Chapter 1
Basic Situation of Carrying Capacity of Beijing, Tianjin, and Hebei Province and Development Countermeasures

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1.1 Research Background and Multiple Perspectives

1.1.1 Background

Globally – The contradiction between the human pursuit for a higher standard of living and the limited resources and environmental carrying capacity of the Earth is growing progressively. With the rapid development of industrialization and urbanization around the world, the development of mega-cities and metropolitan regions has become an irresistible trend. With rapid growth of urban population and rapid expansion of quantity and size of cities, resource environment of cities and regions is facing increasing pressures and serious challenges. In particular, in the context of the global climate crisis, whether development of cities and regions can adapt to the carrying capacity of resources and environment is at stake.

China – In the face of a severe situation of tight resource constraints, serious environmental pollution and ecosystem degradation, achieving sustainable development is a vital objective for its ecological civilization. After the 18th National People's Congress, promoting the construction of an ecological civilization is regarded as a priority for economic and social development to actively promote the transformation of the development mode.

Beijing-Tianjin-Hebei region – There are increasing pressures on the regional resource and environment so that we urgently need to set the foundation, and then explore the valid method to ease the pressure and to enhance carrying capacity. The "Twelfth Five-Year Plan" period is an important phase for Beijing-Tianjin-Hebei

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region to accelerate economic restructuring, industrial upgrading, and to build world-class technology innovation base, advanced manufacturing research and development transformation base, and heavy chemical industry base, and a crucial period of regional industrial integration, spatial optimization, urban and rural integration, eco-building and constructing a city agglomeration with more international competitiveness. With the mass gathering of the modern industry, especially the chemical industry, in coastal areas, the pressure of regional resource and environment is increasing; with the accelerated process of urbanization, more and more population flow into mega-cities such as Beijing and Tianjin, which has brought enormous pressure on urban transportation, resource ecology, and public services. We urgently need to make a basic judgment about the carrying capacity of Beijing-Tianjin_Hebei region, and need to explore effective methods to ease the pressure and to enhance the carrying capacity at the foundation.

1.1.2 Multiple Perspectives

In today's norm of global low-carbon development, the ecological civilization in China is regarded as an objective of sustainable development for the Chinese nation, as well as Beijing, Tianjin, and Hebei, to build eco-livable homes under the guidance of the concept of scientific development, we believe that, when researching and estimating the carrying capacity of a city or a region, and exploring the method of "decompression and increasing capacity," it is necessary to expand the field of research. We not only need to integrate a single element with carrying capacity, urban carrying capacity combined with regional, but also integrate practical carrying capacity with the potential capacity, and absolute capacity and relative capacity. These new perspectives and new understandings help us to grasp the nature, to understand the rule, to broaden our horizons, and to tap into the potential, which provide theoretical guidance for the realization of regional harmonious development between man and environment.

About the studies from carrying capacity of a single element to integrated carrying capacity. Evolution of the concept of carrying capacity experienced the development course from the community carrying capacity, the resource carrying capacity and the ecological carrying capacity to the integrated carrying capacity (See Table 1.1), because the human depends not only on the natural ecological environment, but also complex environments supported by the artificial environment system and socio-economic system. Therefore, it is necessary to expand the studies from a single-element carrying capacity to integrated carrying capacity. Integrated carrying capacity refers to the carrying capacity of a city or a region's natural resources, ecological environment, infrastructure, and social facilities for economic and social activities and urban population. It consists of the carrying capacity of the natural environment and the carrying capacity of the artificial environment, both in regards to the population and it's socio-economic activities, and are influenced and constrained by the socio-economic support system. As for today's large cities, particularly metropolitans, research on single-element natural

Table 1.1 Evolution of the concept of carrying capacity

Name	Background	Meaning
Community carrying capacity	Ecology development	Bearable quantity of ecosystem for communities living in it
Land carrying capacity	Population expansion, shortage of land resources	Productive capacity of land resources in a region, as well as bearable population under certain conditions
Carrying capacity of water, minerals and other resources	Shortage of water, minerals and other resources, population growth, surge in industrial water	Bearable population of water and other natural resources in a region, bearable strength of industrial and agricultural production activities of water and other natural resources in a region
Carrying capacity of environment	Environmental pollution	Holding capacity of regional environmental for pollutants, bearable strength of a regional environmental for human development activities
Carrying capacity of ecology	The integrity of ecosystem damages, functions reduces	Bearable maximum socio-economic activity strength or interference limit of ecosystem
Complex carrying capacity	"Urban disease" of mega-cities	Natural resources and environment, economic and social resources and environment form a complex, multi-level ecosystem; and "human-land system" are opposites

Source: The table is compiled on the basis of precursors' research findings

carrying capacity is clearly not enough. For example, a storm in Beijing on July 21, 2012 exposed the vulnerability and weakness of the urban infrastructure in Beijing – the limit of the carrying capacity of the underground pipe network, which warns us about the city security. Only when perspectives of research expand from the natural carrying capacity to a comprehensive one can our vision, means, and methods to find and solve problems be wider and more in line with the actual development.

About the studies of the carrying capacities from cities to regions. We paid more attention to studies on carrying capacity of a single city in the past, which was necessary at the early stage of single city development. But at the present day of economic globalization and regional economic integration, global resource allocation has changed, and any city is a component part of the urban system in the world, and a highly open system. A city owns limited resources, but through opening to the outside world and exchange, it can obtain and share resources from other regions to achieve sustainable development. Particularly like the capital Beijing, the ultra-mega-city with a population over ten million where it is difficult to bear the burden of its resources and ecological environment, it really needs to have wide regional visual field, and needs to put urban development in a larger region. It is possible for the pressure of a city to be mitigated in a larger region; it is expected that its own “short board” of resources and environment can be extended in a region; it is possible for surrounding areas, with its own resource advantages, to become its resources through functions complementation.

About studies from absolute carrying capacity to relative capacity. The relative carrying capacity can be studied through setting targets of carrying capacity and looking at the relationship between supply and demand of carrying capacity. In the same conditions of resource ecological environment and socio-economic and technology, relative to the different standards of per capita consumption and given life goals, different resources and environments bear different population sizes. “The maximum number of people the earth can support” is very different from “the maximum quality for the people on earth.” The former only meets the basic standard of existence, and the latter meets the ideal or optimal goal, such as wealth and environmental livability, and so on. Similarly, from the point of view of supply and demand of resources and environment, the smaller the population size and economic and social activities as carrying objects are, the smaller the fixed carrying pressure of resources and environment is, the stronger the relative carrying capacity is.

About the studies from practical carrying capacity to potential capacity. Practical carrying capacity can be measured according to the “Barrel Theory.” If the amount of water in the barrel depends on the shortest slab of the barrel, practical carrying capacity of cities or regions is measured by a minimum practical carrying capacity in individual resources and development conditions, and potential capacity can be obtained through change of impact factors, remedy of the “short board” and then upgrade urban integrated carrying capacity. In fact, there is potential carrying capacity in real life. For instance, through technological progress and efficient use of land, the original land carrying capacity for the population can be greatly improved. If analysis and measure of practical carrying capacity of cities or regions are the important prerequisite to grasp the current status and trends and to find the “short board” of carrying capacity, it is more important for us to attach importance to the studies of potential carrying capacity. We can discover, explore and release potential carrying capacity through analysis of various influencing factors of carrying capacity of resources and environment, and can find an effective way to solve the difficult problems, to break through bottlenecks, to mitigate the pressure, and to improve the carrying capacity.

1.2 Analysis Framework and Indicators to Measure

1.2.1 Theoretical Basis

Mechanics theory – the mechanics theories involved in the studies on carrying capacity include theories of statics in classical mechanics, structural mechanics, fluid mechanics, mechanics of materials, soil mechanics, and rock mechanics, and other sub-disciplines. Among them, the statics mainly concerns how to set up equilibrium conditions of various systems of forces in the system under static conditions. Structural mechanics mainly solves the law of stress and transmission of carrying structural system, as well as how to optimize the existing carrying structure. Fluid dynamics mainly focuses on the law of motion of comprehensive carrying factor in variable conditions.

Ecological theory – ecology is the science of the relationships between organisms and their environments. Its development has manifested three main characteristics: from qualitative studies to quantitative studies, from individual ecological systems to complex ecological systems, and from basic science to applied science. The basic theories about ecology include biological environment, ecological factors, the succession of biotic communities and the ecological system theory.

Economic theory – the application of economic theories in the carrying capacity is mainly manifested in the application of the bifurcation theory in economics including development economics, regional economics, population economics, and environmental economics. Many environmental problems can be described by economic terms, such as allocation of scarce resources, allocation of risks and benefits, competitive benefits, and so on, as well as a lot of environmental damage is also due to economic factors. The economic theory is applied to study the carrying capacity mainly to solve how scarce resource environments and artificial environments achieve the optimum allocation and effective utilization in the development process of cities or regions, and how economy, society and ecology achieve their harmonious development.

Sociological theory – sociology is strongly integrated humanities, is concerned with systems, groups, psychology, security, and structure of human society. The sociological theory is applied in studies on carrying capacity to mainly discover characteristics of social activities of regional social groups, such as behaviors, norms, practices, psychology, and structure and the intrinsic mechanism of influencing the carrying capacity, and effective ways to settle how to mitigate the pressure through changes of influencing factors, such as advances in science and technology, lifestyle, values, social systems, to enhance the carrying capacity.

1.2.2 Analytical Framework

This paper argues that, theoretical analytical framework of integrated carrying capacity of a city or region can consist of carrying objects, the carrier, and external environment. Carrying objects mainly include population size, consumer pressure, human socio-economic activities, and pollutants. The carrier consists of two parts, the carrying capacity of the natural environment and of the artificial environment. Carrying capacity of the natural environment consists of the natural resources system and eco-environmental system; the system of natural resources includes land resources, water resources, mineral resources, and forest resources; eco-environmental system includes air, water, soil, and biological species. Carrying

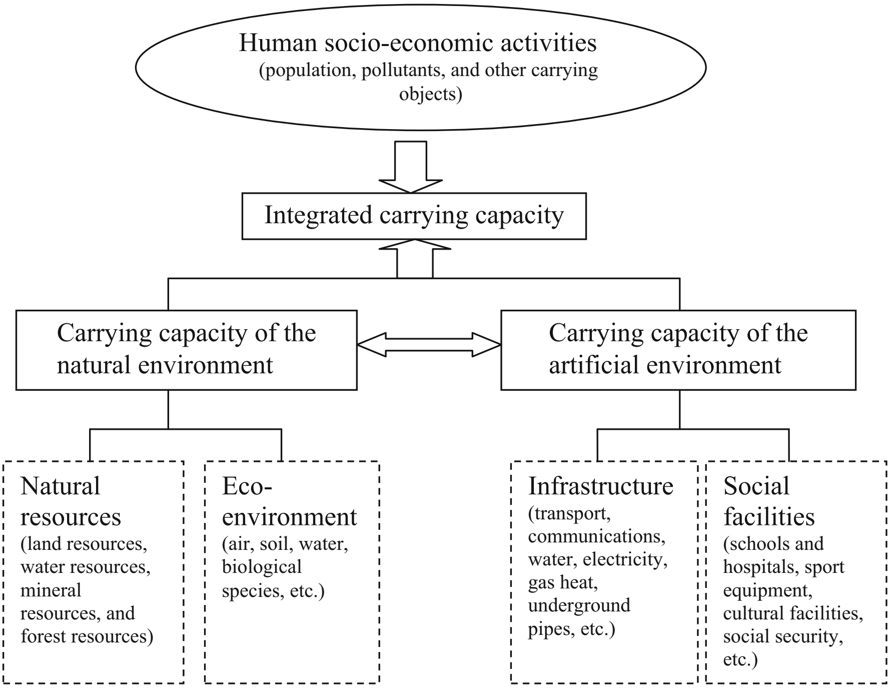

Fig. 1.1 Structure of integrated carrying capacity

capacity of artificial environment consists of infrastructure (such as transport, communications, water, electricity, gas heat, underground pipes, etc.) and social facilities (such as the facilities of science, education and culture and health, including schools and hospitals, public services, social security, etc.). The external environment is the economic and social support system. Whether the carrying capacity of natural environment is the first environmental carrying capacity and the carrying capacity of artificial environment is the second one, all are in economic and social development conditions and environments, and are influenced and constrained by economic hard factors (such as GDP, per capita GDP, financial revenues, etc.) and social soft environment (such as system, culture, management, etc.). See Figs. 1.1 and 1.2.

1.2.3 Interrelation

First one is the relationship of carry and carried and of action and reaction between the carrying capacity of natural environment and the carrying capacity of artificial environment within the carrier. The carrying capacity of the natural environment is also called the first environmental carrier, is the basis of sustainable development of

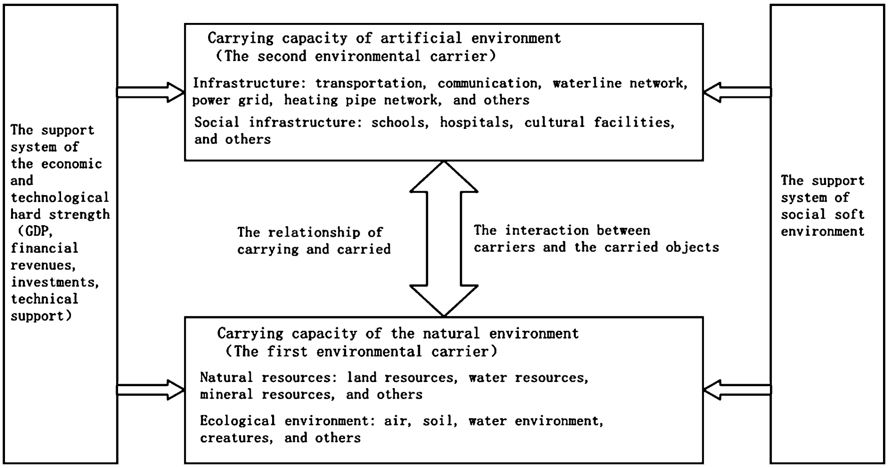

Fig. 1.2 The relationship between carrying capacity and social and economic support system

cities and regions, and it decides the direction, scale, and speed of human activities. The carrying capacity of artificial environment is also called the second environmental carrier, is the indispensable carrier for the normal operation of the human economic and social activities. Carrying capacity of artificial environment has carrying capacity for carrying objects (such as population size, consumer pressure, pollutants, and human socio-economic activities), and has some pressure on the carrying capacity of the natural environment; it is restricted and influenced by the carrying capacity of the natural environment, and its development reacts to the carrying capacity of the natural environment and human economic and social activities.

Second one is the interaction between carriers and the carried objects. Natural and artificial environmental carrying capacities together compose the integrated carrying capacity of a city or region, and jointly support cities, regions, countries, their population, and their socio-economic activities. The carrier and carried objects actually have a supply and demand relationship. The basic path of harmonious development between carrier and the carried object can be found through enhancing the carrying capacity and alleviating the pressure.

Third one is the interaction between the carrier and the external environment. Both the carrying capacity of the natural environment and the carrying capacity of artificial environment is influenced and constrained by it. They are both dependent on the economic and social support system, and are influenced and constrained by the economic and technological hard strength (such as GDP, financial revenues, investments, technical support, etc.) and the social soft environment (such as systems, culture, management, etc.). In general, the stronger the economic strength of a city or region is, the stronger the carrying capacity of the artificial environment. The higher the level of social development is, the stronger the people's consciousness of protecting the environment and energy conservation, and the lower the resource consumption and the environmental pollution.

1.2.4 Indicators to Measure

Integrated carrying capacity of a city or region is composed of a series of self-checks and corresponding development variables and constraint variables: (1) Natural resource environment variables: type, quantity and development capacity of land resources, water resources, mineral resources, and biological resources, as well as self-purification capacity of water, gas, and soil; (2) Artificial environment variables: transportation, communications, and underground pipe network, and other infrastructure variables; school, hospital, social welfare, public service facilities, and social facility variables; (3) Variables of economic and social conditions: population, per capita GDP, per capita disposable income and other economic variables, as well as education of science and technology, system management, cultural awareness and other social variables. If the objects we study are the first two variables, the carrying capacity, the variable of economic and social conditions is an indispensable factor to influence the carrying capacity. This study focuses on six elements of carrying capacity, namely land, water resource, ecological environment, population (object carried), transportation, and other infrastructure, social facilities such as science, education, culture and health, as well as economic and social influencing factors. This study regards the above three variables, namely natural resource environment variable, artificial environment variable, and variable of economic and social conditions as the Level-I indicators, regards the six factors focused on as Level-II indicators, and respectively selects some indicators that can reflect the development variables (namely supply support) and constraint variables (demand pressure) as Level-III indicators, so as to compose the measuring indicator system of integrated carrying capacity. See Table 1.2.

1.3 Analysis of the "Short Blab" of Carrying Capacity in Beijing, Tianjin and Hebei

This study has respectively made empirical analysis to land, population, water resources, ecological environment, infrastructure and social facilities of Beijing, Tianjin and Hebei, and integrated carrying capacity analysis of Beijing, Tianjin and Hebei using integrated carrying capacity evaluating indicators, and has found that the carrying capacity of Beijing, Tianjin and Hebei follows the "short board," which urgently needs to be resolved.

Table 1.2 Evaluating indicator system of integrated carrying capacity of cities and regions

Level-I indicators	Level-II indicators	Indicators of reflecting supply and demand	Level-III indicators	Measurement unit
Carrying capacity of natural resource environment	Carrying capacity of land	Pressure	Population density	Person/sq.km.
			Per capita residential land area	sq.m./person
			Per capita industrial land area	sq.m./person
			Per capita dwelling space	sq.m.
			Land area required GDP per hundred million RMB	sq.km./a hundred million RMB
			Per capita area of land used for building	sq.m./person
		Supporting capacity	Regional land area	sq.km.
			Per capita built-up area	sq.m./person
			Per capita arable area	sq.m./person
			Proportion of unused land	%
			Per capita land area	sq.km./person
			Building floor area ratio	
	Carrying capacity of water resources	Pressure	Per capita water consumption	cu. m./person
			Water consumption of farmland per Mu	cu. m./Mu
			Unit GDP water consumption	cu. m./Mu
		Supporting capacity	Per capita fresh water resources	cu. m./person
			Annual rainfall-water resources	A hundred million cu. m.
	Carrying capacity of eco-environment and energy sources	Pressure	Annual per capita domestic refuse discharge	kg./person year
			Water consumption of ten thousand RMB GDP	cu. m./ten thousand RMB
			Unit GDP energy consumption	ton/ten thousand RMB GDP
			Non-fossil energy proportion	%
		Carrying capacity	Per capita green area	sq.m.
			Built-up area green area percentage of coverage	%
			Percentage of treatment of domestic sewage	%
			Percentage of waste innocent treatment	%

(continued)

Table 1.2 (continued)

Level-I indicators	Level-II indicators	Indicators of reflecting supply and demand	Level-III indicators	Measurement unit
			Percentage of number of good days of city zone at level-II air quality above	%
			Proportion of self-generated energy in current drain (%)	cu. m./person
			Proportion of environment treatment investment in GDP	%
Carrying capacity of artificial environment	Carrying capacity of infrastructure	Pressure	Gross volume of passenger traffic	Ten thousand person-times/year
			Gross freight amount	Ten thousand ton/year
			Unit GDP annual gross freight amount	ton/ten thousand RMB
			Unit area traffic flow	Vehicle/ha.
			Quantity of cars per hundred households	Vehicle/hundred household
			Illegal road use rate of vehicles	%
		Supporting capacity	Urban per capita valid traffic land use area	sq.m./person
			City zone underground mileage density	km/sq.km.
			Car park area density	km^2/sq.km.
			Per capita overall railway mileage	km./ten thousand persons
			Per capita overall highway mileage	km./ten thousand persons
			Urban ponding space density	M^3/sq.km.
			Percentage of urban ponding domain coverage	%
			Urban drainpipe density	km./sq.km.
	Carrying capacity of social facilities	Pressure	Number of students in general colleges and universities	Ten thousand persons
			Proportion of aged population in total population	%
			Percentage of social security coverage	%

(continued)

Table 1.2 (continued)

Level-I indicators	Level-II indicators	Indicators of reflecting supply and demand	Level-III indicators	Measurement unit
		Supporting capacity	Per land employed population and job vacancy	Person/ha.
			Sickbed amount per ten thousand persons	Piece/ten thousand persons
			Number of qualified doctor and nurses per thousand population	Person/thou-sand persons
			Possible quantity sup-plied 9-year compul-sory education	Ten thousand persons
Economic and social support system	Economic hard strength and social soft environment	Influencing factors	Population size	Ten thousand persons
			Gross GDP	A hundred million RMB
			Per capita GDP	Ten thousand RMB/person
			Per capita disposable financial revenue	Ten thousand RMB/person
			Gross investment in fixed assets	Hundred mil-lion RMB
			Proportion of R&D funds in GDP	%
			Number of doctors per thousand person	Ten thousand persons
			Proportion of job-age population in total population	%
			Number of jobholder at end of the year	Ten thousand persons
			Proportion of employed population in total population	%
			Number of college stu-dents in per hundred thousand persons	Person
			Number of technolo-gists in ten thousand persons	Person
			Per capita educated fixed number of year	Year
			Annual quantity applied and approved for patents or inventions	Piece

1.3.1 Water Resource Has Become the Biggest "Short Board"

Beijing, Tianjin and Hebei belong to "resource-based" water shortage areas, where per capita water resource is far below the severe water shortage standard accepted internationally. According to findings of research fellow Shi Minjun of the Chinese Academy of Sciences (see the 5th monographic study in this book), Beijing's total water resources was 2.681 billion m^3 in 2011, in accordance with the 20.19 million resident population at the end of 2011, adding about 2.4 million in floating population, per capita share of water resource in Beijing was only 119 m^3, which is far below the severe water shortage standard per capita share of water resources 500–1,000 m^2. (Beijing Municipal Bureau of Water Affairs, 2011). Tianjin's per capita shares of water resources was only 116 m^3. Water resource in most of the municipal districts of Hebei province also faces shortage, and per capita share of water resources is below the severe water shortage international standard. See Fig. 1.3.

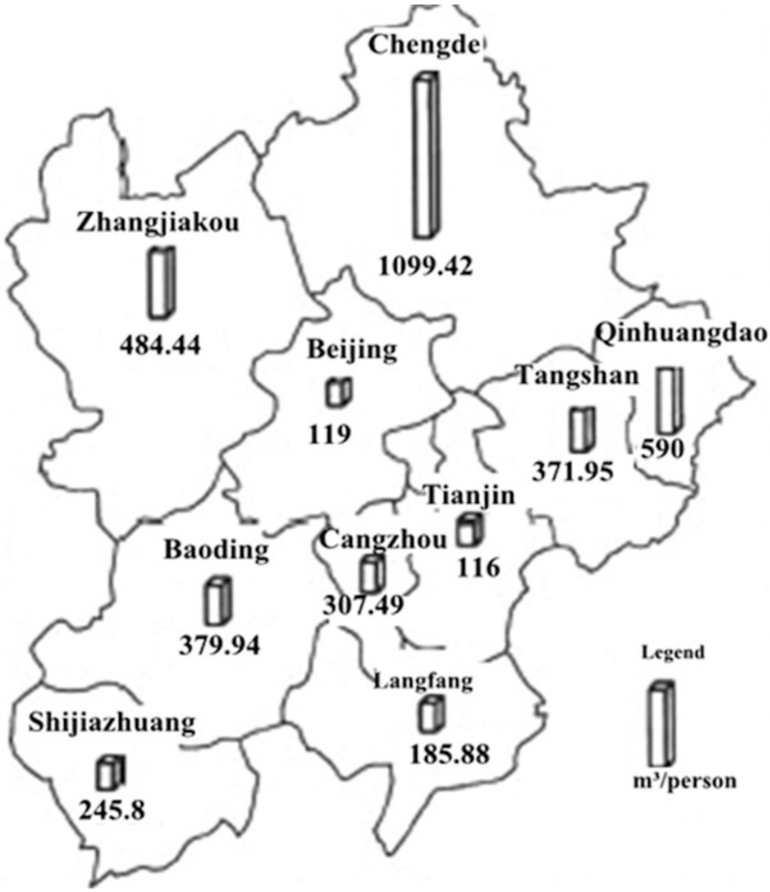

Fig. 1.3 Water resources per Capita in Beijing, Tianjin and Hebei

Water resources in Beijing, Tianjin and Hebei have "two gaps": one is the gap between local water resources and actual water supply volume; another is the gap between actual water supply volume and the actual water demand. The former is mainly made up through interregional water diversion and groundwater overflow; the latter is mainly solved through net inflow of virtual water outside the region. From the perspective of supply, Beijing's average amount of water resources was 2.3 billion m^3 for many years, but total amount of water consumption in recent years is about 3.5 billion m^3, in which the gap of water utilization is about 1.2 billion m^3; Tianjin's amount of water resources was about 1.2 billion m^3 on average, water consumption is about 2.3 billion m^3 in recent years, in which water shortage is about 1.1 billion m^3, and the gap is made up mainly through groundwater overflow and water transfer from neighboring provinces. From the perspective of demand, water consumption of a region actually consists of two parts: one is from "visible" water resources, local water resources, and interregional water diversion; another is the flow of "invisible" virtual water from inter-regional trade in goods and services. Some experts characterize actual demand for water with water footprint. The water footprint of Beijing was 5.748 billion m^3 2007, and 3.152 billion m^3 in Tianjin, in which local amount of water resources was less than half of the water footprint, and actual supply of water was less than the water footprint (water demand). The gap was made up mainly through the net inflow of virtual water from outside the region.

Existing population size of both Beijing and Tianjin has been severely more than the supportable reasonable scale of local water resources. Beijing's per capita demand of water resources is about 345 m^3, and Tianjin's per capita demand of water resources is about 279 m^3. From this calculation, Beijing's local water resources can only support 6.67 million people, which is equivalent to 40 % of the existing population scale; water resources of actual water supply can support about ten million people, which is equivalent to 60 % of the existing population scale; Tianjin's local water resources can only support 4.31 million people, which is equivalent to 38 % of the existing population scale; water resources of actual water supply can support about 8.39 million people, which is equivalent to 74 % of the existing population scale. This shows that the local amount of water resources in Beijing-Tianjin-Hebei is difficult to support water demand of existing population size and economic and social development.

Although total amount of water resources in Beijing, Tianjin, and Hebei increased, and water consumption slightly reduced in recent years, there is still a serious situation of the groundwater overdraft. According to findings of Professor Wu Yiqing et al. (see the fourth special report in this book), in total water consumption in Beijing-Tianjin-Hebei region, groundwater accounted for 78.47 %, water consumption for agriculture accounted for 71.49 %, 14.55 % for industry, and 18.36 % for domestic water. Relative to average volume of water resources for many years, water resources in Beijing, Tianjin and Hebei region since 2006 have showed an increasing trend due to the growth in volume of rainwater resources, actual water consumption also showed signs of decrease due to structural adjustment and water and energy conservation and other measures, but there is serious groundwater overdraft so that the groundwater depth has increased. According to the data from “Monthly Report on Groundwater Regime in the Plain Terrain of North China” issued by the Ministry of Water Resources in early July 2012, groundwater depth in most of the plain terrain of Beijing was 12–50 m, 1–8 m in Tianjin, on average 12–50 m in Baoding and Shijiazhuang areas of Hebei, and more than 50 m in some parts. In comparison with the same period in 2011, most groundwater depth increased, and groundwater reserves reduced.

1.3.2 Atmospheric Pollution and the Water Environment Has Become an “Achilles Heel”

Ongoing fog and haze exposed a serious problem of air pollution in Beijing, Tianjin, and Hebei. In early 2013, in regions that continuously suffered serious haze and fog, as a result of severe air pollution, the most serious situation was in the Beijing-Tianjin-Hebei region; Beijing, Shijiazhuang, Baoding, Handan, Tianjin, Cangzhou, Langfang, Tangshan, and other cities all issued heavy fog orange warning. Increase of fog and haze reflects worsen air quality and an aggravating hazard.

Urban surface water and groundwater sources are polluted in varying degrees, and the carrying capacity of water to the pollution is close to limit. On one hand, Beijing, Tianjin, and Hebei lack freshwater resources, on the other hand, the water quality worsens because urban surface water and groundwater sources are polluted in varying degrees; some reservoirs have had a phenomena of eutrophication, and show an increasing trend; the number of aquatic animals has obviously decreased in big basins. Because construction of the sewage plants and associated pipelines lag behind, carrying capacity of water body to the pollution is close to limit.

Rapid expansion of the population has largely increased domestic waste of big cities so that “garbage encircles a city.” Taking Beijing as an example, in 2009, the city’s domestic waste reached 6.69 million tons, and produced 18,300 t every day, but the city’s waste treatment capacity is only 12,700 t/day, in which there is a large gap. The main reason is low level of waste reutilization, insufficient recycling, and unreasonable waste treatment structure (mainly landfill, incineration, and very low percentage of biochemical treatment) in Beijing. According to present waste output and landfill speed, most of the city’s landfills will be filled in 4–5 years.

Soil erosion, desertification, sandstorm, and ecological degradation coexist. With the accelerated pace of population expansion in recent years, the natural environment in the Beijing-Tianjin-Hebei region sharply worsens. Soil erosion mainly occurs in east Taihang Mountain and Yanshan Mountain in the west and north and windy weather in North Hebei province largely influences Beijing and Tianjin because resource-depletion development mode of excessive land reclamation and overgrazing have resulted in serious damage of grassland and vegetation, and the natural environment has been caught in a vicious circle. Some industry-dominated urban "ecological overshoot" produce a lot of wastewater, waste gas, and solid waste emissions due to rapid industrial development, resulting in air pollution, and environmental degradation, which damages the ecosystem.

Development of the regional ecological carrying capacity is unbalanced, and Hebei's eco-environment basis is fragile. Beijing's green ecological construction started early, with a high starting point and fast development, and has upgraded from the pursuit of "green" to "beautiful"; Tianjin has good economic base and a large wetland, which has obvious ecological environment advantage; in contrast, Hebei province has obvious gap in green ecological construction due to poor economic strength, such as a low overall green level, insufficient total forest resources, unbalanced distribution, and low quality; there is a large area of sandy land and soil erosion, sharp reduced wetland area, and greatly depressed ecological role of wetland. Beijing and Tianjin also have the same problem.

1.3.3 Overload of Urban Traffic Carrying Capacity, Arduous Mission of Flood Control and Disaster Reduction

Traffic jams have become an outstanding problem that affects the city operating efficiency and the livelihood of residents in Beijing. Due to an excessive concentration of functions in Beijing, "imbalance between vocation and living" causes huge traffic pressures in downtown and tidal traffic flow is obvious. In addition to huge population density, rapid growth of motor vehicle ownership, high convergence of functional zones, unbalanced development of north and south city zones, excessive concentration of good public resources such as schools and hospitals, etc. and large coefficient of variation between vocation and living, low rail traffic density, limited capacity of tridimensional high-speed roads, chaotic parking of non- moving vehicles and random occupancy and use of roads also contribute to traffic jams in Beijing.

The carrying capacity of traffic infrastructure has been severely overloaded in Beijing, and carrying capacity of transit traffic has been saturated. If you simply compare the carrying capacity of traffic infrastructure, then the three metropolitan areas in China, Beijing, Tianjin, and Hebei are ranked first, and Beijing is ranked first in the Beijing-Tianjin-Hebei region, but relative to demand pressures of traffic facilities, Beijing's traffic carrying capacity is seriously overloaded. Motor vehicle ownership has grown rapidly since 2000, peak hour traffic of motor vehicles has seriously surpassed the carrying capacity of urban roads, and transit traffic carrying capacity has been saturated. See Fig. 1.4.

Urban water storage space is limited, drainage facilities have hidden trouble, and flood control and disaster reduction tasks are arduous. A city's major disasters include flood, fire, forest fire, mudslide, earthquake, stampede, pollution exposure, and so on. Beijing's "July 21 flood" in 2012 exposed the limited water storage space in the city, and vulnerable drainage facilities have become the bottleneck affecting urban security.

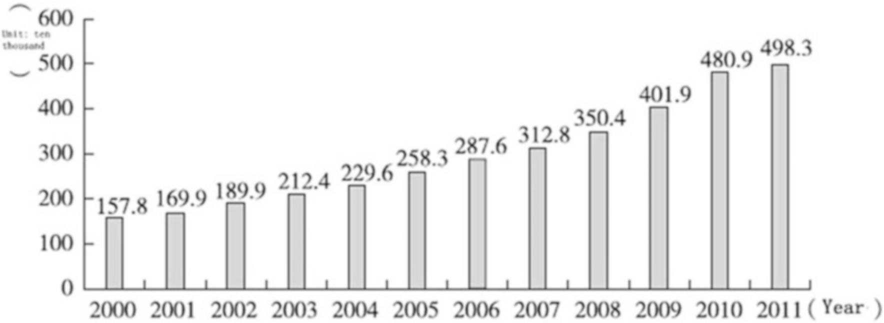

Fig. 1.4 Growth trend of motor vehicle possession (unit: ten thousand)

1.3.4 Continued Increase in Population Size and Aging Structure, Increased Pressures of Public Services and Social Security

Immigration to the megacities continues to increase. Through comprehensive survey to the data in the recent ten years, we discover that, natural population growth was slow in Beijing-Tianjin-Hebei region, natural growth rate of population in Beijing and Tianjin was less than 4 %, and less than 7 % in Hebei province. The immigration increase in Tianjin and Beijing areas is the main reason to the population growth in Beijing-Tianjin-Hebei region. According to future population prediction in Beijing, Tianjin and Hebei by Professor Zhang Yaojun, Renmin University of China (See the second special report in this book), Beijing's net immigration growth is maintained around 500,000 since 2006, assuming that Beijing's net immigration size keeps constant (500,000) every year or continuously increases (calculating by 700,000) in 2010–2020, Beijing's population will be 25.06 million and 26.18 million respectively in 2020. Similarly in Tianjin, Tianjin's net immigration was on average 513,000 each year in 2006–2009, assuming that Tianjin's net immigration size is maintained at 500,000 in 2010–2020 each year or continuously increases (calculating by 700,000), Tianjin's population will be 19.36 million and 19.45 respectively in 2020. By 2020, total population in Beijing-Tianjin-Hebei region will be from 116.8 million and 121.37 million. If considering possible-satisfaction, the following results may appear: if possible-satisfaction is 0.6, considering various indicators (including economy, society, natural resources, etc.) that affect population can be met synchronously, the population carrying capacity in Beijing, Tianjin and Hebei region will be 86.2 million people in 2015; considering mutual compensation in internal factors, the population carrying capacity in Beijing, Tianjin, and Hebei region will be 98.07 million people; considering mutual compensation between all elements, the carrying capacity of population in Beijing-Tianjin-Hebei region will be 101.83 million. But total population reached 104 million in Beijing-Tianjin-Hebei region in 2010, therefore population size has overloaded.

Population structure is aging. Through analysis of the regional population structure, percentage of job-age population in Beijing-Tianjin-Hebei region has dropped from 77 % in 2010 to 73 % or 72 % in 2020, the population of children and juveniles (0–14 years old) and aging population (65 years old and over) are a growing trend, which shows increasingly serious aging because the growth of the aging population is significantly faster than the growth of children and juveniles.

The pressure of public services and social security is increasing. Although the job-age population proportion drops in Beijing, Tianjin and Hebei region, absolute number of labors is sufficient since most immigration to Beijing and Tianjin is job-age young adults. It is estimated that, by 2020, labor supply in Beijing-Tianjin-Hebei region will be 84.73–87.94 million, which indicates that Beijing and Tianjin can still enjoy labor bonus over a period under the background of China's accelerated urbanization and transfer of a large number of farmers from rural area to urban area. On the one hand, the labor supply maintains sufficiency in Beijing-Tianjin-Hebei region, and the employment situation remains severe, on the other hand, aging is intensifying, and the pressure of public services and social security is increasing. Therefore, solving the issues of employment in the working population and "age before it gets rich" has become a key part of future development in Beijing-Tianjin-Hebei region.

1.3.5 Tension in Urban Land Space Grows, and the Conflict Between Land Used for Building and Basic Farmland Protection Becomes Sharp

Population density of mega-cities continuously increases so that the contradiction between people and land has become increasingly prominent. In 2011, resident population reached 20.186 million in Beijing, and population density increased from 766 persons/km^2 in 1999 to 1230 persons/km^2 in 2011; continuous decrease of per capita land use area and per capita area of land used for building reflects continuous increase of population bearing pressure of land resources in Beijing. See Fig. 1.5.

The conflict between land used for building and basic farmland protection becomes sharp. With social and economic development and the advancement of urbanization, the strength of land development and construction is growing. As shown in Fig. 1.6, the proportion of Beijing's area of land used for building in total area is on average increasing by 0.4 % every year, but per capita tillable field is continuously reducing. Beijing has extensive mountainous areas, and land used for ecological purpose has big demand, therefore, potential land resources have been very limited.

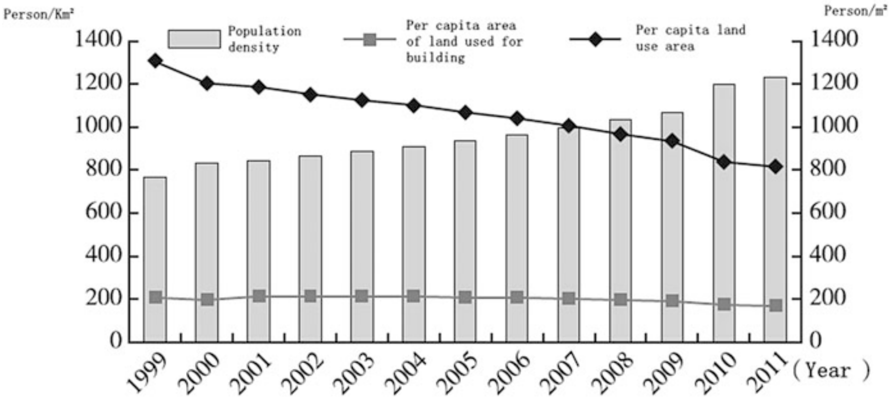

Fig. 1.5 Population density and growth of tension in urban land space of Beijing from 1999 to 2011

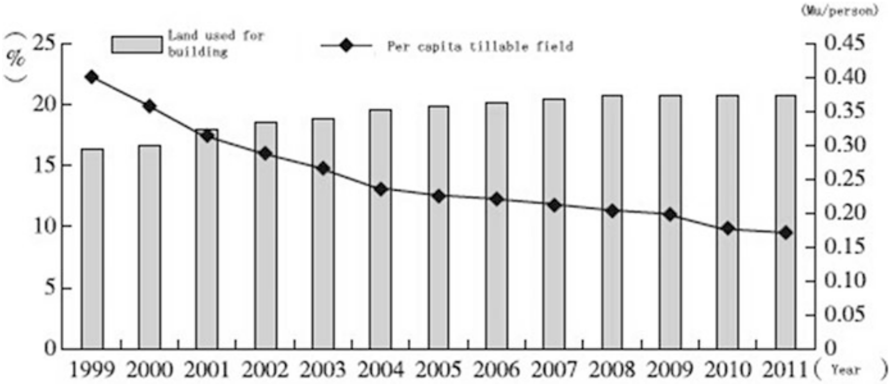

Fig. 1.6 Proportion of Beijing's area of land for building in total area (per capita)

Land resources in Hebei province have still bigger potential for development. Hebei's total land area is 187,693 km^2. Though Hebei's population density also continuously increased from 328 persons/km^2 in 1990 to 386 persons/km^2 in 2011, and per capita land use area also constantly declined from 3,047 m^2/person in 1990 to 2,592 m^2/person in 2011, in comparison with Beijing and Tianjin, its population density is relative smaller, per capita land use area is relative larger, and its land resources has still bigger potential for development (See Fig. 1.7).

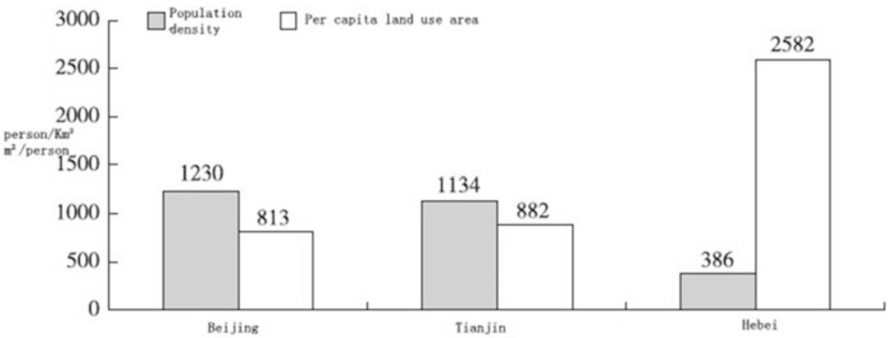

Fig. 1.7 Population density and land use per Capita in Beijing, Tianjin and Hebei

1.4 Methods and Countermeasures of Improving the Carrying Capacity of Beijing-Tianjin-Hebei Region

1.4.1 General Thought: Exploring the Ways Around "Energy Increase and Pressure Reduction"

As evident in our analysis above, carrying capacity of any city or region is subject to the influence of supply supporting capacity and demand pressures. By some measures, reducing pressures on demand means relative enhancement of supply supporting capacity. We can start from both supply and demand of carrying capacity to explore the valid ways of energy increase and pressure reduction. We can enhance the regional carrying capacity through many ways, including improve performance and efficiency by tapping into the latent power through progress of science and technology, by making up the investment in the short board, by regional complementary capacity expansion, and by opening the region wider to the outside world and energy gathering; we can also mitigate the pressure on resource and environment through mitigation of city functions, transformation of the development mode, optimization of space layout, and improvement of management level (See Fig. 1.8).

1.4.2 Fundamental Ways: Optimizing Urban Spatial Layout, Building a Low-Carbon, Ecological and Green House

To give priority to advancing urbanization, speeding up construction of new cities, and building scientific and rational pattern of urbanization that big, medium, and small cities coexist and interact. Practices and development of big cities domestically and abroad prove that excessive expansion of big city size and excessive

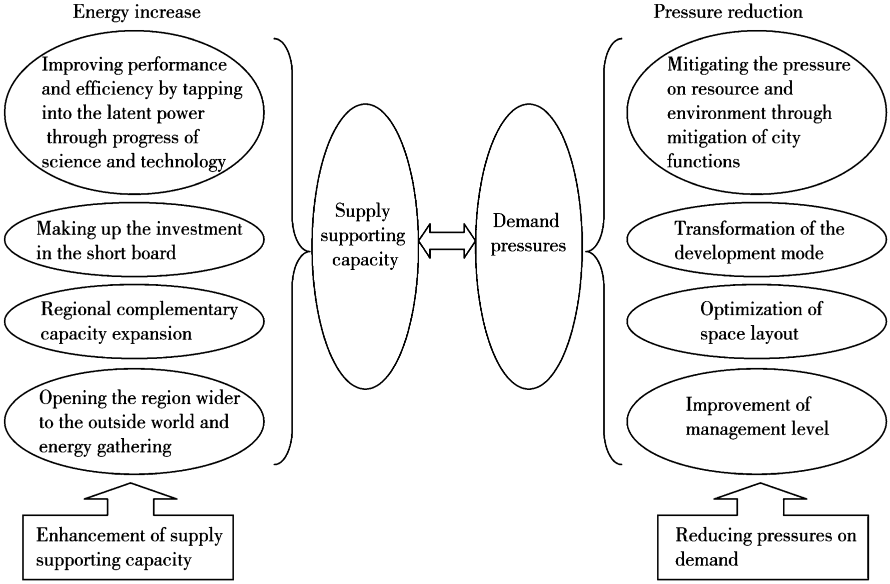

Fig. 1.8 Regional carrying capacity's influence of supply supporting capacity and demand pressures

concentration of urban functions can result in "big city disease" including traffic jam, environmental degradation, tight housing and excessive pressure of public services, and so on, thus the bearing pressure of central cities is generally mitigated through construction of new cities domestically and abroad. For actual development of Beijing-Tianjin-Hebei region, on the premise of scientific planning, in the course of promoting strategy of country principal function area and regional integration, the construction of small cities and towns should be actively promoted, particularly construction of new cities around metropolis and development of medium and small cities should be sped up to strengthen their industrial development, public services, employment attraction, and population aggregation function. In this way, chaotic spread of the center city can be effectively restrained, some functions of the center city zone can be promoted and organically dispersed, and big cities' bearing pressure on resource environment would be mitigated; in the process of industrial transfer and upgrading, core status of center cities can be further strengthened, peripheral new cities and medium and small cities can be cultivated into multiple growth poles to drive economic and social development of the entire region through convergence, proliferation, and linkage effect of growth poles; spatial structure can be further optimized to promote intensive and high efficiency of production space, and livable moderate life space and beautiful eco-space according to the principles of balanced population resources and environment and the integration of economic and social ecological benefits. Thus more repair spaces can be left to nature, and a beautiful home of blue sky, green land, and clear water can be left to posterity.

To change the way of development, to develop a circular economy, and to build low-carbon, ecological, green houses. Changing the way of development and building a resource-saving and environment-friendly society are fundamental safeguards and radical prerequisite to achieve low-carbon, green, recycling, and sustainable development. Changing the way of development must start from the intensive use of land, and highly efficient use of water resources and energy. Although there is severe shortage of water in Beijing, Tianjin, and Hebei region, there is still untapped potential. According to the principle of economical use, optimum utilization of good quality water and recycle, we should achieve joint operation and optimizing regulation of water sources. The intensive use of land should be to guide rational distribution of industry and population based on regional differences of the intensity of land development, including insisting on industrial agglomeration, concentration of layout and highly effective utilization; full utilization of advantages of old town location and society, tapping land-use potential of old city zones, enhancing economic viability and land carrying capacity in old cities; at the same time, paying attention to the intensive utilization of new city land, and considering more economic use of land resources through the approach of "fertile backfill." By undertaking functions of central area, scientific planning and layout, improving public services, and so on, the attractiveness of new cities may be further enhanced. Development of a circular economy is to make comprehensive utilization of waste produced as a resource in accordance with the principles of "reduction, reuse, recycle" to achieve waste reduction, recycle, and harmlessness. In the social consumption link, green consumption should be strongly advocated. Promotion of green development is to speed up the urban green belt and regional forest ecological construction and perfection based on the current ecological environment situation of Beijing-Tianjin-Hebei region to provide a steady stream of "oxygen bar" and forest "carbon sink" for the Beijing-Tianjin-Hebei region, thus to achieve prevention and cure of regional pollution of air, water, and solid waste. Advancement of low carbon development is to promote industrial upgrading and change generation, and to gradually reduce the energy consumption per unit output value and water consumption. The proportion of new energy should be increased to achieve low carbon and clean utilization of energy. Low-carbon traffic, construction and consumption mode should be advocated to build a low-carbon society.

1.4.3 Countermeasures Suggestion: Taking Multi-pronged Approach for the "Short Board", and Upgrading Overall Efficiency of Regional Carrying Capacity

1. Developing carrying capacity of water resources from "raising sources" and "reducing expenditure"

"Raising sources" means water transfer, including both interregional water resource transfer and virtual water transfer of commodity-based trade; "reducing expenditure" refers primarily to the control of the growth of per capita water footprint or even to reduce the per capita water footprint, and the principal means including improving water use efficiency through the progress of science and technology, and adjusting industrial structure, consumption structure, and urban space layout.

As for Beijing, structural water-saving is significant for control of the water footprint growth and enhancing carrying capacity of water resources. Interregional water transfer such as north – south water transfer engineering will directly increase Beijing's available water resource volume, but after all it is its supplementary water source; enhancing Beijing's carrying capacity of water resources through technical progress and improvement of utilization efficiency of water resources has limited potential, and expected marginal cost will rise in different degrees; and structural water saving (including optimization of industrial structure, consumption structure and city spatial structure) has major significance for enhancing Beijing's carrying capacity of future water resources. Industrial structure adjustment has played an important role in the control of Beijing's water footprint growth, but water-saving effect of consumption structural adjustment is not yet fully realized. In order to achieve future economic development strategies and indicators of population control in the condition of existing water resources, Beijing needs to unceasingly promote industrial restructuring and optimization of consumption structure, and gradually build a water-saving industrial system. In the future, Beijing should pay more attention to strengthening the integration of infrastructure construction with peripheral areas, and promoting the spread and integration of industries and functions to surrounding areas.

Tianjin should place importance to the implementation of virtual water strategy; technical progress and structural adjustment are main ways to restrain the per capita water footprint growth. Building-up and water delivery of the "north – south water transfer" eastern line engineering has played a positive role in alleviating the shortage of water resources and enhancing the carrying capacity of water resources in Tianjin. Technical progress has made significant progress in the establishment of water-saving in Tianjin. It is possible for the steady development of epigenetic water utilization and seawater desalination technology to become new supplementary water source of Tianjin in the future. Through the adjustment of industrial structure and consumption structure in the future, restraining the growth of the water footprint has great potential. Tianjin should attach great importance to the virtual water strategy for the future, and should further expand the transfer of products from the sectors of higher water footprint content to enhance the carrying capacity of water resources in the future development of Tianjin.

As for Hebei and the whole Beijing-Tianjin-Hebei region, it is imperative and significant to optimize the allocation of regional water resources, and to establish a regional integrated water resources management system, including consummation of a basin water allocation program, gradual establishment of a water rights system and water conservation compensation system of trans-provincial rivers; construction of safe water sources protection mechanism, establishment of emergency response systems, implementation of emergency water supply mechanism of groundwater; implementation of a strict system of water resources management, establishment of three control red lines including controls of total utilization of water resources, water use efficiency, and limited pollutants of water function zones in the Beijing-Tianjin-Hebei region.

2. Focus on treatment of air pollution and water environment to reverse the deterioration of the ecological environment

Development of green, low-carbon, and a circular economy is a fundamental way. Green, circular, and a low-carbon economy should be actively developed, and should be integrated into the development planning of governments at all levels so as to form a spatial pattern, industrial structure, production mode and lifestyle of saving resources and protecting environment, which reverses the trend of deterioration in the ecological environment from the source to create a good living environment for the people.

Comprehensive measures should be taken to treat air pollution. For the cause that easily forms haze and heavy fog in the winter, a radical way is to take a drastic measure to reduce the intensity and concentration of pollutants in the region, including strictly controlling possession quantity of motor vehicles in Beijing, Tianjin, and other extra cities within the region, encouraging public transportation and other green models, and reducing exhaust emissions, encouraging purchase of new-energy car, improving oil quality, rigorously enforcing exhaust emission standard, focusing on living and industry supporting in city planning, reducing trip rate of urban population, and levying a high environment tax on trans-city zones and long-distance work, reducing urban invalid traffic; implementing the engineering of coal modifying into oil and coal modifying into gas for winter heating within region, encouraging concentrated heating and concentrated processing of heating exhaust and emissions, through industrial restructuring and upgrading, reducing emissions from industrial production, and so on.

Water environmental governance and testing should be strengthened, and the construction of regional joint defense and control mechanism should be enhanced. Water quality monitoring of water sites and main lakes and rivers should be strengthened; construction of urban rainfall and sewage diversion, sewage interception and diversion works should be strengthened; the sewage treatment rate and sewage network coverage should be increased. In terms of pollution control, the promotion of carrying capacity of eco-environmental improvement is also a big system where many links, domains, and sectors closely cooperate, which must establish joint defense and joint control mechanism.

Urban living environment should be improved to advocate a "green roof plan," and water saving project of ecological communities should be constructed to advocate and implement low-carbon consumption patterns. The construction of urban sewage and garbage treatment facilities, urban green development and water bank economic zones should be accelerated, and the wetland should be emphatically protected. Urban dwellers' sense of crisis regarding resources, energy, and environment should be enhanced to change consumers' consumption behaviors and lifestyle, and to establish healthy cities and eco-livable home should be regarded as the emphasis of ecological civilization construction. Mild water recycle facilities should be further popularized. Rainfall in roofs, roads, and green space should be collected to be used for flushing toilets, washing cars, fighting fires, irrigating greenery, and washing clothes. Water permeability materials should be first used in construction, and the speed of rainwater collection at the surface should be decelerated to effectively impound rainwater resources so as to expand urban water sources. Developers should be encouraged to take ecological community water-saving projects, to implement dual water supply, to use dual water quality drainage, where sub-quality water is used in sanitary cleaning, greenery irrigation, road cleaning, car washing, and so on; water seepage floor should be built, and groundwater should be conserved as compensation for landscape water bodies and groundwater to dilute salinity in the groundwater.

3. Emphasizing comprehensive governance of traffic jams, optimizing structure of the traffic network, improving carrying capacity of infrastructure

Multiple measures should be taken to comprehensively govern traffic jams in big cities, including encouraging public means of transportation, such as bus and subway, inhibiting rapid growth of private car ownership. Under the situation of unchanged existing number of vehicles, through control of passenger number, reducing stop sites, improving punctuality rate and upgrading intelligent service level, and so on, more people may be attracted to take mass transit; Bike and pedestrian traffic space should be guaranteed so that more people can take walk and bike in due range; according to consumption levels, mass transit supply differences should be achieved through corresponding rise of fare and increase of comfortable degree to meet personalized needs so as to attract more private car owners and taxi passengers to take public transportation. Beijing should continue to insist on controlling the growth of motor vehicles, and should change from existing administrative ballot-drawing intervention to license auction. Only when a car is discarded as useless can a new license be auctioned; then the quantity of cars can really be controlled, and high-emission, high-energy cross-country vans should be levied an environment tax, and new energy vehicles should be given a policy of unlimited number, free travel restriction, and tax exemption to promote rapid development of the new-energy auto industry. The management of vehicles should be strengthened to reduce the phenomenon of parking on the road, and so on. Traffic hub stations should achieve joint-less integration of various transport modes as soon as possible. The region should promote the construction of traffic hub and transit center stations to form integrated a tridimensional traffic system that regards transfer stations as the nodes and linking-up of various transportation modes (such as plane, train, coach, subway, bus, etc.) as soon as possible, and plans to build a large underground and above-ground tridimensional parking facilities in transport hub areas.

The structure of the traffic network should be optimized. The region should improve the microcirculation system of regional roads, increase the density of urban road net, establish reasonable road net structure, open dead end highways in city zones; strengthen the construction of tridimensional transport systems, pay attention to construction of supporting facilities (such as construction of the car parks), and fully use underground spaces. We suggest planning and constructing large underground and above-ground tridimensional parking facilities in transport hub areas. For example, Beijing has more than 200 subway stations. By building 5,000 underground parking spaces (P + R car park) in every subway station, one million passenger cars above ground can be moved into the underground space, which will greatly reduce the phenomenon of parking on road, widen the actual width of roads, reduce traffic jam, reduce emissions of PM2.5, guarantee traffic space of bicycles and pedestrians, and ease traffic pressure. The government can give appropriate subsidies for parking fee, encourage and lead people to take the subway after driving their car and arriving at the subway stations. Underground spaces can also be equipped with supporting food services and shopping centers because bustling passenger flow carries with it huge consumer demands, thereby it will boost consumption, and promote regional employment.

The region should build a highly efficient transport network between the central cities and new cities to strengthen the accessibility of intercity transportation between the center cities such as Beijing and Tianjin and the surrounding cities. Consummation of public service facilities of new cities and medium and small cities and construction of shortcut traffic infrastructure should be organically integrated. In accordance with equalization principle of basic public services, high-quality resources of center city zones' public services should be actively promoted and transferred and diffused to the suburbs so that new cities' residents can also enjoy high-quality public services based on enjoying basic public services, which has important significance for enhancing new cities' attraction and mitigation of center city population.

International and private capitals should be attracted to invest in the infrastructure construction so as to improve and enhance the carrying capacity of urban water supply and drainage systems. International experiences indicate that infrastructure construction should not be monopolized by the governments, and the best way of investment and financing is the government-led and encouraging international and private capitals to invest in infrastructure development, and reduction and exemption of taxes should be given to those enterprises which reinvest the profits from infrastructure operations into new infrastructure projects. As a megalopolis that regards constructing it into a world city, Beijing should raise the standard for design of water supply and drainage system to gradually line up with the international standard; strengthen international cooperation of science and technology, strive for international advanced water conservancy standards and experiences of design and management; consult with water supply and drainage design of mega-cities similar to the regional environment, make integrated planning of the entire urban equipment pipeline layout, and coordinate the joints of regional pipelines; predict the impact of extreme weather on water supply and drainage system in Beijing, gradually upgrade and replace the current drainage pipes of design flood with recurrence interval of 1 year for the city zones into that of 3–5 years, and improve the pipeline standards in special sections. Urban water supply and drainage pipe should be laid by grading; management and maintenance should be separated, professional maintenance team should be established to check, drain contamination, and perform maintenance on schedule.

4. Alleviating population bearing pressure through function mitigation, industrial upgrading, urban–rural integration, and layout optimization

Non-core functions and some industries of Beijing, Tianjin, and other mega-cities should be transferred around so as to achieve harmonious development between population and regional elements. Excessive concentration of population in center zones should be restrained, and construction of new cities and medium and small cities should be promoted to form a reasonable pattern of intercity organic integration, which may increase the carrying capacity of the regional population; mega-cities' traffic jam should be solved, concentrated emission of automobile exhaust and pollutants from winter heating should be reduced, which will help reduce fog and haze and other extreme weather phenomena.

Industrial upgrading in the region should be promoted, and the absorbability of regional industries to low-end population should be reduced to optimize the structure of population. Labor elements should be promoted to freely flow within the region, including eliminating system barriers, and realizing the integration of labor markets within the region; speeding up the reform of the household registration system and the reform of the employment system, and establishing a unified labor skill certification system within the region.

Urban and rural integration should be promoted so that more of the rural population can be stabilized in the region. Governments should make great efforts to create conditions that can be fused into urban society as soon as possible. Inflow and outflow of population is a dynamic equalization process, which facilitate not only urban management, but also economic and social harmony between population and resources and environment.

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