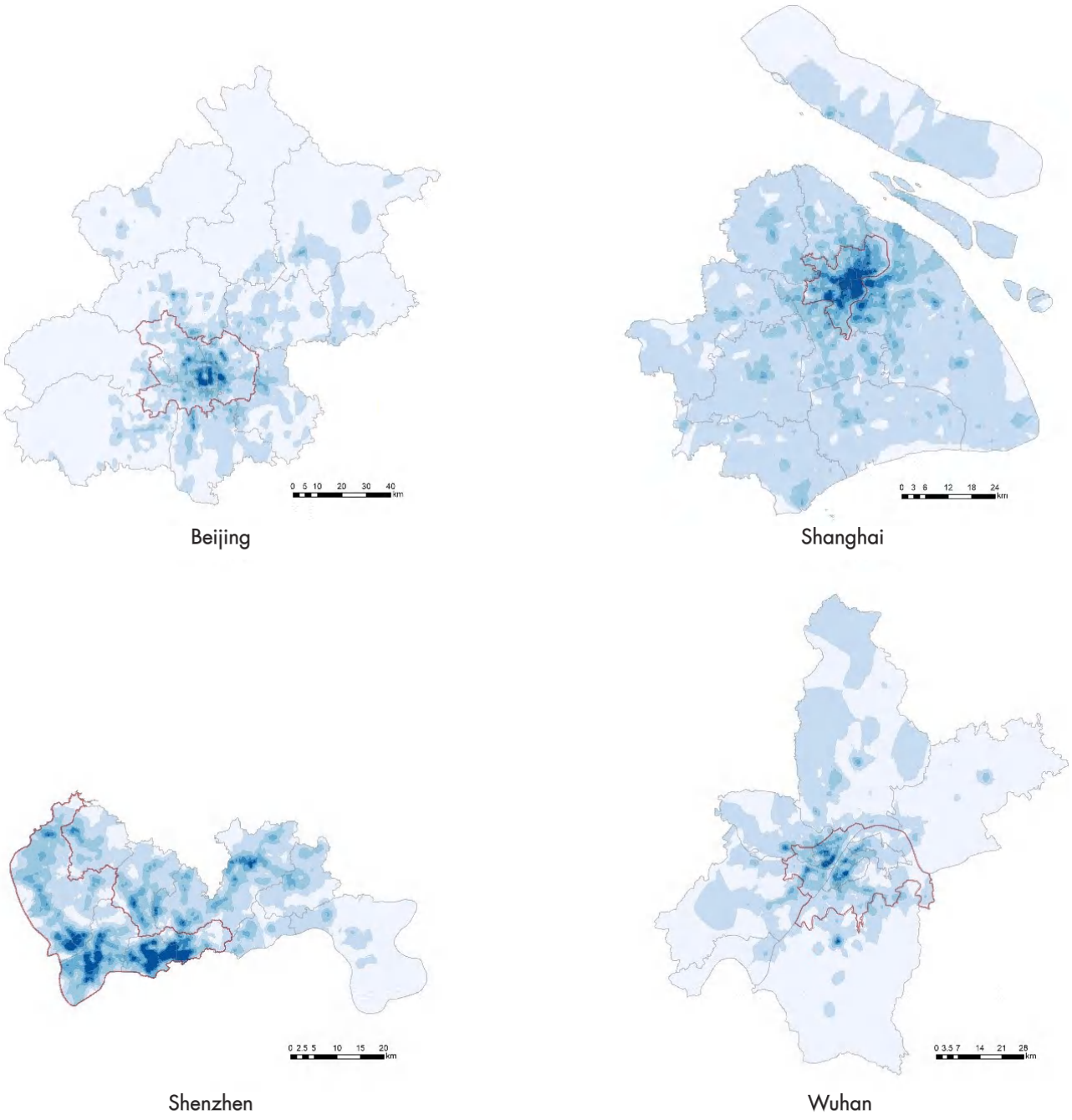

Figure 15 Spatial evaluation of the Beijing-Shanghai-Shenzhen-Wuhan healthy travel index, Source: Author

outside, showing a radial distribution. In terms of transportation resilience index, both Beijing and Wuhan have considerable areas of low levels in the suburbs, accounting for more than 50% of the whole city. The proportion of areas with extremely low indexes in Shanghai and Shenzhen is less than 30%. Except for Chongming District, there are almost no large areas with extremely low index in Shanghai, which has excellent performance in terms of transportation resilience.

Finally, in the assessment of environmental resilience, illustrated above, Shenzhen and Beijing benefit from higher per capita public green space, ranking the top two (Figure 13). Although the per capita public green space area in Wuhan is higher than that of Shanghai, due to the impact of accessibility, the overall environmental resilience index still ranks behind Shanghai. The environmental resilience index of the central urban areas of the four cities is higher than that of the suburbs, among which the difference between center and suburbs in Shenzhen is the largest, and the difference in Wuhan is the smallest.

Chapter 4 Case Studies

A bustling street stall night market during the resumption of work during the Pandemic Source: 58pic.com

Chapter 4

4.1. City Cases

4.1.1 Chengdu High-tech Zone: "1+5+N" Urban COVID-19 Pandemic Integrated Comprehensive Control

Chengdu High-tech Zone "1+5+N" integrated comprehensive control of the urban pandemic is based on: "1" screen overview, "5" cores include: isolated hotel supervision system, pandemic prevention and control integrated database, community entrance and exit automatic temperature measurement, health code place code application, key personnel one person one file control system. In addition, "N" refers to multiple integrated risk supervision modules (including prevention and control in the domains of medical institutions and individual clinics, food cold chains, transportation ports, special key institutions, communities, materials stockpile, etc.). The "1+5+N" urban COVID-19 pandemic integrated comprehensive control program benefits everyone in the city, maximises the pandemic control, protects people's health and safety, and helps pandemic prevention and control departments and personnel to work and manage more efficiently.

4.1.2 Wuhan Bairuijing Community: "Resilience"

Figure 16: One-screen Overview

Figure 17: "N" Integrated Risk Supervision Modules

Figure 18: Isolated Hotel

Helps Bairuijing Community's Grassroots Governance Responses to the Pandemic

Bairuijing community, faced with the severe situation of many residents, immense needs, few staff, and lack of service power. However, they followed the requirements of pandemic prevention and control, led the community and volunteers, to work on regular pandemic prevention and protection of residents' life. The following principles were applied:

(1) Flexible interchange of section-level governance and central governance due to the situation.

(2) Adaptation Model - Formation of creating WeChat groups.

(3) Recovery Model - Formation of grid service teams.

(4) Stable Model–forming the core management team of the community.

(5) Construction Model - Formation of medical personnel care team.

(6) Community control did not reduce its force/ Resumption of work and production in order.

(7) Advance planning helped community effective management and governance.

Bairuijing community quickly reacted and adapted to the current pandemic situation, and reasonably arranged and negotiated to develop a grassroots governance model. The following actions were taken:

(1) Consolidate community strength and promote community autonomy from the bottom up.

(2) Improve and enhance community emergency governance capabilities.

(3) Nurturing quality community self-governance subjects and fostering "civic spirit".

4.2 Enterprise cases

4.2.1 Early Stage of Anti-Pandemic Period

• Wanxiang Group Company joint with WeDoctor Group (Zhejiang) Co., Ltd : Internet Telemedicine Remote Service Helps Prevention, Control and Consultation of COVID-19 in Urban Communities;

Telemedicine is remote, professional, convenient and efficient. Through innovative digital medical services, it realises triaging of patients and screening for minor illnesses during the pandemic, the platform solves the problem of patients' difficulties in accessing medical treatments and purchasing medicines, the platform also reduces the risk of cross-infection during patient visits and shares the pressure on medical institutions to receive medical consultations. The "COVID-19 Real-Time Relief

Platform" relies on information technology to support the prevention and control of the pandemic and provides an average three-minute response time for rapid, free-of-cost consultation services. Other platforms launched were; "Psychological Assistance Section", "Chinese Medicine Anti-Pandemic Platform", "Anti-Pandemic Public Welfare Consultation Platform", "Convenient Outpatient Clinic" and "Anti-Pandemic Shortage Supplies at Affordable Prices".

• Xinchao Culture Media Group: Public service propaganda against the pandemic remotely published on elevators' smart screens;

Most of Xinchao Media's elevator screen products were placed in the community. Since the community was closed, the advertising content could not be uploaded manually, Xinchao launched the "Life Circle Intelligent Display '' program, which solves the problem of advertisements' replacement and operation through online uploading. Xinchao's elevator screens are perfect channels sto disseminate anti-pandemic contents. Although residents could only move around within the community, they could still receive effective knowledge through the elevator screens.

4.2.2 Mid-term of the Anti-Pandemic Period

Figure 19: Elevator Pandemic Prevention Advertisement, Source: Xinchao Media & People's Daily

Figure 20: Elevator Pandemic Prevention Propaganda

Figure 21: Elevator Pandemic Prevention Publicity, Source: Xinchao Media & CCTV News

• BOE Technology Group: "Prevention - Detection - Treatment" whole process technology solutions to help cities fight the COVID-19 pandemic

In the early stage of the pandemic, BOE Hefei Hospital responded to the call of Anhui Province and joined hands with five famous hospitals in Hefei to open "Online Fever Clinic". Patients can, via cell phone or computer, access "Online Fever Clinic", and avail the video consultation option of a certain doctor.

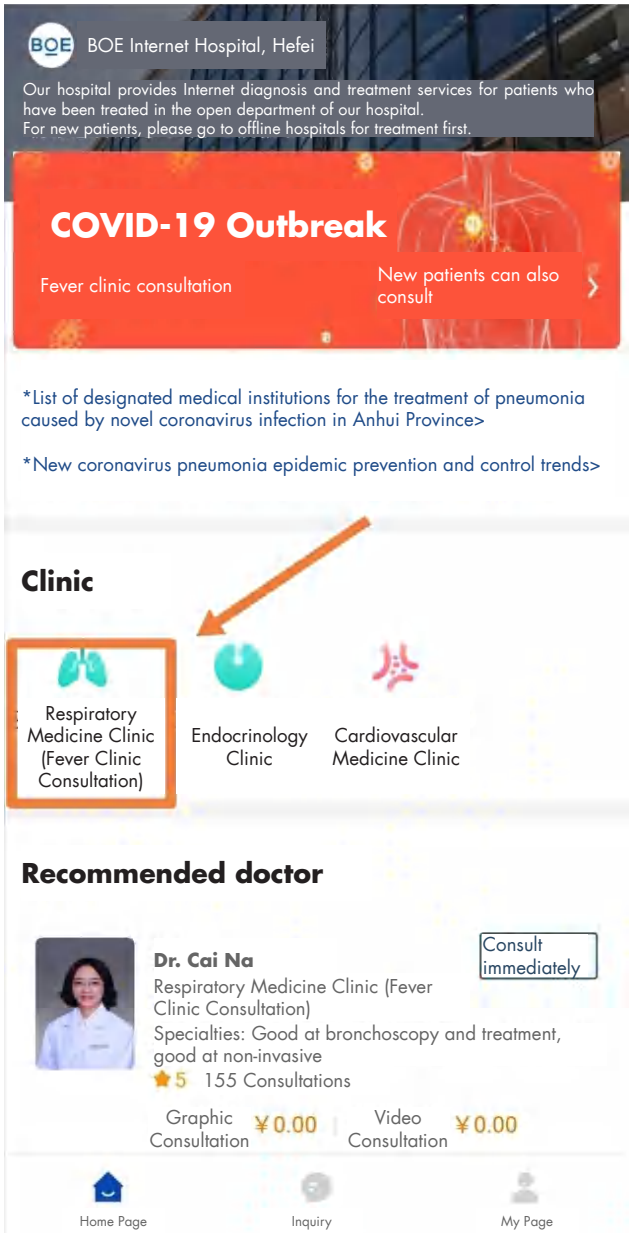

Figure 22: Hefei BOE Internet Hospital

Additionally, BOE independently developed the AI body temperature warning system to help traffic sites, parks, airports, hospitals, office buildings and other scenarios to promote the resumption of work and production under the normal state of pandemic prevention and control. AI body temperature early warning system has face recognition (people with masks) and mask detection technology.

• Zhihui Hutong Science And Technology Co., Ltd. : Serving the integrated management of urban dynamic and stationary transportation, reducing manual intervention to interrupt virus transmission

Before the outbreak of the pandemic, Zhihuihutong (AIPARK)'s city-level smart parking project had been applied in many large, medium and small cities, including Beijing, Shanghai and Guangzhou. At the same time, "AIPARK Sky Eye '' incorporates VSA vehicle state sensing technology, with a powerful algorithm family, it can, for special vehicles from areas with high infection rates, achieve accurate data track and assist with pandemic control departments. As a result of these applications, it eliminates cross-infection caused by travel, provides all kinds of unprecedented convenience for travel and people's life, and allows car owners to travel safely and securely.

• Daojia Home Service: Internet + Home Services: Supporting the rigid demands of urban households during the pandemic

Since the pandemic, the number of home services workers recruited by enterprises has dropped sharply, and the number of orders from the customers has also dropped sharply. To cope with the supply and demand dilemma, Daojia group accelerated the process of conducting online services. The system covers a complete set of home services transaction systems, including completely online services such as training for service workers, completion of the courses, resume updating, job search, resume viewing by employers, video interview by three parties, remote order signing and payment. By minimising exposure, this upholds the health and safety of both service workers and employers.

4.2.3 Late Stage of Anti-pandemic Period

• Alipay (China) Network Technology Co., Ltd: e-consumer vouchers help the recovery of urban economy

In order to revive the economy and stimulate

Figure 23: Building a Digital Infrastructure for Human-Centric Service Transactions, Source: Daojia Group

consumption, China became the first country in the world to issue digital consumption vouchers. The digital consumption vouchers have been effective in stimulating consumer spending, promoting businesses to resume work and production, and improving financial efficiency, achieving a triple win situation for consumers, businesses and the government. In the long term, China has taken the lead in the development of the global digital economy. Whether it's mobile payments, e-commerce or digital consumer vouchers, these digital innovations ultimately land on serving consumers and micro and small businesses and helping them cross the digital divide one at a time.

• Jingdong Technology: Digital Technology Helps Precise Prevention and Control and Balanced Supply and Marketing of Agricultural Products

In January 2020 when the pandemic appeared in Beijing the above situations became more obvious, the importers could not enter the village, and fruits planted by the farmers were not suitable for long-term preservation. In response to this problem, Jingdong Technology, Beijing suburban agricultural production bases,

Figure 24: Fenghe Large Canteen Mini Program

agricultural cooperatives, agricultural poverty alleviation cadres and their related platform operators , jointly explored this issue. They combined the application scenario in Beijing's intelligent community services "online community food basket" , and through the digital supply and marketing platform, the "Fenghe Canteen" online community food basket applet was created.

Chapter5
Future Development Proposal of New Urban Resilience

Night View of Lujiazui, Shanghai Source: 58pic.com

Chapter 5

5.1 Technology Rebuilds Urban Resilience

In this COVID-19 pandemic, innovative technology has been involved in the front line of the fight against the pandemic, which becomes a game changer in rebuilding the resilience of modern cities. The pandemic effectively drove the development of China's urban technology and even the upgrading of the urban operation system. Meanwhile, China's successful practice of integrating intelligent technology into new infrastructure development is shared. Then we discourse that the cross-border capability of innovative technology will rebuild global urban resilience.

Over the course of pandemic prevention and control experience, China has changed and developed a new way toward a more advanced cities wide operation. With the speed-up development of digital technology and use cases for their applications, the new digital infrastructure was used to achieve the goal of "Comprehensive Control and Full Coverage", to realise remote operation and epidemic monitoring through smarter and finer urban governance, and to allocate the livelihood materials so that social production capacity can be quickly restored in the pandemic. The demand for pandemic prevention and control has driven the construction of new urban resilience represented by digital infrastructure.

China's determination and commitment to advance intelligent technology has been showcased everywhere from the national policy to encourage the development of the intelligent technology industry, to the investment and construction of novel intelligent infrastructure and its application across the board. The evolution of technology is highly correlated with the iteration of urban development. With the growing importance of smart technology in urban operation and governance, the value of product-oriented intelligent technology approach will be gradually revealed and manifested in the construction of new infrastructure systems and will penetrate into the operation and governance of cities.

As the world has shared common features in the impact and countermeasures of the pandemic, in the fight against the pandemic, China's experience of improving urban resilience through intelligent technology is worth sharing with other countries. Technology has already begun to transform the concept and pathway of urban resilience around the world, accelerate mankind's steps toward green production and lifestyle, and reshape the global landscape of urban resilience.

5.2 New Urban Resilience Development Outlook

Having understood that technology is an essential factor but not the only one in shaping new urban resilience, it is crucial to expand our knowledge of new urban resilience and to grasp

its value, meaning and application.

The New Urban Resilience realises value for sustainable development by:

(1) Better Responding to Uncertain External Impacts in the Future; The external forces that threaten the urban health and safety in the future may carry the features of unpredictability, borderless spread, and constant mutations, which are more challenging to prevent, control and respond to than the havocs wreaked by climate and natural disasters. Therefore, the value of "new urban resilience" is manifested in a more effective response to mounting uncertain external impacts in the future.

(2) Combining the Trends and Applications of Technology Development; The new urban resilience will become the main driving force of science and technology development rather than a passively produced result. The value of the new resilience is embodied in navigating such development to contribute to urban safety.

(3) Managing the Investment and Return of Infrastructure and Urban Operations Effectively; Building new infrastructure based on intelligent technology can help upgrade traditional infrastructure on the one hand and on the other, effectively monitor and manage the transition between traditional and new functions and also optimise the operations through intelligent overall coordination.

(4) Improving the Attention for Social Equity and Humanistic Quality; The new infrastructure integrated with intelligent technology needs to benefit the vulnerable groups of all social strata in cities to avoid the digital gap and the inequality of input across regions and populations.

(5) Summary: New Urban Resilience Realises Core Values of Sustainable Development

In addition, the new urban resilience has in the specific case of China brought the following advantages:

• Economic Value: The pandemic has accelerated the growth of China's digital economy as intelligent technologies such as Cloud Computing, Blockchain, IoT, Big Data, and Artificial Intelligence are leading the industrial economy onto the path of smart development.

• Social Value: Through the application of new infrastructure, the public service efficiency is improved; the life, work and education of people are ensured in an organised manner during the pandemic.

• Environmental Value; Intelligent technology will support us to achieve environmentally friendly production and lifestyles, and steadily realise the 2060 carbon neutrality goal.

• The Core Value Commonly Supported by The New Urban Resilience and Sustainable Development Lies in "People"

The new urban resilience should stay committed to the human-centricity, meaning ensuring technologies reflect the principle of "responding to the citizens need" and ensure they act as equalizer rather than posing challenge to digital

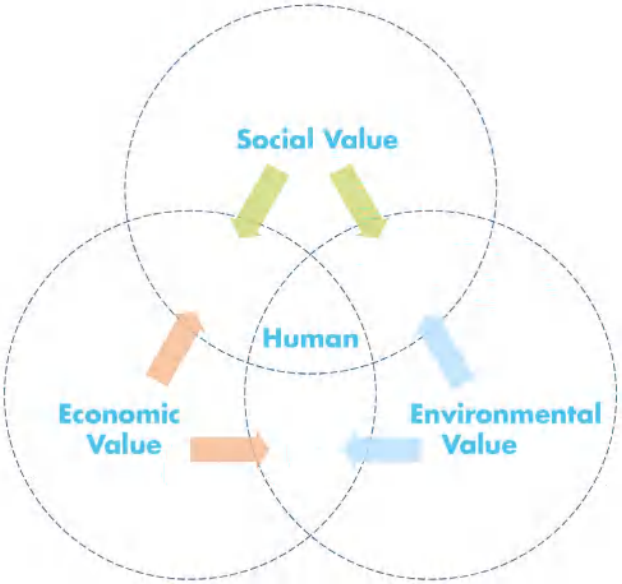

Figure 25: New Urban Resilience Practices the Core Values of Sustainable Development

inclusion.

5.2.1 Identifying the Essence of New Urban Resilience

The list below summarizes the principles of the new urban resilience:

• Value Enhancement: From "Bottom Line Demand" to " Growth Promotion"

Traditional resilience protects the bottom-line needs of safe urban operation and maintenance; new urban resilience focuses on maintaining growth of urban value under external pressure through new infrastructure and efficient public services. The new infrastructure creates a technological shield for cities to withstand shocks while facilitating "people-oriented" social, economic, and environmental value enhancement and sustainable growth in all respects.

• Autonomous Iteration: From "Static Passivity" to "Dynamic Autonomy"

Traditional resilience mostly relies on static physical engineering facilities based on empirical data to cope with external shocks; new urban resilience relies on new infrastructure of big data collection and analysis and intelligent computing to achieve transformation and change to a dynamic urban operation system of active investigation and autonomous management.

• Cross-over Integration : From "Block System" to "Ecological Collaboration"

While traditional resilience building is usually based on external force categories or governance sectors, forming independent operation of block systems, new urban resilience infrastructure building focuses on cross-sectoral and multi-sectoral linkage and collaboration to achieve the most cost-effective urban disaster prevention.

• Diversity InclusionFrom “Blocked and Monolithic” to “Open and Adaptable”

Compared with traditional infrastructure, the new urban resilience based on new infrastructure will break the barriers of technology, space, and society in its focus and coverage to achieve more diversified and inclusive development.

• People-Centered: From "Technological Orientation" to "Human Orientation"

New urban resilience initiatives lead in values such as "data sharing", "security and privacy", "fairness and justice", and establish people's participation in the dynamic decision-making and construction process to achieve resilience construction goals. The New Urban Resilience favours a people-oriented approach, shifting from "technological orientation" that focuses on the resilient infrastructure itself to "people orientation" that focuses on the benefits of these infrastructures for human beings..

To summarize, the New Urban Resilience is a core capability to empower future urban development based on science and technology innovation, helping cities to establish their "autoimmune system", thereby leveraging engineering technology, information technology, and policy systems, developing the effectiveness of infrastructure with independent insight, independent recovery, and independent construction. It can proactively respond to uncertain disturbances and external shocks, maintain the people-oriented development of high quality with minimum resources and maximum time efficiency, and in the end achieve the goal of enhancing the sustainability of the city.

5.2.2 Envisioning a Bright Future of New Urban Resilience

The new urban resilience development will encourage joint research and development of

Figure 26: Action Plan for New Urban Resilience

global science and technology enterprises, urge a collaborative urban development strategy with governments around the world, thus ultimately realising the goal of a Community of Shared Future for Mankind.

The Action Plan consists of three action areas with the aim to promote the collaboration of implementing entities and interdisciplinary technical fields.

First, we call on technology enterprises all around the world to join hands in face of this pandemic which threatens lives and health of all human beings and try to promote the development of innovative technology and medical technology, to achieve the goal of a Community of Shared Future for Mankind.

Secondly, countries and their respective governments around the world should establish collaboration models with focus on shared benefits, support the innovative development of intelligent technology and medical technology with incentives via governance mechanisms and authoritative navigation.

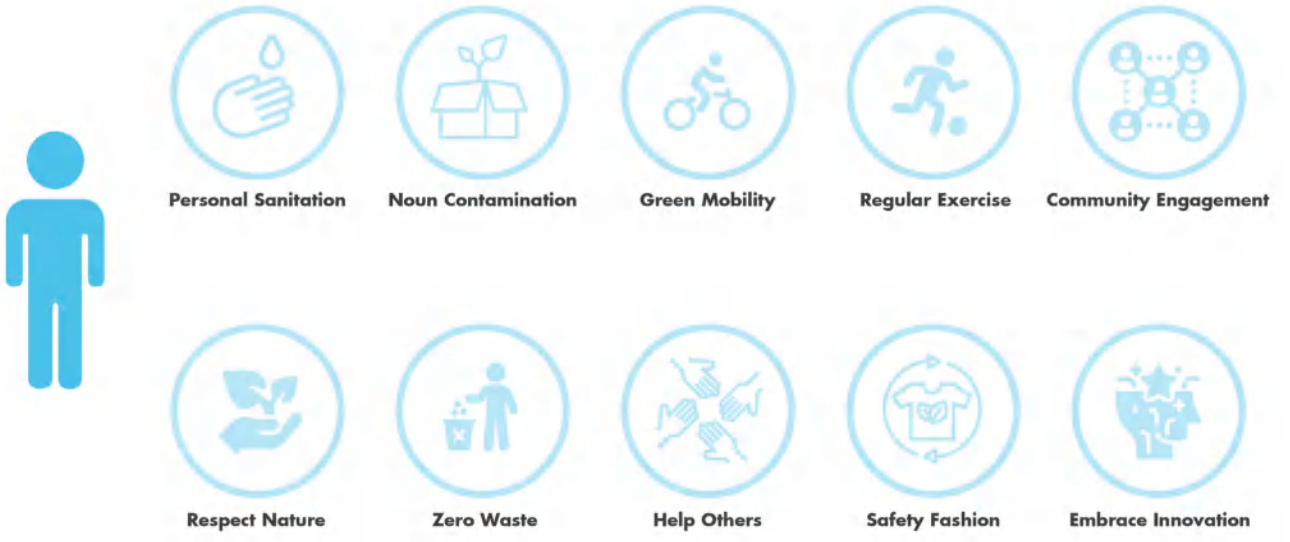

Figure 27: 10 Individual Actions to Help Build New Urban Resilience

Last, the fight against the pandemic is not only a top-down action of the city, but also a bottom-up initiative collecting views from the citizens. Relying on "technology empowerment", "intelligent fight against the pandemic" is advocated, where the new scenarios of urban development are driven by community feedback.

Based on this, Five Action Initiatives are foreseen for Global Collaboration:

Table 3: Five Action Initiatives

	Resilience Initiatives	Key elements
1	Nature Harmonised Resilience: Resilience Underpinned by New Harmony between Nature and Cities	• Harmonious coexistence with nature and avoiding over-exploitation is advocated • Sustainable farming to prevent land degradation • Taking urgent measures to mitigate climate change
2	Technology Empowered Resilience: Guiding Smart Technology Development toward the Construction of New Urban Resilience	• Intelligent technology empowers the integration of global urban resources • Intelligent technology develops global urban security management; We should enhance the security system of global urban interconnection through intelligent technology and build a digital security barrier for urban resilience in the future. • Intelligent technology promotes global urban resilient infrastructure construction
3	People-Centered Resilience: Addressing Emphasis on the Cultural-human Quality Driven New Urban Resilience	• Focus on regional differences and cultural diversity • Focus on the inclusiveness of new urban resilience building
4	World Collaborative Resilience: Progressing Global Collaboration on the New Urban Resilience	• Set up the special fund and think tank to explore the path of new global urban resilience development • Develop and improve a global public health system that benefits all of humanity • Call on the world to collaborate on global intelligent technology
5	Individual Driven Resilience: Individual actions	• Building new urban resilience starts with personal lifestyle changes, starting with the little things in life: 10 personal actions to help build new resilience in cities (refer to figure below).

5.3 Conclusion

The purpose of exploring the new urban resilience is to equip future cities with the ability to deal with more uncertain external impacts under the pressure of environmental changes, to manage the costs and benefits of urban operations more precisely with limited resources, and to pay more attention to the values of social equity and humanistic quality with the trend of technology-led development.

In response to the outbreaks of COVID-19, Chinese cities are working closely with enterprises, government and society to explore how the development and application of technology can intensify our focus and development of urban resilience, as well as expand our understanding and expectations of the public services and infrastructure on which urban operations and governance depend - intelligent technology is evolving our cities, which is another opportunity of the times for the human habitat to seek a win-win symbiosis with nature, and will become a core capability for the development of a people-oriented city with new resilience qualities.

We firmly believe that new urban resilience is a necessary and effective effort to rebuild the healthy ecosystem of global cities. The start is to fully understand the new values, new essence, and new future of new urban resilience, and to establish a global collaborative vision of urban development and value chain, which is also the focus of new urban resilience construction. Based on China's practical experience, we propose a global initiative for collaborative actions on New Urban resilience. We strongly hope that we can build a sustainable new resilient human habitat.

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