Chapter 2

China

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Chapter 2

China

Hongyuan Yu, Yunjie Zhu, and Yanfei Li

1. Introduction

Climate change has emerged as a top security challenge of the early 21st century. Although China's ability to adapt to climate change is still insufficient, it has been significantly enhanced. Its policies should continue to focus on the ability to respond to extreme weather events, to resist climate risks to agriculture and major infrastructure projects, to adapt to climate change in essential realms, as well as to develop and to use climate resources for climate-change adaptation measures.

As a developing country experiencing rapid urbanisation and industrialisation, China has significant development inequality amongst its regions, which forces the country to focus on both huge and incremental development-oriented climate-change adaptation needs. Even for the developed coastal areas, where the infrastructure is relatively complete, the increasing climate risks have significantly increased its vulnerability. Therefore, it is necessary to rely on government-backed financial investment to promote development-oriented adaptation, including for infrastructure.

In this chapter, China's policies and regulations for financing and investing in climate resilience are reviewed. Five climate-change adaptation engineering projects, which are the most prominent in the country, are discussed. The typical financing sources, mechanisms, and tools are also detailed accordingly.

2. Overall Country Policies and Regulations

In 2019, the Global Commission on Adaptation released *Adapt Now: A Global Call for Leadership on Climate Resilience*, which posited that climate-change adaptation can provide a triple dividend – it avoids economic losses, brings positive gains, and delivers additional social and environmental benefits (China Meteorological Administration, 2019). Following this, China worked to combine climate-change adaptation with the implementation of sustainable development strategies by accelerating the construction of a natural resource-saving and environmentally friendly society; building innovative cities that focus on energy conservation, optimising energy structure, and strengthening ecological protection and construction; supporting scientific and technological progress; and striving to control greenhouse gas emissions. Outlined as follows, a series of climate-change mitigation and adaptation plans and policies have materialised, and many important climate-change adaptation projects have begun.

In 2009, China announced that by 2020, it will lower carbon dioxide emissions per unit of gross domestic product (GDP) by 40% to 45% from the 2005 level, increase the share of non-fossil fuels in primary energy consumption to about 15%, and increase forested area by 40 million hectares and forest stock volume by 1.3 billion cubic metres compared to 2005 levels (China.org.cn, 2015).

To build an energy-efficient and low-carbon industrial system in China, the industrial sector is being encouraged to embrace low-carbon development through the *Action Plan of Industries Addressing Climate Change (2012–2020),* which details carbon-emission control targets and action plans (China.org.cn, 2015). In the same year, the National Development and Reform Commission (NDRC) launched national demonstration projects of low-carbon technology innovation and industrialisation and approved 20 demonstration projects in three industries – steel, non-ferrous metals, and petrochemicals. During 2011–2012, 59 science and technology projects began in the energy sector, with CNY2.74 billion allocated by the state. These projects focussed on formulating plans for developing energy technologies, clean and efficient coal transformation, and wind-power generation; they also worked to issue the *Fourth Batch of the National Key Energy Savings Technology Promotion Catalogues* (SCIO, 2012). China also implemented the National Climate Change Programme. Specific policy documents include the *Comprehensive Work Plan for Energy Conservation and Emission Reduction for the 12th Five-Year Plan Period*; *12th Five-Year Plan for Energy Conservation and Emission Reduction*, *2014–2015; Action Plan for Energy Conservation, Emission Reduction, and Low-Carbon Development*; and *National Plan on Climate Change (2014–2020)* (SCIO, 2014).

Further, China established the National Committee for Biodiversity Conservation and enacted the *China Biodiversity Conservation Strategy and Action Plan (2011–2030)* to implement the relevant provisions of the Convention on Biological Diversity (Government of China, 2016). In 2009, it approved the *Plan for the Protection and Construction of the Eco-safety Barrier in Tibet (2008–2030)*. By the end of 2017, 10 projects under this plan had been implemented, with a total investment of CNY9.6 billion.

In 2005, the State Council of China approved *The Overall Plan of Qinghai Sanjiangyuan National Nature Reserve's Ecological Protection and Construction*, marking the official opening of the first phase of ecological protection and construction project of the Sanjiangyuan Nature Reserve in Qinghai Province. The first phase of the project covers the headwaters of the Yellow River, Yangtze River, and Lancang River. The administrative scope includes all 21 counties in Qinghai Province and Tanggulashan town in Golmud City, with a total of 22 projects and a total investment of CNY7.5 billion (Government of China, 2006a). The government, in 2011, implemented the *Plan for Regional Ecological Construction and Environmental Protection on the Qinghai-Tibet Plateau (2011–2030).* Under this plan, several eco-projects have been implemented, achieving positive results in ecosystem conservation, helping control the degradation of the local ecosystem, and restoring biodiversity (SCIO, 2018).[1]

In 2013, *China's National Climate Change Adaptation Strategy* was released to cope with climate-change challenges such as extreme weather conditions and impacts on livelihoods (MEE, 2016). It recommended that adapting to climate change should be included in China's economic and social development in a holistic manner. The strategy set the main objectives of adaptation

[1] For example, to date, about 71,300 hectares of degraded wetlands have been restored, 20,000 hectares of farmland have been returned to wetlands, and 112 national wetland parks have been created. Six cities have the title of 'International Wetland City'. At the provincial level, 13 provinces and cities – including Yunnan – have designated 541 important wetlands.

to climate change by 2020, including enhancing adaptability, fully implementing key tasks, and forming a regional pattern of adaptation. Promoting international cooperation is also encouraged by the strategy to help ensure its implementation.[2]

Regarding the goal of limiting global temperature increase to 1.5°C, the *Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions, Third National Assessment Report on Climate Change,* and *China's Policies and Actions on Climate Change: 2017 Annual Report* propose related strategic plans and policy advice towards this goal and the reduction of carbon emissions (Government of China, 2015, 2017).

The United States (US)–China Joint Announcement on Climate Change*,* issued in November 2014, is a major landmark in the cooperation between China and the US in the field of climate change; it is also proof of China's readiness to undertake international obligations as a major developing country. Both countries reiterated that in the context of meaningful mitigation actions and implementation transparency, developed countries must commit to jointly mobilise $100 billion per year by 2020 to meet the environmental needs of developing countries (Government of China, 2013).

In sum, China's commitment to environmental quality is on a stable and sound trend, and the deterioration of its various ecosystems is being curbed. The quality of key ecological project areas has been improved, and the framework for national ecological security has been established. The *Master Plan of National Major Ecological System Protection and Restoration Projects (2021–2035),* issued in May 2020, states that ecological protection and restoration will be strengthened through the implementation of major ecological protection and restoration projects by 2035. Major projects include the Qinghai-Tibet Plateau Ecological Barrier Area, key ecological areas of the Yangtze River, the Three-North Shelter Forest, the Northern Sand Protection Belt, several southern hilly and mountainous areas, and coastal zones (NDRC, 2020). The following figure summarises the main policies issued in China.

2 This cooperation does require developed countries to fulfil their obligations under the United Nations Framework Convention on Climate Change, promote the research and development of key adaptation technologies, and carry out South–South cooperation.

Figure 2.1. Main Climate-Change Adaptation Policies Issued in the Past 2 Decades

Year	Plan for Climate-Change Adaptation	Department
2005	*The Overall Plan of Qinghai Sanjiangyuan National Nature Reserve's Ecological Protection and Construction*	The State Council
2009	*Plan for the Protection and Construction of the Eco-Safety Barrier in Tibet (2008–2030)*	National Development and Reform Commision
2013	*National Climate Change Adaptation Strategy 2035*	National Development and Reform Commision
2014	*US–China Joint Declaration on Climate Change*	Governments of China and United States
2015	*Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions*	Government of China
2016	*China Biodiversity Conservation Strategy and Action Plan (2011-2030)*	Ministry of Ecology and Environment
2020	*Master Plan of National Major Ecological System Protection and Restoration Projects (2021–2035)*	National Development and Reform

Source: Authors.

3. Adaptation Projects

Climate-change adaptation projects in China can be divided into two types: (i) passive engineering measures to deal with natural disasters caused by climate change (e.g. Three Gorges Dam, South-to-North Water Diversion Project, and Qinghai-Tibet Railway); and (ii) dedicated climate-change adaptation projects, usually supported by national and local governments (e.g. Sanjiangyuan Ecological Protection Project and Three-North Shelterbelt Project).

3.1. The Three Gorges Dam

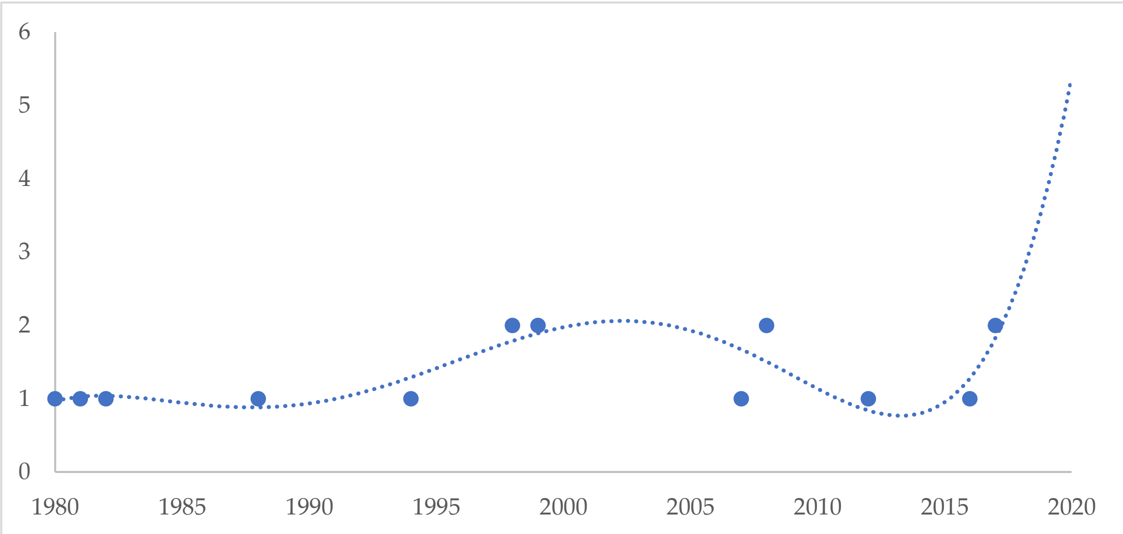
The Three Gorges Reservoir is in the upper reaches of the Yangtze River, at the junction of the economically developed eastern region and the resource-rich western region. It is an important ecological barrier, national strategic freshwater resource, and strategic position in China's social and economic development. The Three Gorges Dam is in the Xiling Gorge section of the Three Gorges of the Yangtze River. It controls a drainage area of 1 million square kilometres and an average annual runoff of 451 billion cubic metres (Wertz, 2011). It is not only the world's largest water conservancy project but also a key project for the treatment and development of the Yangtze River. The operation of the Three Gorges Dam is of great significance to guaranteeing national economic security, social security, and ecological security.

Rainfall and reservoir water trigger landslides around the reservoir; the monitoring and early warning of landslides affect people's lives and property. The reservoir water level also impacts the economic benefits from the Three Gorges Hydropower Station. A rapid drop in water level is beneficial to power generation, but a too-fast drop may cause landslides along the riverbank. The land mass sliding into the reservoir may generate huge swells, thereby threatening the safety of hydraulic structures and personnel.

In addition, climate change has had an impact on the integrated management and operation of the Three Gorges Reservoir and Dam, especially in terms of the safety of hydraulic structures and staff, water resources management and operation, and vegetation and ecosystem security.

Due to climate change, the hydrological characteristics of the Three Gorges Reservoir's incoming water has been altered. Extreme weather events – such as high temperatures, continuous droughts, strong autumn floods, and floods during the monsoons – have created new challenges. Indeed, from 1980 to 2020, the area in which the Three Gorges Dam is located has witnessed 16 disasters, including 1 drought, 9 floods, and 6 storms. The main form of disasters are riverine floods and convective storms, and the number has increased significantly since 1995. Based on the trend of the number of disasters through a sixth-order polynomial, the period between 1995 and 2010 was the peak period for natural disasters. After a short-term decline after 2010, the number of natural disasters showed an accelerated trend of increases (Figure 2.2).

Figure 2.2. Sixth-Order Polynomial Trend Line of Disaster Frequency for the Three Gorges Project Area



Source: Authors based on CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be.

The construction funds for the Three Gorges Project include the Three Gorges Project Construction Fund allocated by the state, loans from the China Development Bank, and various monies raised by the China Three Gorges Corporation. The China Three Gorges Corporation is responsible for the fundraising, project construction, and operational management of the Three Gorges Project, as well as the preservation and appreciation of assets.

According to the construction content and price level at the end of May 1993, the Three Gorges Construction Committee's static investment totalled CNY135.266 billion, including the hub project (CNY50.090 billion), power transmission and transformation project (CNY32.274 billion), and resettlement funds (CNY52.902 billion). Calculated according to factors such as prices and interest rates, the total dynamic investment is CNY248.537 billion, including the hub project (CNY126.385 billion), power transmission and transformation project (CNY36.499 billion), and resettlement funds (CNY85.653 billion).

The Three Gorges Construction Fund, established in 1992, became the most stable source of funds. In January 1997, the State Planning Commission formally approved the Three Gorges Bond issuance plan. In February, the Three Gorges Corporation issued bonds for the Three Gorges Project for the first time in China, with a quota of CNY1 billion.

By the end of 2002, export credits and international commercial loans for the purchase of foreign equipment totalled $1.12 billion (i.e. export credits of $700 million and commercial loans of $420 million involving 26 commercial banks, 21 years of loan terms, 9 years of use, and 12 years of repayment). The annual average interest rate was 7.8%.

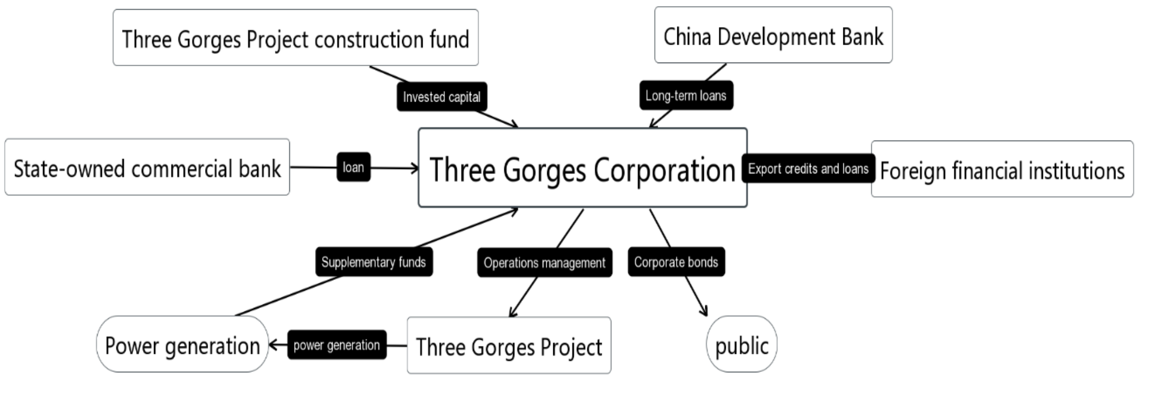
As of the end of December 2011, CNY207.873 billion was invested in the construction of the Three Gorges Project. This included the Three Gorges Project Construction Fund of CNY161.587 billion, revenue from the sale of generator sets to the Yangtze Power Company totalling CNY35.03 billion, power grid income of CNY11.069 billion, and the infrastructure fund and other special funds of CNY186 million. During the construction process, the funds raised through loans from the China Development Bank and the issuance of corporate bonds were fully repaid.

The funds were divided into three stages: (i) investment stage, from 1993 to 2003; (ii) input-output stage, during which the first batch of power generation units began to yield economic returns (2003), and the power generation income of the year plus the profit income of the Three Gorges Project Construction Fund and Gezhouba Power Plant reached a balance with the capital demand of the year (2005); and (iii) output-loan repayment stage, during which a surplus of funds occurred starting in 2006, and the loan principal and interest were repaid. Preliminary estimates show that after 2010, all principal and interest of the loan were paid off.

The government issued three supporting policies in terms of fundraising (Figure 2.3). The first was to assign the Gezhouba Power Plant to the China Three Gorges Corporation, and its power-generation profits were used for the construction of the Three Gorges Project. In addition, the on-grid power price was increased, and the revenue was also used for the construction of the Three Gorges Project. The second was to raise electricity prices for users and to enact levies across the country according to different regions and different standards for the Three Gorges Project Construction Fund. This raised about CNY110 billion, accounting for more than 50% of the total investment in the Three Gorges Project. The third was loans from the China Development Bank, which advanced CNY3 billion to the Three Gorges Project each year from 1994 to 2003, totalling CNY30 billion. The above three policies raised more than CNY140 billion for the Three Gorges Project, accounting for about 70% of the total project investment.

In addition, since 2003, the power-generation units were put into production, adding new sources of funds for the Three Gorges Project from the sale of electricity. A small amount of funds was also raised from domestic and foreign capital markets, through facilities such as export credit and bond issuance.

Figure 2.3. Financing Mechanism of the Three Gorges Project



Source: Authors.

3.2. South-to-North Water Diversion Project

The South-to-North Water Diversion Project involves drawing water from southern rivers and supplying it to the dry north. This massive scheme has already taken 50 years from conception to commencement and is expected to take almost as long to construct. Planned for completion in 2050, it will eventually divert 44.8 billion cubic metres of water annually to the population centres in the north.

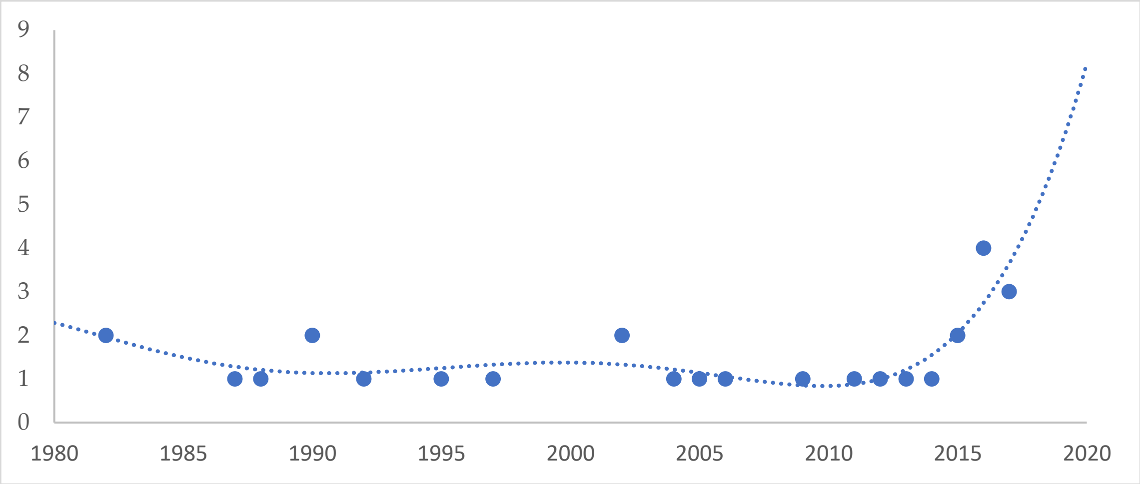
Since the 1950s, based on the analysis and comparison of more than 50 planning schemes, three water transfer areas have been planned in the lower, middle, and upper reaches of the Yangtze River, forming the East, Middle, and West routes of the South-to-North Water Diversion Project. Three water transfer lines are to be connected to the Yangtze River, Huai River, Yellow River, and Hai River. The three water transfer lines complement each other and cannot be replaced. The planned final scale of the South-to-North Water Transfer Project is 14.8 billion cubic metres in the East Line, 13.0 billion cubic metres in the Middle Line, and 17.0 billion cubic metres in the West Line.

The shortage of water resources in the water source area, frequent floods and droughts, and serious soil erosion – combined with the long-term trend of global temperature rise, droughts, and water shortages – make the South-to-North Water Diversion Project face the systemic risk of unsustainable water transfer as well as indirectly lead to the decline of water quality in the water sourcing area.

From 1980 to 2020, there were 27 disasters in the areas covered by the East Line, including 5 droughts, 12 floods, and 10 storms. The main forms of disasters were riverine floods and convective storms. Similarly, there were 25 disasters in the areas covered by the Middle Line, including 3 droughts, 9 floods, 10 storms, and 3 extreme temperature stretches. The main forms of disasters were riverine floods, convective storms, and heat waves.

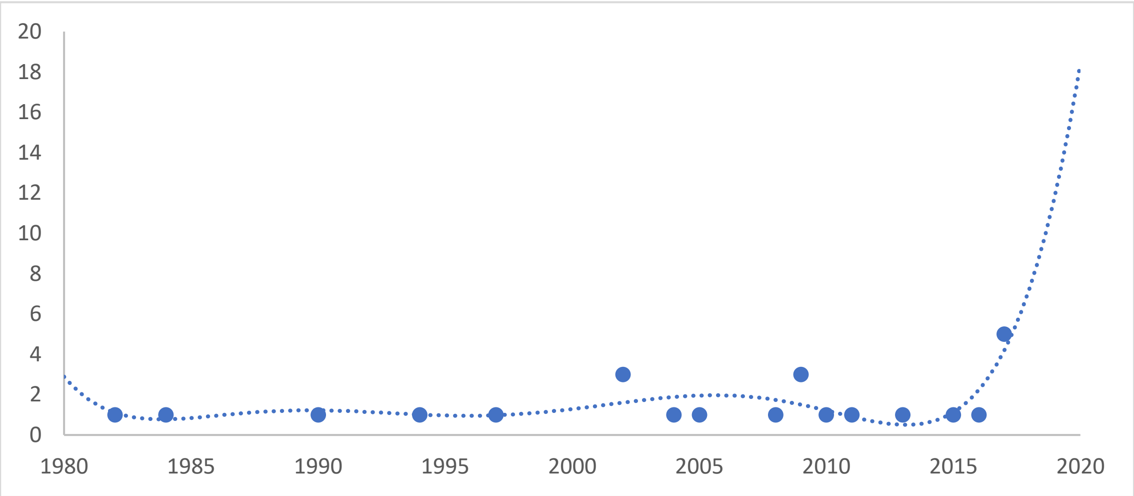
According to data from 1980 to 2020, the frequency of disasters along the East and Middle lines is stable. However, both the number and frequency of disasters show a significant increase in the past 5 years. This will pose a greater threat to both routes of the project (Figures 2.4 and 2.5).

Figure 2.4. Sixth-Order Polynomial Trend Line of Disaster Frequency for South-to-North Water Diversion Project, East Line



Source: Authors based on CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be.

Figure 2.5. Sixth-Order Polynomial Trend Line of Disaster Frequency for South-to-North Water Diversion Project, Middle Line



Source: Authors based on CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be.

On 5 September 2008, the South-to-North Water Diversion Project Construction Committee issued fund management measures, which stipulated that project would be funded through the central budget (including special funds from the central budget), South-North Water Diversion Project Fund, and bank loans. Of the CNY194.3 billion in the main project investment, the central government funded CNY31.26 billion; the South-to-North Water Transfer Project Fund, CNY18.02 billion; bank loans, CNY40.72 billion; and major water conservancy project funds, CNY104.3 billion.

On 15 June 2004, the main project financing syndicate for the South-to-North Water Transfer Project was established, led by China Development Bank, China Construction Bank, Agricultural Bank of China, Bank of China, Industrial and Commercial Bank of China, four wholly state-owned commercial banks, Bank of Communications, Shanghai Pudong Development Bank, and the three joint-stock commercial banks of China CITIC Bank. The syndicate provided loans of the CNY40.72 billion.

The South-to-North Water Diversion Project Fund was raised within Beijing, Tianjin, Hebei, Jiangsu, Shandong, and Henan Provinces, which are the water-receiving areas of the South-to-North Water Diversion Project. The amount of funds raised by the six provinces and cities is as follows: Beijing, CNY5.43 billion; Tianjin, CNY4.38 billion; Hebei Province, CNY7.61 billion; Henan Province, CNY2.60 billion; Shandong Province, CNY7.28 billion; and Jiangsu Province, CNY3.70 billion (SCIO, 2008).

As of May 2016, the Ministry of Water Resources allocated CNY261.92 billion in the first phase of the South-to-North Water Diversion Project, including CNY25.42 billion from the central budget, CNY10.65 billion from special funds (i.e. national bonds) from the central budget, and CNY19.65 billion from the South-to-North Water Diversion Project Fund. CNY158.61 billion was from a national major water conservancy project construction fund, and loans totalled CNY47.59 billion.

On 28 September 2020, the China South-to-North Water Diversion Group was established, with registered capital of CNY150 billion. It is a wholly state-owned enterprise to accelerate the South-to-North Water Transfer Project.

3.3. Qinghai-Tibet Railway Project

The Qinghai-Tibet Railway is a plateau railway at the highest altitude that has the longest line in the world. As the first railway that reaches the heartland of the Qinghai-Tibet Plateau, it will strengthen the connection between the Qinghai-Tibet region and the more economically developed regions of China.

The Qinghai-Tibet Railway is listed as one of four landmark projects in the *10th Five-Year Plan* and ranks first amongst the 12 key projects in the country's development of western areas. It is often referred to as the most difficult railway project in history due to its location and features (Government of China, 2006b).

The Qinghai-Tibet Railway is a national, Grade I railway, connecting Xining to Lhasa. The total length is 1,956 kilometres, including 814 kilometres from Xining to Golmud and 1,142 kilometres from Golmud to Lhasa. There are 85 stations with a designed maximum speed of 160 kilometres per hour (Xining–Golmud section) and 100 kilometres per hour (Golmud–Lhasa section). As of March 2015, the operating speed of the Qinghai-Tibet Railway was 140 kilometres per hour (Xining–Golmud section) and 100 kilometres per hour (Golmud–Lhasa section) (Ma, 2015).

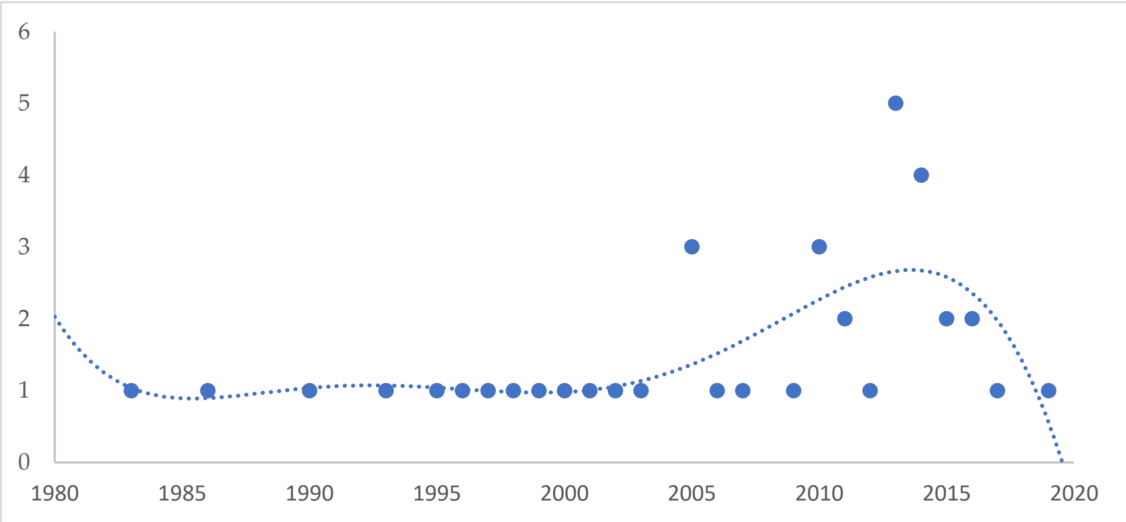
Due to global warming, the permafrost on the Qinghai-Tibet Plateau is currently degrading. Of the total length of the railway, 960 kilometres are at least 4,000 metres above sea level and run about 547 kilometres through permafrost areas. Further, the Qinghai-Tibet Railway is changing the original hydrothermal conditions, influencing the thermal stability of the permafrost along the railway line.

First, the warming and humidifying climate on the plateau may lead to increasing lateral hydrothermal erosion of the roadbed side, resulting in uneven subsidence and deformation of the roadbed. The roadbed may tilt or even collapse. Second, due to global warming and humidification, glacial meltwater and increased precipitation may lead to glacial lake outbursts, contributing to floods and mudslides. These could destroy the Qinghai-Tibet Railway, highway, and other supporting infrastructure.

From 1980 to 2020, there were 37 disasters in the areas of the Qinghai-Tibet Railway Project, including 2 droughts, 16 floods, 15 storms, 2 extreme temperature stretches, 6 landslides, and 1 wildfire. The main forms were riverine floods, convective storms, cold waves, and severe winter conditions.

According to data from 1980 to 2020, the frequency of disasters along the Qinghai-Tibet Railway was relatively low and stable before 2005. However, since 2005, disasters along the Qinghai-Tibet Railway have seen significant peaks both in terms of number and frequency (Figure 2.6).

Figure 2.6. Sixth-Order Polynomial Trend Line of Disaster Frequency for the Qinghai-Tibet Railway Project



Source: Authors based on CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be.

The Tibetan Plateau is the 'starter' and 'amplifier' of global climate change, with its warming occurring earlier than and higher than the global average (Cheng and Wu, 2007). In the past few decades, the permafrost on the Qinghai-Tibet Plateau has been melting. From the 1970s to 1990s, the ground temperature of seasonal frozen soil, thawing area, and island permafrost along the Qinghai-Tibet Highway increased by 0.3℃ to 0.5℃, and the annual average ground temperature in continuous permafrost regions increased by 0.1℃ to 0.3℃ (Wang, Hou, Jia, 2006).

The Qinghai-Tibet Railway passes through the most developed permafrost region. As global warming will affect the permafrost, engineers have taken this effect into consideration when designing the railway. The idea of active cooling, foundation cooling, and frozen soil protection has been established, and the natural cold energy is being used to protect the permafrost. In addition, a complete set of frozen soil engineering and technical facilities, such as rubble aircooled subgrade, hot-rod technology, subgrade insulation materials, and bridges passing through extremely unstable permafrost sections, has also been developed.

In the design process, the number of stations was reduced to lessen emissions. After completion and operation, sewage treatment plants and garbage treatment plants will be built at some stations along the line, and clean energy such as solar energy and wind energy will be used as much as possible at these locations (Wang, Hou, Jia, 2006).

According to a press conference of the State Council Information Office on the construction and commissioning of the Qinghai-Tibet Railway, the total investment approved was CNY33.09 billion. More than CNY2.00 billion has been invested in environmental protection, accounting for about 7% of the total investment. In addition, each station along the railway will use clean energy, mainly electric energy and solar energy (CKNI.net, 2006).

In view of the frozen soil problem, 96 ministry-level scientific research projects were listed under the construction of the Qinghai-Tibet Railway, and the scientific research funds have totalled nearly CNY100 million. Under the Ministry of Science and Technology, Chinese Academy of Sciences, and Chinese Academy of Engineering, domestic and international frozen soil engineering has been coordinated. Scientific research and design units carried out frozen soil research, and theoretical research, field tests, survey and design, and scientific construction were actively explored. A breakthrough was made in the combination of frozen soil theory and frozen soil engineering practices, and many scientific and technological innovation achievements with independent intellectual property rights were obtained (Chinese Academy of Sciences, 2009).

For the permafrost area, the entire 32-kilometre subgrade adopted heat-treatment measures, such as the hot-rod technology. More than CNY30 million of investment can be saved per kilometre compared with replacing roads with bridges. The total cost savings of the Qinghai-Tibet Railway has reached more than CNY1 billion. Moreover, the destruction of permafrost ecological environment and resources caused by engineering activities such as surface excavation, vegetation removal, and embankment construction has been largely avoided (Xie, 2009; Wang, Hou, Zhou, 2004; Wu and Mi, 2000).

In the process of building the Qinghai-Tibet Railway, the government has invested CNY1.2 billion in environmental protection. Many kinds of rare wild animals, such as Tibetan antelopes and kiangs, live along the Golmud–Lhasa section. Indeed, about 14 species of rare wild animals live on both sides of the line. To ensure the normal life, free migration, and reproduction of these animals, 33 animal passages – with a total length of 59.8 kilometres – have been set up along the railway through gentle sloping of the subgrade, under bridges, and above tunnels. During the peak construction period in 2004, 1,660 Tibetan antelopes were recorded crossing the wildlife passages. At the beginning of the project in 2006, the number of Tibetan antelopes moving were over 2,000; after 2011, the number exceeded 5,000. The utilisation rate of wildlife passage increased from 56.6% in 2004 to 100% after 2011 (NFGA, 2016).

3.4. Sanjiangyuan Ecological Protection Project

The Sanjiangyuan Nature Reserve was established in 2000 and promoted to a national nature reserve in 2003. The ecological protection and construction project in the Sanjiangyuan Nature Reserve was officially approved in 2005, officially launching the ecological restoration and management of the Sanjiangyuan region. The project includes measures such as returning cropland to forest and cultivated grasslands to natural grass, controlling rodent infestations, conserving soil and water, developing protection and management facilities, and building capacity. The overall goal is to curb the trend of grassland ecological degradation.

The dynamic process of degradation or restoration of grassland ecosystems entails a combination of environment and anthropogenic activities. The Sanjiangyuan Nature Reserve is in the Tibetan Plateau, where climate change has had a vast impact on its grassland ecosystem and is a determining factor on vegetation productivity. The climate of the Sanjiangyuan has been warm and humid overall over the past 50 years, and some scientists have argued that this climate-change trend is favourable for vegetation growth and recovery. However, the climate-change trend has shifted to unfavourable vegetation growth and intensified grassland degradation, posing a threat to ecological security.

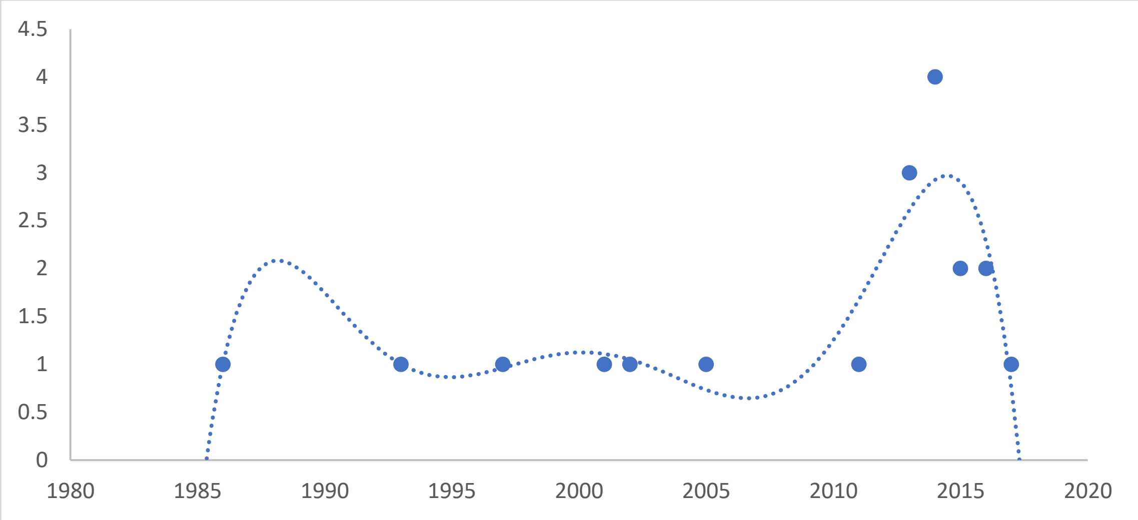
The first phase of the project covers the source areas of the Yellow River, Yangtze River, and Lancang River in Qinghai Province. The administrative scope includes all 21 counties in Qinghai Province and Tanggulashan town in Golmud City. There are 22 projects, with a total investment of CNY7,507.4412 million, including 12 ecological protection and construction projects. The first phase of Sanjiangyuan project was completed in 2011 and achieved good results. The current project, Phase Two, seeks to evaluate the effect of the first phase and to develop the second phase (Zhang and Zhuang, 2014).

As previously discussed, Sanjiangyuan is located on the Tibetan Plateau, one of the most sensitive and vulnerable areas of the natural ecosystem. As an independent climate region with the highest altitude and the most complex terrain in the world, Sanjiangyuan plays an initial role in the water cycle of several major rivers, which has a significant impact on the atmospheric circulation in China, South-East Asia, and even the entire Northern Hemisphere.

From 1980 to 2020, there were 19 disasters in the Sanjiangyuan, including 1 drought, 7 floods, 10 storms, and 1 extreme temperature stretch. The main forms were riverine floods, convective storms, and cold waves.

The frequency of disasters in the Sanjiangyuan was relatively low and stable before 2010. However, since 2010, their number and frequency in the Sanjiangyuan area have seen significant peaks (Figure 2.7).

Figure 2.7. Sixth-Order Polynomial Trend Line of Disaster Frequency for the Sanjiangyuan Ecological Protection Project



Source: Authors based on CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be.

Since the 1990s, three national nature reserves – Longbao, Kekexili, and Sanjiangyuan – have been established; policies and regulations, such as ending natural forest cutting and prohibiting the mining of sand and gold, have been issued; and the ecological protection of the Sanjiangyuan has been strengthened through various laws. The province has insisted on putting ecological protection in a prominent position. In 2007, three objectives – scientific development, ecological protection, and improvement of people's livelihoods – and the strategy of ecological province building were established.

As of 2010, the Sanjiangyuan has created 6.687 million hectares of grassland, 6,500 hectares of farmlands for forest, 122,000 hectares of closed hillsides for afforestation, 13,000 hectares of black soil beach treatment, and resettled 40,000 ecological immigrants and 21,000 nomadic herders. The ecological function of some areas of the source of the three rivers has been restored, the productivity of grasslands has been improved, and the Thousand Island Lake that has been dried up for many years has begun to again appear (Luo, 2010).

The Normalized Difference Vegetation Index (NDVI) was used to study the change of vegetation cover in the Sanjiangyuan area (Ma et al., 2022). With the establishment of Sanjiangyuan Nature Reserve in 2000, environmental management in the area achieved good results, and the vegetation shows a trend of recovery. Based on the change intensity of NDVI, combined with the scope of Sanjiangyuan Nature Reserve and the corresponding protection measures, before 2000, the vegetation of Sanjiangyuan was degraded due to human and natural factors, and the NDVI of six counties decreased significantly. In 2006, the declining trend of NDVI in Yushu, Nangqian, and Shengda counties was weakened, and the NDVI of Changdu and Leiwuqi counties improved. This phenomenon shows that the Sanjiangyuan Nature Reserve has achieved its initial results. At this time, the NDVI in most areas shows a stable or slight increased trend, but there are still large areas of Qumalai and Zaduo counties in the middle of the source area showing a strong downward trend, and the specific reasons for the decline need to be further studied (Zhao, Jiang, Li, 2008).

On 26 January 2005, the State Council approved the *Overall Plan of Qinghai Sanjiangyuan National Nature Reserve's Ecological Protection and Construction*, which plans to invest more than CNY7.5 billion. In August 2005, the plan was implemented, and the construction of nature reserves has been steadily promoted. Until the first half of 2012, the state invested CNY5.6 billion, accounting for 74.6% of the total planned investment. A total of 22 projects have been implemented, including returning grazing land to grassland and comprehensive treatment of black soil beaches, with an investment of CNY5.18 billion, accounting for 92.5% of the total investment. About 3.3 million hectares of grassland have been restored; 92,267 hectares of black soil beach were treated; 5.9 million hectares underwent rodent control; 6,540 hectares of forest were restored; 0.19 million hectares of hillsides were closed for afforestation; 44,106 hectares underwent desertification control; 38,667 hectares of wetlands were protected; 75.2 square kilometres of soil and water were conserved; 1,667 hectares of irrigation and forage bases were created; and 28,588 livestock-raising households, 10,733 ecological immigrants, and more than 55,000 people were resettled (NFGA, 2012).

From 2014 to 2018, in the first 4 years of Phase Two, CNY9.711 billion was released, accounting for 60.5% of the total planned investment. The total investment reached CNY9.548 billion, accounting for 98.3% of the released investment.

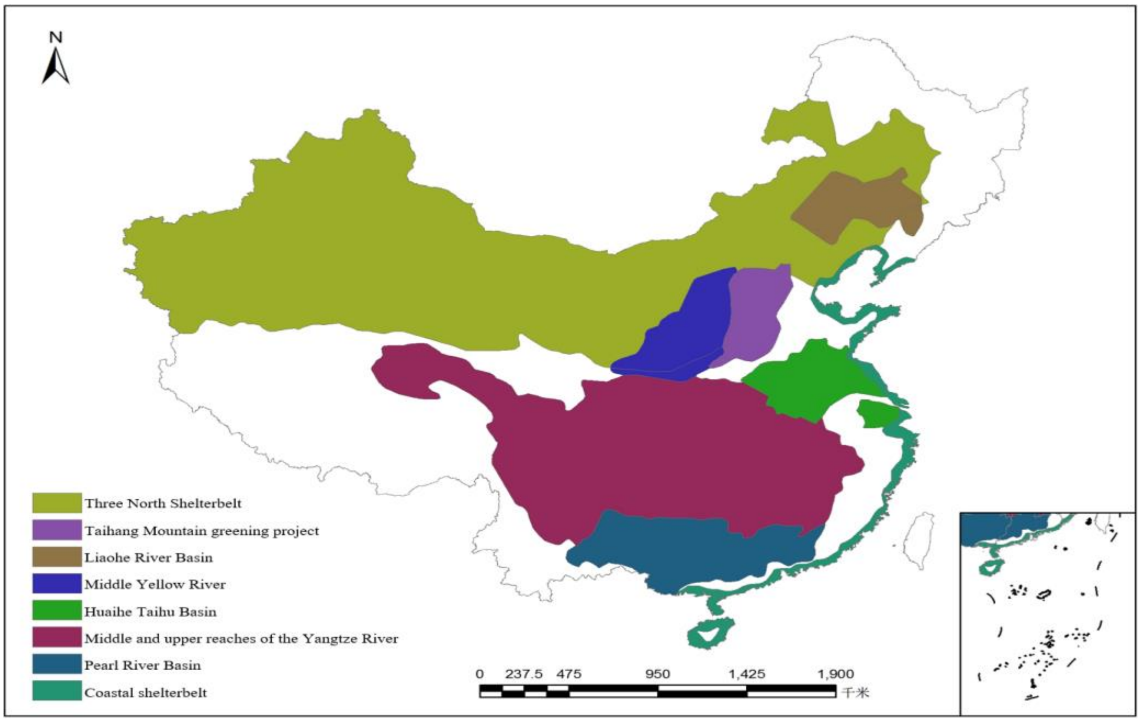
3.5. Three-North Shelterbelt Project

The Three-North Shelterbelt Project refers to a large-scale artificial forestry ecological project in the three northern regions of China. To improve the ecological environment, the government listed it as an important project of national economic construction in 1979. The planning period of the project is 73 years. It is divided into eight phases, and the sixth phase has been started.

The Three-North Shelterbelt Project was launched to improve the ecological environment in Northern China and to prevent sandstorms and soil erosion. The forest protection system starts from Binxian County, Heilongjiang Province in the east; reaches the Uziberi mountain pass in Xinjiang Province to the west; touches the country’s northern border; and continues along the Hai, Yongding, Fen, Wei, and Tao rivers downstream and Kunlun Mountain in the south. The total area is 4.069 million square kilometres, accounting for 42.4% of the land area in China. The planned afforestation area is 35.7 million hectares. By 2050, the forest coverage in the three areas will increase from 5.05% to 14.95%.

There are eight deserts and four sandy lands in the three north areas in the master plan, comprising 1.33 million square kilometres, which is larger than the total cultivated land area of China. Annual sandstorm days in this area number 30 to 100, and the riverbed in the lower reaches is more than 10 metres above ground. The construction of the project not only plays a decisive role in improving the ecological environment of the three north areas, but also plays an important role in improving the national ecological environment.

Figure 2.8. Three-North Shelterbelt Project



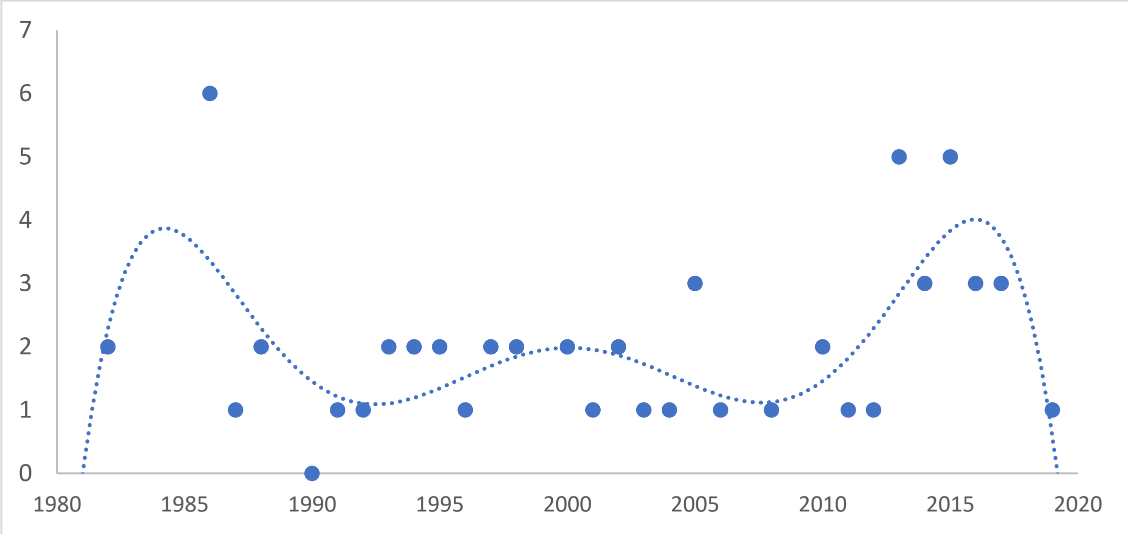
Source: Resources and Environment Science and Data Center, Spatial Distribution of Forestry Engineering in China, http://www.resdc.cn/data.aspx?DATAID=138&WebShieldDRSessionVerify=7pmmBPgaHhIKm2iZPr7U.

Wang et al. (2014) found that over the past 52 years, the temperature in the project area showed a significant increase, while precipitation showed a decreasing trend, which will limit the implementation of the protective forest project. Research has also showed that the climate of Northern China will see a warm and humid trend in the next 30 to 60 years, which will be beneficial to merge and to expand the ecological construction achievements of the protective forest and grassland, shortening the ecological recovery time. However, the warming climate will increase the occurrence and frequency of forest and grassland fires, diseases, and pests. Xie et al. (2020) found that precipitation is a key climatic factor influencing the growth of vegetation in the growing season of the protected forest project area. Warming promotes vegetation growth, but the decrease in precipitation brought about by the increase in temperature in the growing season makes warming inhibit the growth of vegetation. Whether the shelter forest has a strong climate ecological adaptability will directly affect the success or failure of the project.

From 1980 to 2020, there were 56 disasters in the areas covered by the Three-North Shelterbelt Project, including 9 droughts, 22 floods, 21 storms, 3 extreme temperature stretches, and 1 landslide. The main forms included riverine floods, flash floods, convective storms (including sand/dust storms and winter storms/blizzards), and heat and cold waves.

The frequency of disasters in the project area was stable before 2010. However, since 2010, disasters have seen significant peaks both in terms of number and frequency. In addition, due to the vast area covered, the Three-North Shelterbelt Project area has suffered frequent disaster over the past 40 years, of which 6 occurred in 1986, 5 in 2013, and 5 in 2015 (Figure 2.9).

Figure 2.9. Sixth-Order Polynomial Trend Line of Disaster Frequency for Three-North Shelterbelt Project



Source: Authors based on CRED, EM-DAT: The International Disaster Database, Brussels, http://emdat.be.

To protect the existing forest and grassland vegetation, methods of artificial afforestation, aircraft-seeding afforestation, closing mountains and closing sand for afforestation, and grass cultivation are adopted to build windbreak and sand-fixation forests, soil and water conservation bodies, and forests. It is a shelter forest system with a reasonable allocation of trees and coordinated development of agriculture, forestry, and animal husbandry.

The construction of the ecological forestry project in the Sanbei region has played an important role in the restoration of vegetation in the region, and the overall condition of the vegetation in the project has improved over the past 3 decades (He et al., 2015). The Three-North Shelterbelt Project has contributed to changes in the ecosystem's wind and sand-control services, with contribution rates ranging from 85% to 89% and 11% to 15%, respectively (Lin et al., 2018). The influence of climatic conditions on the project is mainly realised through changes in temperature and precipitation.

On 18 August 2020, according to a State Forestry and Grassland Administration report, the fifth phase of the Three North Shelterbelt Project was about to be completed; 30.14 million hectares of forestation and preservation, increasing the forest coverage rate from 5.05% to 13.57% (*Xinhuanet,* 2020).

The total planned investment of the Three-North Shelterbelt Project is CNY57.68 billion.[3] Furthermore, the total investment of the fifth phase (2012–2020) has reached CNY90.21 billion. The planned project areas include 725 counties of 13 provinces in the Three North region and Xinjiang Production and Construction Corps. A total of 16.473 million hectares have been afforested, and 1.936 million hectares of degraded forests have been restored (*Sohu*, 2016).

[3] State Forestry Bureau, 'Introduction on the Three North Shelterbelt Project', http://www.forestry.gov.cn/portal/main/s/414/content-273078.html

For more than 40 years, the timber reserve of the project area reached 1.83 billion cubic metres, with an economic value of CNY913 billion. A total of 4.63 million hectares of forests have been created, forming several important production bases for walnut, jujube, chestnut, pepper, apple, and other fruits. The annual output of dry and fresh fruits is 48 million tonnes, and 15 million people rely on this forest and fruit industry for their livelihoods. The project area has also formed a new pattern of eco-tourism, with the forest park network as the core and the wetland and desert parks as supplements.

New forestry industries such as *Corylus heterophylla*, oil peony, and *Gleditsia sinensis* have been introduced and developed. A batch of new industrial bases have been built, such as the 666-square kilometre *Haloxylon ammodendron* forest and another 666-square kilometre *Corylus heterophylla* forest. Forest tourism, ecological convalescence, recreation, and other emerging service industries are other developments. At present, the Three-North Shelterbelt Project area receives 380 million tourists annually, and the direct tourism income is CNY48 billion (State Forestry Bureau, 2020).

4. Financing Mechanisms and Policy Tools for Climate-Adaptive Infrastructure Projects

The financing mechanisms and policy tools for climate-adaptive infrastructure projects in China are analysed in this section, based on the previous two sections.

4.1. Typical Financing Mechanisms

To finance climate-change-related projects, besides routine sources such as the central budget, commercial banks, equity financing, and domestic financial markets, the following mechanisms play an important role in leveraging multiple sources of financing and therefore enabling the projects.

(i) **Multilateral banks**. Multilateral banks are leaders of climate-impact management tools and innovation of investment and financing activities. The World Bank, Asian Development Bank, Global Environment Facility, and other institutions have experience in climate risk and benefit management of investment and financing activities, both in terms of policy tools and technical tools (CIFA, 2020).

(ii) **Bilateral development agencies.** The United Nations Framework Convention on Climate Change (UNFCCC) website provides a list of the bilateral development cooperation agencies, such as AusAid, Canadian International Development Agency, Global Climate Alliance under the European Commission, Japan Bank for International Cooperation, Japan International Cooperation Agency, and United States Aid for International Development.

(iii) **Climate funds.** Climate funds help countries adopt low-emission, climate-resilient development trajectories. They have a role in capacity building, research, piloting, and demonstrating new approaches and technologies, and removing barriers to other climate finance flows. Multilateral climate funds also hold critical political significance, reflecting developed countries' acknowledgement of historical greenhouse gas emissions, and are in line with the commitments made by developed countries under the UNFCCC to support developing countries mitigate and adapt to climate change. There are several types of climate funds currently available, such as the Green Climate Fund, Climate Investment Funds, Global Environment Facility, REDD+ funds,[4] adaptation funds, mitigation funds, and regional climate change funds.

(iv) **Clean Development Mechanism.** The Clean Development Mechanism allows a country with an emission-reduction or -limitation commitment under the Kyoto Protocol to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction credits, each equivalent to 1 tonne of carbon dioxide, which can be counted towards meeting Kyoto targets. The Sustainable Development Mechanism could become a successor of these credits under the Paris Agreement (Rashmi and Ahuja, 2019).

(v) **National carbon emission trading market mechanism.** On 18 December 2017, NDRC issued the National Carbon Emission Trading Market Construction Plan, announcing the establishment of a national carbon emission trading market in three phases. Several provinces and cities initiated local carbon emission trading markets. *The Guidance on Promoting Investment and Financing in Response to Climate Change*, which was issued by the Ministry of Ecology and Environment along with NDRC and financial market authorities in October 2020, has also emphasised a carbon emission trading system as a key pillar in China's climate-change finance. Subsequently in November 2020, the Ministry of Ecology and Environment stated that national measures for carbon emission trading were about to be officially announced so that a nationwide carbon emissions trading market could be formally established.

4.2. The Role of Policies

Kimura et al. (2016) summarised a comprehensive framework to facilitate the financing of renewable energy. In this regard, energy policies focus on addressing perceived market risks, revenue and profit risks, technological risks, and risks due to policy uncertainty, while financial policies address the availability of funds, provision of financial instruments, lowering financial costs, and improving the capacity of the financial sector, for example, in green finance. Moreover, it is highlighted that the focal points that link these policies are the business models of investment projects, financial mechanisms, as well as the energy market design. Chang, Fang, and Li (2016) counted the frequency of different policies applied in East Asia to promote the financing of renewable energy. Accordingly, policies addressing legislative uncertainty are ranked highest in prevalence, followed by policies that promote profitability, financial resource availability, market creation, and development of technologies. In China, since 2005 when the Renewable Energy Law was enacted, the government has launched a variety of policies to

[4] REDD+ refers to a process moderated by the UNFCCC that supports countries' efforts to reduce emissions from deforestation and forest degradation as well as to foster conservation, sustainable management of forests, and enhancement of forest carbon stocks. See Green Climate Fund, REDD, https://www.greenclimate.fund/redd and Climate Funds Update, https://climatefundsupdate.org

promote investment in renewable energy; China has thus become a leading country in developing renewable energy.

The financing of climate-adaptive infrastructure presents a wider scope of challenges than those in developing renewable energy. The previously mentioned *Guidance on Promoting Investment and Financing in Response to Climate Change* issued in October 2020 represents the first top-level government policy for climate-change financing in China. A total of 15 measures were put forward under five aspects, including speeding up to build investments and a financing policy system, gradually improving the climate financing standards system, encouraging investment by foreign and private investors in climate-change financing, supporting local practices in climate-change investment and financing, and deepening the climate investment and financing of international cooperation. These goals aim to create a favourable policy environment for the development of climate investment and financing by 2022, which includes promoting relevant standards and launching local pilot programmes. The major climate investment and financing targets for 2022 and 2025 and related actions proposed in the guidance are in line with the need to reach the peak ahead of schedule and to achieve carbon neutrality as announced by the government (Xinhuanet, 2020).

Climate-change finance is a component of a larger concept in China’s ecology and environment policy framework – green finance. In 2016, a consortium of government bodies, led by the People’s Bank of China, issued the *Guidelines on Building a Green Finance System*, the first document to officially define green finance in China and to announce the development plan, incentive mechanisms, and risk monitoring and regulation measures for green finance products.

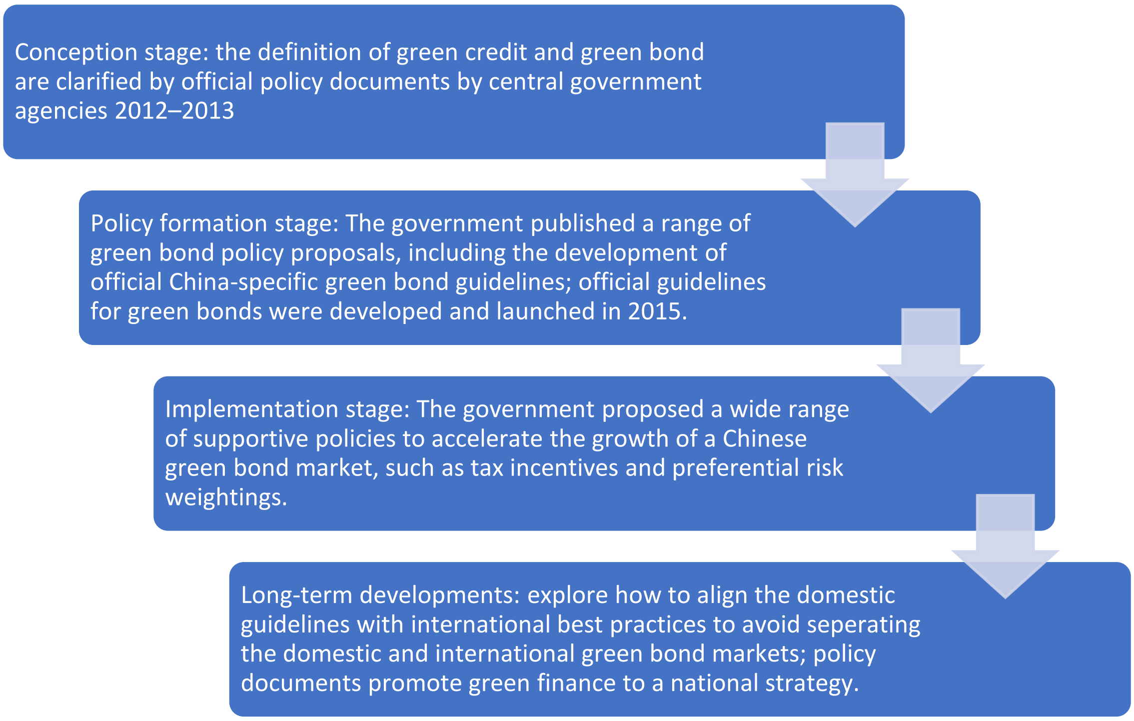
4.3. The Development of Green Finance System in China

Following the abovementioned policies, China is rapidly developing green finance and green innovation. In 2017, the State Council approved the establishment of pilot zones for green finance reform and innovations in five provinces – Guangdong, Guizhou, Jiangxi, Xinjiang, and Zhejiang. In the same year, China became the second-largest country globally in issuing green bonds, reaching $37.1 billion in value. Since then, there has been an increasing variety of issuance, covering financial bonds, corporate bonds, medium-term notes, asset-backed securities, Panda bonds, and non-public targeted debt financing instruments.

This could not have occurred without strong support from the government. In 2012, the China Banking and Insurance Regulatory Commission issued a green credit guide. The definition of a green bond was then built around the domestic definition of green credit, which was given by the China Banking Regulatory Commission in 2013. In April 2015, the Green Finance Taskforce, co-convened by the People's Bank of China and the United Nations Environment Programme, published a range of green bond policy proposals, including the development of official China-specific green bond guidelines.

At the end of 2015, the People’s Bank of China and NDRC issued green bonds. In March and April 2016, the Shanghai Stock Exchange and Shenzhen Stock Exchange issued notices on the pilot implementation of green corporate bonds and green business corporate bonds to encourage institutional investors. In the same year, *Guidance on the Construction of the Green Finance System* further promoted green finance to a national strategy. It encourages social capital to actively participate in green projects by reducing entry barriers for funding and fundraising while creating a healthy institutional environment for the development of the new sector (CIFA, 2019).

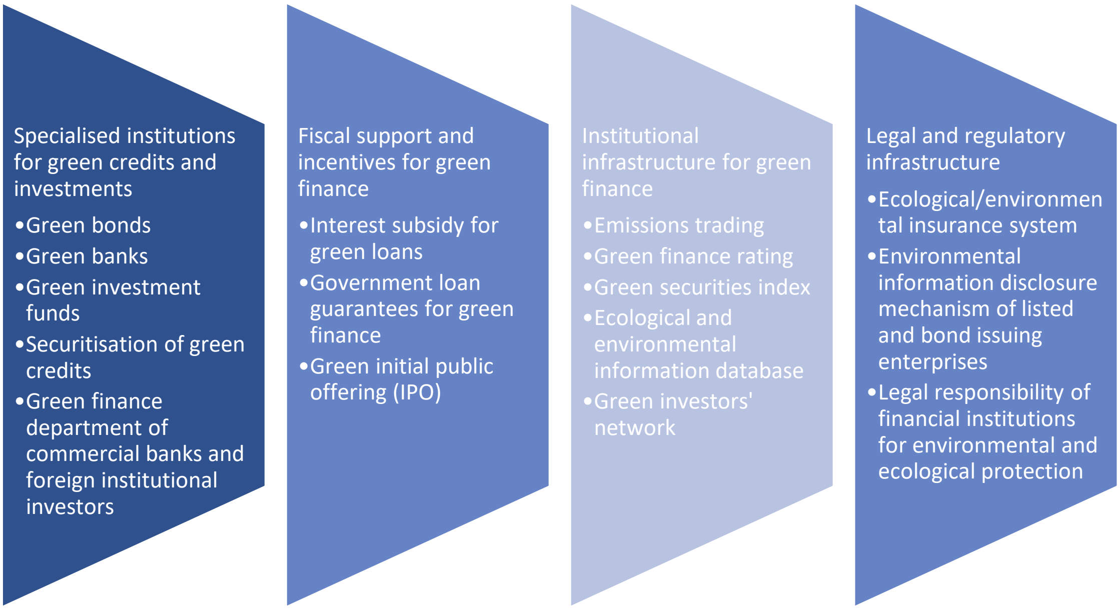
Figure 2.10. Developing a Policy Framework for Green Bonds in China



Source: Authors based on CIFA (2019).

Beyond green bonds, China established a comprehensive green finance system after 2020, supported by the issuance of corresponding legislation and regulations (Guotai Junan Securities, 2021). This system mainly consists of specialised institutions for green credit and investments, fiscal support and incentives for green finance, institutional infrastructure for green finance, and legal and regulatory infrastructure (Figure 2.11).

Figure 2.11. Green Finance System in China



Source: Authors based on People's Bank of China (2015).

In addition, in 2020, the Ministry of Ecology and Environment issued the *Guidelines on Promoting Investment and Financing in Response to Climate Change.* It clarified the definition of climate investment and financing and elaborated the specific work of promoting climate investment and financing from the aspects of a policy system, standards system, social capital, local practice, international cooperation, organisation, and implementation. This policy document also makes clear that climate investment and financing are important parts of green finance in China.

4.4. Lessons Learned

The financing of climate-adaptive infrastructure in China presents a changing landscape as new policy frameworks are being developed. The financial and fiscal sustainability of such projects are also improving accordingly.

Many of China's climate-adaptive infrastructure projects, such as the five mega-projects discussed in this chapter, started before a modern green finance system and the corresponding policy framework were well established. Therefore, the government, both at the central and local levels, played key roles in providing the necessary financing, especially before green credit guidelines were issued in 2012. The private sector was also mobilised to engage in the parts where regular commercial revenues could be generated or externalities internalised, such as in the Three Gorges Dam and the South-to-North Water Diversion projects. The remaining externalities were borne by public funds.

Additionally, state-owned companies and state-owned banks are playing increasingly larger roles in investing in climate-adaptive infrastructure projects in China. They mobilising high-revenue streams in the economically developed regions of the country to subsidise the high costs and externalities of these projects. One example is the ultra-high voltage power transmission lines built to link the renewable energy-rich western regions and energy-consuming east.

Lastly, climate-adaptive infrastructure projects, along with green energy and environmental protection projects, are moving towards market-based financing mechanisms. On the market end, more companies are aware of green financing mechanisms and facilities, such as the Clean Development Mechanism and carbon emission trading. Especially at local levels, government-backed financing vehicles and public–private partnership models are widely used in environment protection and restoration projects. Local governments typically expect returns from such investments by auctioning lands with higher economic value supported by improved environment, as well as higher tax revenue brought by the sprawl of commercially developed urban areas.

5. Conclusions and Policy Recommendations

Climate change presents China with an array of shared economic, resource, environmental, and security challenges. China is a critical player in both regional and global efforts against global warming, particularly in global climate-change mitigation and adaptation. The five projects reviewed all have created better capacity for climate-change adaptation within the country. However, new projects need to address global warming, land deterioration, and biodiversity loss, and developing countries need to scale up support for such projects in financing, technology, and capacity building.

Aside from strengthening law and policy support for green development, China is encouraging green finance for better developing climate-adaptive infrastructure, along with green technological innovations. Multilateral banks, bilateral development agencies, climate funds, Certified Emission Reduction credits and the Clean Development Mechanism, and the national carbon emission trading market mechanism play an important role in leveraging multiple sources of financing and therefore enabling associated projects.

While China aims to have carbon emissions peak before 2030 and to achieve carbon neutrality before 2060, the risks of future climate change should not be underestimated. Climate-adaptive infrastructure and its corresponding technologies should thus receive sufficient investment and financing as clean and green technologies do.

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