Disaster Risks and Response Strategies in Process of Urbanization in China

Fang Chen, Huadong Guo,

Key Laboratory of Digital Earth Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing 100094, China;

Chinese National Committee for Integrated Research on Disaster Risk (IRDR CHINA), Beijing 100094, China;

Digital Belt and Road Program (DBAR), Beijing 100094, China

Zeeshan Shirazi,

Key Laboratory of Digital Earth Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing 100094, China;

Digital Belt and Road Program (DBAR), Beijing 100094, China

Abstract

This paper overviews the Chinese urbanization process especially in light of the national new-urbanization plan released by the Chinese Government in 2014. Over the past three decades, the economic opportunities in urban centers of China have accelerated urbanization process, mainly as a consequence of rural to urban migrations. The new urbanization plans hopes to increase the proportion of urban population in the next decade, and it is projected that 80% of the China population will reside in urban areas by 2050. However, this process is faced with certain systemic risks due to disasters. Changing climate, increasing risk due to inter-connectivity of complex urban lifelines and weaknesses in disaster management complicate the disaster risk reduction efforts in urban areas of China. It is recommended that the urbanization process should move forward with an urban management theory integrated with disaster risk, vertical and horizontal integration of responsibilities, utilizing Big Earth Data and new emerging technologies, and supporting risk reduction by employing financial tools to confront disaster risk and finally efforts to improve international and regional cooperation.

1 Introduction

Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework), adopted for the next 15 years as a new action framework of global risk reduction, shifts the focus from the development of disaster management to the management of disaster risk, requiring consideration of risk reduction within social and economic activities and understanding of linkages between patterns of human behaviors and vulnerability to disaster risks. This has brought a conceptual revolution in the development of urban disaster strategies around the world. This concept of disaster risk management has also been reflected upon in the ensuing Sustainable Development Goals of the United Nations and the Paris Agreement on Climate Change.

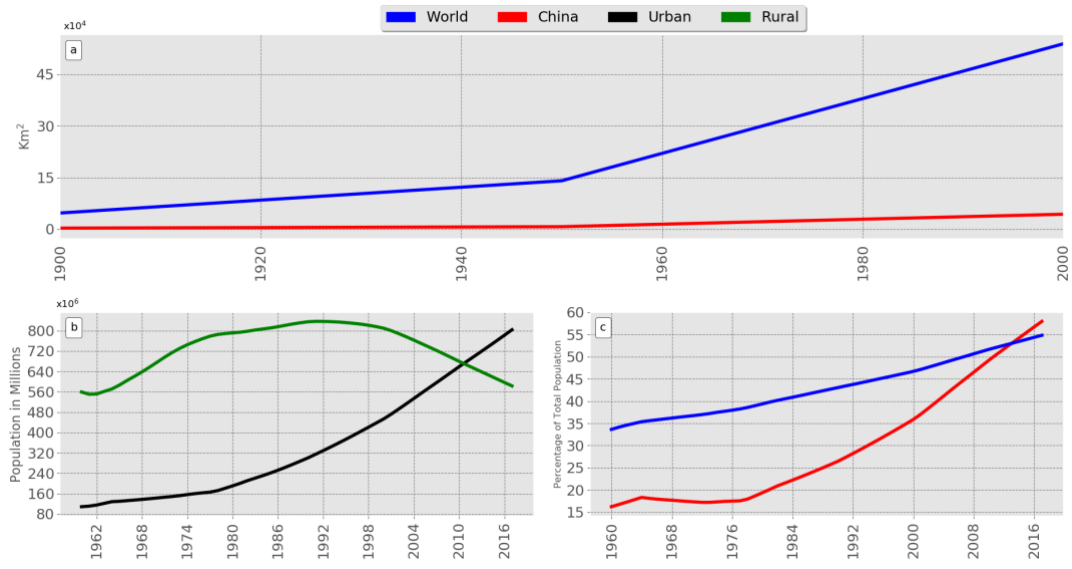
The Belt and Road (B&R) region stretches across Asia, Europe and Africa, covering large parts of land, and encompasses important regional economic zones. The B&R region also features complex terrain and diverse climate types and are generally at high risk of earthquake, drought, flood, typhoons, as well as other natural hazards, responsible for rising economic losses every year. There are many naturally large and medium-sized cities developed along transportation networks of B&R region, which are vulnerable to mortal and economic losses due to disaster risks.

In China, in light of global climate change, rapid economic progress and the resulting urbanization process, there has been increasing pressure on environment and ecology, making disaster risk reduction and response even more complicated, especially in the urban areas of China. Over the past few years, cities in China have experienced increasing number of disasters of various kinds, while at the same time urbanization process is increasing the risk of these natural hazards (J. A. Wang et al.,2008). It is, therefore, urgent to have a firm grasp on the major disaster risks in process of urbanization in China and understand the vulnerabilities and shortcomings from previous examples to guide development of relevant policy and management concepts to minimize disaster risk in the future. It is also very likely that the experiences of disaster risk reduction in process of urbanization in China would contribute to the development of a regional strategy for disaster risks in the B&R region, promoting economic, social and environmental dimensions of sustainable development through collaboration and cooperation. Therefore scientific research on the disaster risks needs to be focused and improved, with objectives of aiding the government in planning and development of risk prevention strategies, raising public awareness, capacity building for disaster response and exploring new opportunities for businesses and to participate in the prevention of social risks.

This paper will analyze the systemic risk as a consequence of disasters during China's new type of urbanization process, describing the implications of earthquakes and other geological disasters, floods and droughts,

windstorms and climate change-related disasters on the processes of new type of urbanization, and list the disaster risks encountered during the process along with countermeasures and suggestions.

Box 1.1 –Story In Data

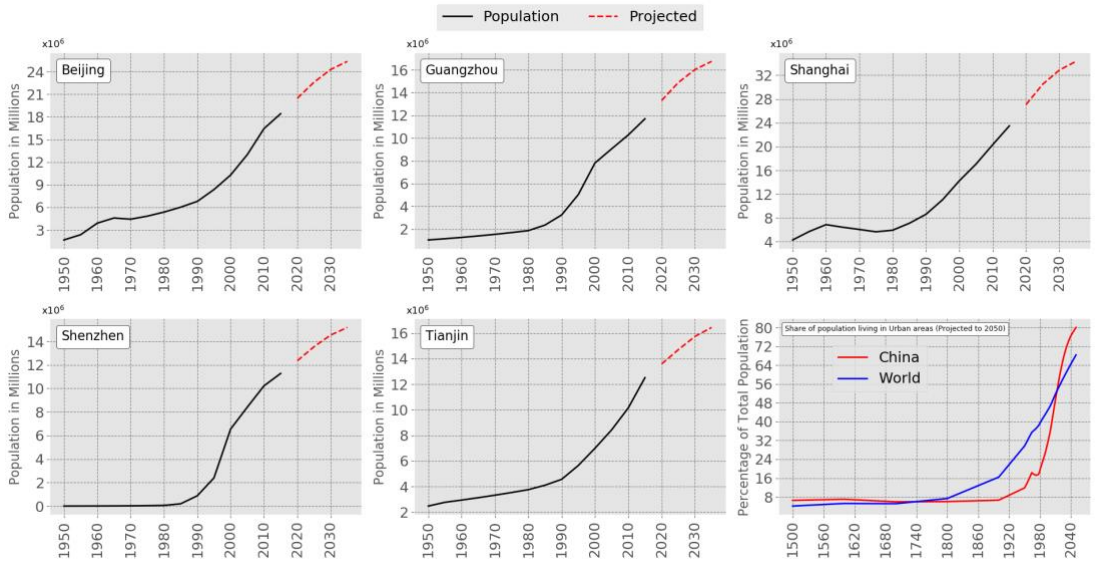


Trend of Urbanization in China (a), began to increase rapidly after1980s, resulting in migration of population from rural to urban areas (b) which is even faster than global trend since 2013 (c). (Source: Ritchie & Roser, 2019)

2 Urbanization in China

Ever since the Chinese economic reforms and its opening up to the outside world, there has been rapid development in Chinese economy resulting in infrastructure development and accelerated urbanization. By the end of 2016 the proportion of urban population reached 57.35% of the total national population (NBS, 2017) and is estimated to rise to 70% by 2030 (UNDP, 2013), increasing the importance of urban economics in the national and global economy. For example the Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta, three of the largest city clusters only cover 2.8% of total land area but they generate 36% of China's total GDP (Hu & Chen, 2015).

Box 2.2–Story In Data



The major cities of China are projected to have rapid increase in urban population, and it is likely to reach 80% by 2050. (Source: Ritchie & Roser, 2019)

Improved economic opportunities also enhanced rural to urban population migrations, a phenomenon that is still in progress. The tree aforementioned city clusters accounts for 18% of China's total population (Hu & Chen, 2015). Such population migrations apart from improving economic activity also lead to development of semi-urbanized regions around the periphery of large cities vulnerable to both natural and anthropogenic calamities. Most of these cities are at high risk to wide range of disasters, for example, Shanghai has high risk of exposure to floods and cyclone (Gu, Gerland, Pelletier, & Cohen, 2015). Direct economic losses in urban areas caused by weather related disasters amounts to a large portion of total disaster related losses with floods alone accounting for approximately 40% of total mean annual disaster losses (J. A. Wang et al., 2008). Since 2009 the Chinese government, in order to improve urban management, had accelerated policy development regarding disaster prevention and reduction for large and medium-sized industrial bases, transportation trunk lines, communication hubs and lifeline projects.

In terms of public safety, the importance of public awareness and public capacity building projects have been emphasized, such as trainings of local population in both urban and rural settlements for improved emergency response, improving emergency facilities by building safety projects such as shelters in disaster prone areas and increasing awareness through community disaster reporters. These policies are aimed at improving public

resilience in event of disaster (The Chinese Government's Official Web Portal, 2009).

Considering that urbanization in China is greatly influenced by government policies and their implementations, therefore, in response to these growing administrative and economic requirements, China launched the National New-type Urbanization Plan (2014-2020). The plan aims at optimized city layouts, efficient use of land, and assurance of clean air and safe drinking water for all urban population (State Council, 2014). The plan targets land reforms to improve land use efficiency, improve hukou (city residence permits) to improve labor access and distribution, improve fiscal systems to facilitate other targets and to motivate local government to improve proper and efficient use of urbanized lands, and improve environmental conditions to improve livability in urban areas (*Urban China: Towards Efficient, Inclusive and Sustaibable Urbanization*, 2014)

Urban centers have their own ecosystems that are designed towards economic development and rely on physical infrastructure having design limitations and finite stress bearing capacity. Central and local governments regularize infrastructure development through legislation and policy. Unfortunately rapid rural to urban migrations and slow reaction to changing population dynamics, in terms of policy or infrastructure development or maintenance, may it be due to lack of financial capital, initiative or will, leads towards unplanned development with reduced to no compliance of governmental guidelines and regulations, resulting in increased stress on the urban ecosystems, pollution and degradation of environment.

Disasters push these urban systems towards failure, degree of which depends on the intensity of the natural event and the vulnerability of system based on numerous underlying factors such as population at risk, disaster response and relief infrastructure and awareness, resulting in mortal and monetary losses. The modernization of urban services infrastructures has also increased inter-connectivity and inter-dependence of these urban lifelines and their monitoring systems. For example, natural gas distribution system depends on modernized control centers running on essential equipment using electricity and hence dependent on a proper functioning electric supply system, in turn certain electricity production unit depends on natural gas for their production. Another example is of the promotion and subsidy of electric transportation services in an effort to reduce fossil emissions. However, this policy is creating a new inter-dependence between two essential urban services. These drives towards inter-connectivity leading to dependencies are essential and inevitable and characterizes future development, however, understanding risk and vulnerabilities of an urban ecosystem allows for necessary oversight of policies and regulation required to reduce disaster risk both financially and in terms of human mortality.

What is predictable is that the expected growth in Chinese economy will continue to feed urbanization and

infrastructure development, resulting in changing city layouts, land use and land cover. However, due to the "lock-in effect" of the socio economic system, it is likely that these developments and changes will trigger complicated conflicts, if not addressed properly in a scientific manner, and may hinder continued future development in the long run (Li, Chen, & Hu, 2016).

3 Systemic risks to China's Urbanization Process

Presently and for the next 15 to 20 years, the urbanization process in China will encounter the following systematic risks, which are closely associated with extreme natural events and worth paying attention to.

3.1 Unpredictability of changing climate

Due to climate changes, in China, some disasters have begun to appear in new and unusual areas and seasons. For examples, heavy snowfall and freezing has begun to appear at subtropical zones at lower latitudes. In recent years, China's subtropical zones including Yunnan and Guangxi saw frequent severe droughts, while residents in temperate zones and cold temperate zones including Northeast China and Inner Mongolia experienced high temperatures in summer. The latest research using satellite remote sensing has showed that over the past 30 years the typhoon landfall routes in East China, South Korea and Japan have an obvious tendency of northward movement. The changes in spatial and temporal distribution of disasters as a consequence of climate changes are a new challenge for the management of disaster risks.

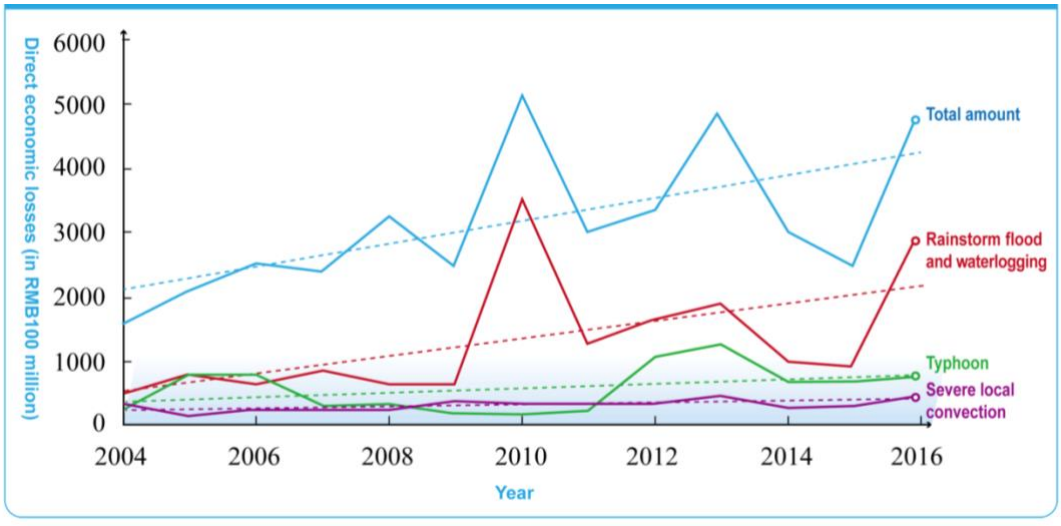


Figure 1- Variations in the direct economic losses caused by weather disasters on Chinese mainland over the years (CMA, 2015)

Box 3.1 - Freezing Rain and Snow Disasters in Southern China

In 2008 and 2011, southern China experienced large-scale freezing rain and snow, which are rare events since the beginning of the meteorological record. This happened in Guizhou, Yunnan, Chongqing, Hunan, Guangxi and Jiangxi provinces. Since these areas lack experience in dealing with snow and ice-related hazards therefore the urban-rural transportation, electric power and communication systems were seriously hit by these unexpected weather anomalies. The changes in the spatial and temporal distribution of extreme weather and climate bring a new challenge to urban planning, hazard assessment and risk management.

Climatic changes are interwoven with urban effects. On the one hand, urbanization exacerbates climate changes by changing the underlying surface and greenhouse emissions; on the other hand, dense cities and towns are prone to damages caused by disasters related to extreme climatic events. For example, extreme precipitation may give rise to urban water logging and climate warming increases the risks of urban heat island and heat wave, weather featuring static stability caused by local circulation changes is closely related to heavy urban pollution, while frequent typhoons will cause great losses to coastal cities.

Disasters are inherently natural processes that pose danger to economic and mortal wellbeing of humans. Risk associated with natural hazards exacerbate with vulnerability of the population, for example human settlements on a flood plain or near a geological fault line. Therefore disaster risk reduction in addition to mitigating the effects of climate change requires reducing vulnerability of population to disaster risk. Internationally and also at national level disaster risk reduction and climate change were treated as separate policy issues, which has begun to change and the two have begun to be interlinked in recent years (ISDR, 2005). However, disaster risk reduction needs to be integrated in the policy development of all social services for a population including environmental, education, health, infrastructure and economic development.

Urbanization is an ongoing process in China and cities have an important role in implementation of policies and actions in response to climate change(Ng & Ren, 2017). Under the backdrop of climate change the risks and losses of new urbanization are rising. As in other places, extreme weather and climatic events in China seem to occur more frequently and at a higher level of intensity as a consequence of climate change. For this, the anti-disaster standards for urban infrastructures developed during the early periods are seriously inadequate and the capabilities against major extreme weather and climate disasters are poor. Preparing or coping up for climate

change is manageable in new cities as mitigation measures can be in cooperated at the planning stage however, the problem becomes difficult when adopting counter measures in old cities as it is slow and difficult process and requires large undertaking (Xu Nan, 2018).

3.2 Complexities of Urbanization and Agglomeration

Urban agglomeration is one of the major features of the urbanization process in China. For well-functioning urban systems, the risk of natural hazards do not deter people to move away from proximities of these urban centers due to the potential economic opportunities and other facilities of the urban infrastructure. Previous experiences from developed and developing economies suggest that efforts to control city sizes and urban form ends up hurting urban areas economically and land use regulations causes economically disadvantaged populations to move in locations of high disaster risks due to rising real estate prices (Lall & Deichmann, 2009).

The policy of controlling the scale of large cities in China was abandoned since 1980s, however, vulnerable populations in cities still exists in China. This can be understood by understanding the difference phases of China's urbanization. Initially the urbanization efforts were not efficient and were characterized by immoderate development of urban land, resources and environment. Later the cities expanded rapidly engulfing surrounding villages without the necessary development that characterizes an urban environment, leading to phenomenon of villages within cities. Merger and movement of villages for urbanization also lead to vulnerable population in urban agglomerations (J. Wang & Wang, 2015).

Box 3.2- Flood Prevention and Emergency Response in Anhui
In Anhui province construction of water conservancy projects during winter and spring has traditionally been undertaken by local farmers. However, this traditional model is hard to sustain further as youth labor force is migrating to the cities. With reducing competent man-power, the prevalent management and maintenance system of basic water conservancy infrastructure in rural areas is weakening, making flood prevention and resistance as well as disaster identification and response weak while increasing the vulnerability of the population.

Urbanization has greatly influenced the urban hydrological process by changing land-use practices, residential settlements and urban related water consumption, which have been exacerbated due to climate change (Cai et al.,2017). Taking Wuhan, China, which was once called the "city of a thousand lakes", as an example, the rapid urbanization process has put great pressure on the urban water security as well as on other resources, the

environment and the ecological system. With the violent expansion of built-up areas, flood plains of rivers and lakes and their surrounding areas have been taken up, disturbing the normal river system, and increasing the vulnerability of large population to flooding risk.

In addition, in earthquake or geological disasters prone regions there is considerable increase in threat to population, economy and property in China. From the policy point of view, lack of proper residence facilities and increased rural to urban migration leads to mushroom growth of self-built houses, increasing the vulnerability of population to even small but destructive earthquake or other geological events. From planning point of view, lack of risk assessments on earthquakes and geological disasters in urban development undermines preventive or risk reduction measures at the planning and developmental stages, making these settlements highly vulnerable to disaster risks. All these factors manifested during the 2008 Wenchuan earthquake. Apart from the devastating natural factors such as the high magnitude of 8.0, the human vulnerability magnified the devastation that included high population density and weak response capacity (Renwick, 2017).

Coastal cities have many complex and interlinked issues in addition to the ocean related disasters. Rising sea-levels as a consequence of climate change add to the risks of these cities. High density of buildings and ground water extraction leads to ground subsidence magnifying the rate of sea level rise, consequently reducing the natural drainage capacity of the city and increasing risks of floods and storm tides while at the same time reducing the effectiveness of the sea embankments and tidal gates. The ground water extraction is even more pronounced in urban agglomerations, which not only adds to the disaster risks but also allows sea water intrusion reducing the available fresh water for growing population increasing vulnerability of the population. Zhuhai, Zhongshan, Dongguan city and the eastern part of Guangzhou in the Pearl River delta are greatly affected by salty tides, and 9.6% of the total land area of Shanghai has salinized soil. In addition to sea water intrusions, increased urbanization and industrialization in urban agglomerations increases domestic sewage and waste water discharge, which persist in river channels of the urban districts due to the reduced drainage capacity leading to serious pollution adding to population vulnerabilities (Suocheng et al., 2012).

What's worth noticing is that the urbanization level in China is still 10 to 20% away from the equilibrium state. Debts due to infrastructure development and development pressures in the future are expected to likely increase. In order to restrain the increasing risk of disasters, strengthening the existing disaster reduction system may not constitute efficient response. Introducing latest ideas and models from developed countries, supported by heavy investments will not yield instant results, therefore policies with short term and long terms goals need to be

specified and communicated at multiple level of central and local administration.

3.3 Risks due to inter-connectivity of urban lifelines

The smooth operation of cities depends on lifeline systems, such as water, electricity, heating, transport and communications. There is a complicated network between different systems, with inherent interlinked hazards. The extreme weather and climatic events occur more frequently and at a higher level of intensity as a consequence of climate change. Talking the risk management of urban water-logging as an example, many large and mid-sized cities saw severe urban water-logging over the past decade, causing disorder of urban functions as well as heavy casualties and property losses.

The multi-functionality of urban agglomerations, as feature of an aggregation, makes underlying situations very complex. Dense lifeline engineering projects in urban agglomerations put different regions into close connection; thus, influences on a certain region will spread to and affect other regions. Moreover, local capacities of disaster resistance differ from one another. Hence, this highly integrated social economy within urban agglomerations increases the risks of disasters.

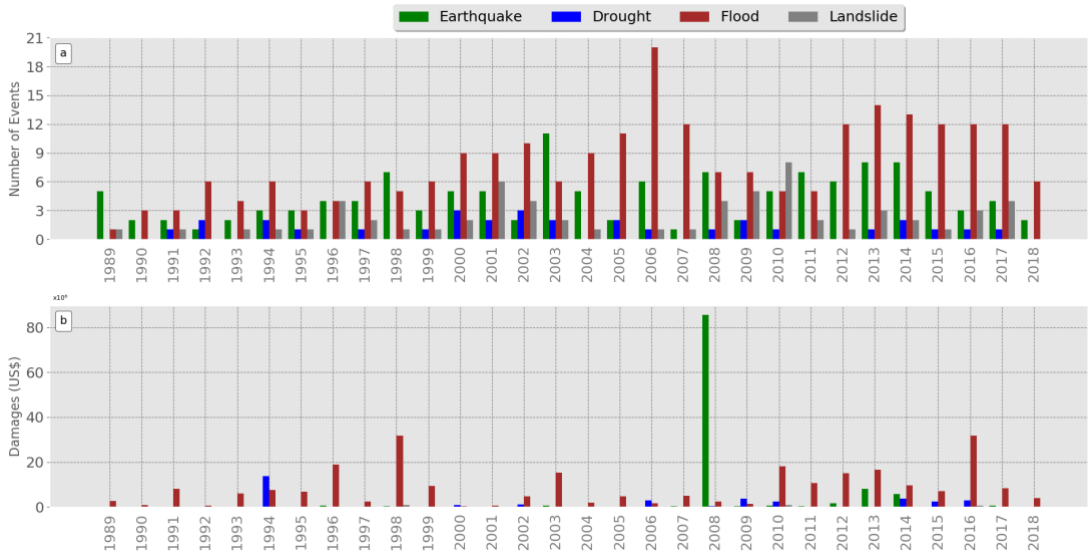
This integration also threatens shutdown or paralysis of cities even if the effects of disaster are localized. Therefore targeted disaster prevention and reduction at the local level are confronted with massive challenges. From economic point of view, functioning supply chains are essential for businesses to flourish. These supply chains are highly sensitive to earthquake and other geologic disasters making economic processes highly sensitive, thus increasing the possibility of a “black swan event” triggered by isolated and small-scale disasters.

In the past three decades, urban planning fell behind the rapid urban development in China, which, along with the separation of management system, has raised multiple management issues, consequently, making urban lifelines of the majority of cities in China extremely vulnerable. In particular, traditional lifelines, such as those of water, electricity, heating and transport, are highly interdependent but lack coordinated development and management between one another. Therefore, there is risk of disasters that resembles the proverbial Chinese saying “pull one hair and the whole body is affected”.

Besides, internet and online connectivity is quickly forming new-type of urban lifeline that have become inseparable element in daily life of millions and have built up services for many important urban tasks, such as flow of goods (for example online shopping and express delivery), flow of passenger (such as online car-hailing, shared biking and other modes of transportation), flow of money (such as Alipay and Wechat Pay) and flow of energy, all

of which have greatly added complexity to the management system of the urban operation. Influenced by the "lock-in effect" of urbanization, sometime in the future, the interdependence and common development between the old and new urban lifelines will be faced with systematic risks, thus, making preemption and management of disaster risk more complicated.

Box 3.3– Selected disaster events and damages in China



The data on disaster is predominantly categorized on base of type (geological, earthquake, climatological, floods etc.)(a), at coarser scales (e.g. Global, Regional, National). Currently no proper long term databases are maintain that quantify and aggregate, different metrics of disasters at the scale of cities. One of the important metric that can help quantify urban damages are economic loss due to the investments and infrastructure concentrated in urban areas, which is on the rise both in terms of improved record and actual damages (b). (Data Source: "International Disaster Database").

For example, among the 32 urban agglomerations, nearly half of them are in typhoon-affected areas, including those located in Beijing-Tianjin-Hebei Region, the Yangtze River Delta and the Pearl River Delta whose goal of development is mega-urban agglomeration. Harbor and river transportation are the critical lifeline of the development of urban agglomerations. Threats to harbors and river channels will aggravate the foreign transportation connection of coastal cities, and exert serious impact on the development of coastal urban agglomerations (Suocheng et al., 2012).

Exacerbating impacts of new and mixed urban disasters and significantly aggravated economic losses will

have a profound effect on the social and economic stability and the sustainable development. The surge of urban population and diversified economic activities make it hard to maintain the existing modes of the urban development. In the context of global climate change, risks faced by cities are increasingly complicated, integrated and diversified, continuously giving rise to new social and environmental risks.

Box 3.4 - Cases of Windstorms Damaging Urban Lifelines
Super Typhoon Nida, No. 4 of 2016, made a front landing on Shenzhen, Guangdong Province with strong wind and heavy rainfall. Emergency mobilization order was issued by the Guangdong to seven cities in the Pearl River Delta, namely Guangzhou, Shenzhen, Huizhou, Dongguan, Zhongshan, Foshan and Zhuhai. The order stated to adopt the “five suspensions”, which refers to the suspension of production, classes, transport, market and business. All flights in and out of Shenzhen were grounded. All logistics arteries, the G-series high-speed trains and traditional trains, connecting the region to the whole nation, were shut down. Long-distance passenger trains and inter-city trains were also all out of service. Due to the timely and accurate forecast and early-warning, combined with adequate prevention measures, Typhoon Nida did not cause deaths. But Shenzhen, being a typical hub city, suffered from immeasurable economic losses, and so did its lifeline engineering projects.

4 Way forward

Traditional urbanization process throughout the world are characterized by the traditional model of economic development, which is industrialization driven by fossil fuels, based on excess consumption of natural resources at the cost of ecological environment, with high efficient production being its sole target and one-sided pursuit of material consumption with encouragement and incentives. Therefore, in the next 15 to 20 years, China’s new-type urbanization process will not only undertake the mission to end the old development model and promote the sustainable development of social economy, but also, improve government planning, management system of urban operation, financial market and financial tools, technological means of engineering and education for public awareness through enhanced scientific understanding of disaster risks. Accordingly integrated prevention capacities of cities can be built up against disasters and strengthen the overall resilience. Through this process we may find out a sustainable development path of new-type urbanization with Chinese characteristics. During and

post-2008 Wenchuan earthquake the central government began to coordinate instead of managing disaster risk representing shift towards an integrated governance for disaster risk. Currently both central and local governments participate in the planning, coordinating, directing and allocation of resources (Sim & Yu, 2018a). The Government is in process of developing a disaster governance system that allows for all stake holders to be involved in the process by integrating top down to down up system however, this will require time (Sim & Yu, 2018b). Chinese studies identify two important problems, 1) coordination between local and regional levels and 2) problems in data collection, classification and quality (Renwick, 2017), adding two essential components to any future developments in disaster risk governance, namely, administrative systems and monitoring and research. Specifically, during the 2020 – 2025 periods, scientific research and application in the following aspects are required.

Integrated theory on disaster risk as the guiding principal: China needs to strengthen its planning, monitoring and assessment of integrated prevention against urban disasters and enhance the top-level design and construction of its early-warning system. China is highly committed to disaster risk reduction, and post–Wenchuan earthquake has enforced different measures, prominently, enforcing building codes, mandatory disaster drills at schools and efforts towards early warning systems. However, there is still slow progress in mitigation sector as compared to the response and recovery. The process of China's new-type urbanization has just begun, with the majority of planning at final stages. Based on the theory of orderly human adaptations, a cross-section coordination mechanism should be established as an information-exchange and decision-making platform, integrate disaster risk management into the sustainable development framework, include disaster risk management in the post-construction planning of new-type urbanization, conduct comprehensive risk assessment and prediction of the occurrence and impact of extreme natural events, and reduce disaster risks through top-level design of system and planning.

To ensure reliable and actionable information, integrated risk assessment should be prioritized for major disasters in major economic, social and cultural hubs. Scientific research should be prioritized to improve the overall disaster prevention capacities of urban lifelines in the older neighborhoods, villages in the city and other highly vulnerable areas, while, the disaster risk research on newly-built and planned cities and urban agglomerations should be enhanced.

Management performance of disaster risk reduction at the primary level needs to be improved. This can be achieved by strengthening professional training for primary-level staff on integrated disaster risks monitoring. More importantly public access to information regarding local disaster risks, risk reduction and prevention

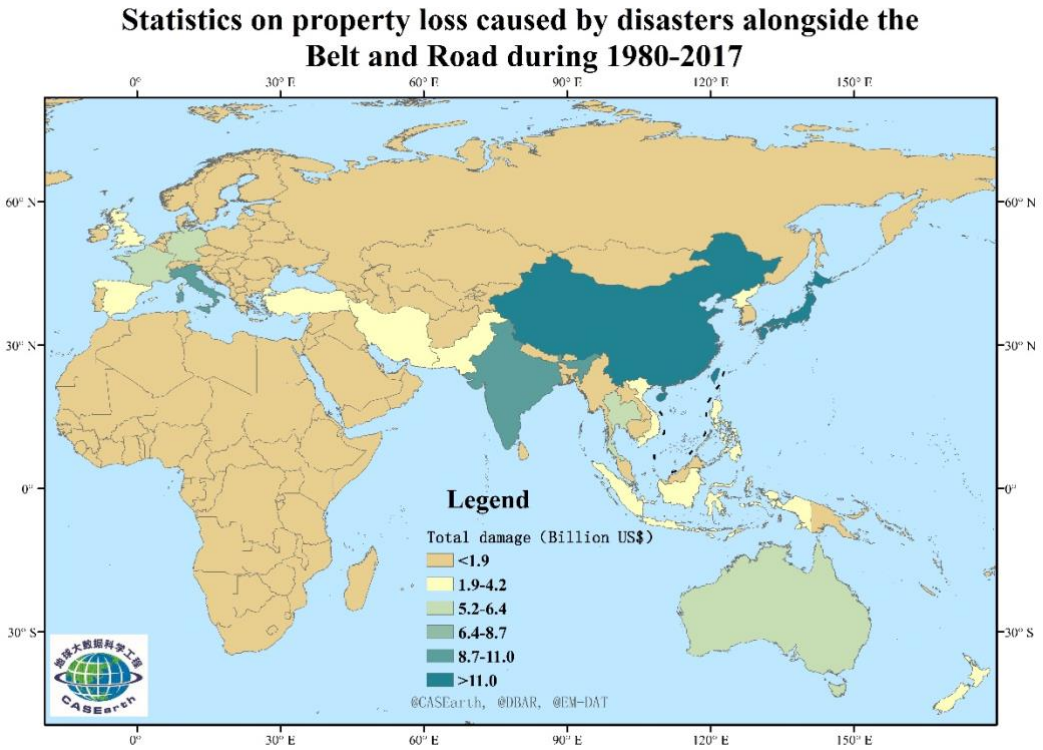
methodologies need to be ensured. This can be achieved by seeking, improving and ensuring visibility of important risk reduction and early warning information on electronic and internet based communication and social networking services. Proper and timely information will also help in mobilization of public support and voluntary services for disaster preparedness and post disaster relief.

Vertical and Horizontal Integration of responsibilities: Previously, one of the problems of Chinese disaster risk reduction efforts is the lack of clarity of responsibilities of different ministries, which often compete to address disasters, resulting in waste of resources poor information sharing and coordination (Cao Yue, 2018b). For example, overlapping mandates of different ministries and departments will result in conflict, especially with the agglomeration process ongoing, more and more mandates of different administrative bodies will overlap. This is inefficient, especially in complex systems such as urban environment due to underlying interactions between different sub-systems, which will only get more complicated with agglomerations as planned in the new-urbanization plan. Good vertical and horizontal integration facilitates disaster management at different levels of government (Florian Roth & Linda Maduz, 2017). In response to these shortcomings, Ministry of Emergency Management was inaugurated in April, 2018 (Cao Yue, 2018a).

Big Earth Data, internet, new &emerging technologies: Supported by Big Earth Data, the Internet of things and other advanced technologies, the capacities related to the monitoring, identification, analysis and early-warning for all disasters needs to be improved, and the technological capabilities for the identification, assessment and prediction of the integrated risk of extreme natural events should be enhanced.

In the present information and technology age, the vast variety of tools available for data collection and data analysis are important resources for testing established disaster risk theories and developing new ones. Presently the growing analytical capabilities for data and information from multiple sources, time and space, fields and disciplines, is enhancing data-oriented decision support mechanisms, and allow development of models that can assess integrated risk and allow for integrated disaster risk reduction strategies.

Box 4.1 – Efforts to utilize Big Earth Data for Disaster risk reduction



There are various national disaster loss databases that have been developed by countries for their use, such as United States, China, Japan, Canada, Australia and Belgium. Other countries rely on international databases that have also been developed by organizations. With data intensive methodologies and improving computational power, multi-faceted aggregation of existing disaster-related databases at various spatial and temporal scales is highly desirable. Such efforts require consistency and standardization of data, minimizing biases and errors while increasing compatibility in quality and the frequency of data generation. The Big Earth Data Science Engineering Project (CASEarth) of the Chinese academy of science integrates existing disaster databases globally (e.g., EM-DAT, Desinventar, and Reliefweb) to generate large disaster datasets through semantic analysis combined with geospatial information, and employs satellite observation data to supplement missing data of disasters. Additionally, it adopts network crawling technology to collect multi-channel disaster information for quality control. Currently it has completed a long time series of disaster information specialization (1980-present). Disaster analysis based on Big Earth Data can improve understanding disasters, their effects, consequent risk and hopefully also improve predictive ability. (Data Source: “CAS Earth Big Data Science Project”).

There are urgent needs to develop the analysis and risk assessment mechanisms tailored to meet developmental, environmental and economic challenges. Disaster sources, threat and exposure levels, risk proliferation and vulnerability of both urban population and infrastructure are key research questions that can benefit from big data analysis. There is also a need for disaster risk zoning at multiple administrative scales for identification high risk and vulnerable zones.

Universities and research organizations should provide adequate base for scientific research on identifying, quantifying risks and develop mitigation strategies. The local governments should facilitate data access of available data and facilitate new data generation primarily through new and advance methodologies and technologies. Academic organization can also help to identify the specific risk through mock scenarios to develop strategies for disasters in extreme cases. This will help to generate reliable data to identify vulnerabilities and develop policies to counter these vulnerabilities.

Financial market and financial tools to confront disaster risk: There are strong needs to explore and innovate energetically to increase the resilience of social and economic systems against disasters. Positive role of financial market and financial tools should be allowed when confronted with risks. In addition to enhancing the integrated capacities of the government in controlling risks, the government should also provide opportunities to businesses participating in management and prevention of disaster risks.

Through the financial policies and tax rates set by the government, as well as products and mechanisms in the financial market related to risk transfer and sharing, mechanisms for strengthening capacities about post-disaster restoration should be explored, and innovative compensation mechanisms such as securitization of disaster risks should be probed into.

It is important to take steps that make economic risks controllable, such as integration of disaster risk response in planning, design, and management of investments for creating new industries, technologies and products. It is also equally necessary to enhance the post-disaster capacities of adjustment, adaptation, restoration and reconstruction. The government needs to strengthen its financial regulations and implementation mechanisms to reduce financial risks. Businesses need to improve their forecasting capacities for future risks, their response capacities, reduce material risks, and improve their responsibility-sharing capacities where the society is confronted with risks, their reconstruction capacities for fast recovery and reduce their foot print in enhancing risks.

International and regional cooperation: As global climate and the environment are changing, countries and regions are also experiencing changes in disaster pattern and frequency that affect multiple nations. This therefore

warrants a collaborative effort for disaster risk reduction. For the Belt and Road region, an integrated risk management platform can be jointly developed involving multiple sections of stake holders from different countries, looking at risks and management of different disaster types.

This will allow pooling in experiences of different nations for countering aggravated disaster risks during the urbanization process and also develop a combined system for large scale multi-national disasters in the region. Such a collaborative network will also enable other countries to take advantage of China's strengths and experiences in the management mechanisms of disaster risks.

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Contributing Organizations