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China: Innovative Green Development

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ISBN 978-3-642-54961-8 ISBN 978-3-642-54962-5 (eBook)
DOI 10.1007/978-3-642-54962-5
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2014936744

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Chapter 1
Introduction: Entering the Green Industrial Revolution

> It doesn't matter if a cat is black or white, so long as it catches mice.[1]
>
> Deng Xiaoping (1962)
>
> China: from the largest black cat to the largest green cat.[2]
>
> Hu Angang (2003)

1.1 Purpose of the Book: Innovative Green Development in Theory and in Practice

In 1939, Mao Zedong described China's natural bounty and great potential in the following way:

> China is one of the largest countries in the world, her territory being about the size of the whole of Europe. In this vast country of ours there are large areas of fertile land which provide us with food and clothing; mountain ranges across its length and breadth with extensive forests and rich mineral deposits; many rivers and lakes which provide us with water transport and irrigation; and a long coastline which facilitates communication with nations beyond the seas. From ancient times our forefathers have labored, lived and multiplied on this vast territory.[3]

In this beautiful land, the Chinese people have worked and lived from generation to generation for tens of thousands of years. The history of Chinese civilization is actually synonymous with the history of the development of the Chinese people

[1] Deng Xiaoping said the following when discussing how to restore agriculture when he presided over the meeting of the CPC Central Committee on July 2, 1962: "For the time being, the most important thing is to increase food production. In so far as individual enterprises can further this production they are a good thing. It is not important whether the cat is black or white as long as it catches mice….The best form of production is that which, within the framework of local conditions, is most likely to restore and develop production." Deng Xiaoping stated that the original source of the saying was Liu Bocheng, who often quoted the old Sichuan saying "It doesn't matter whether it is a yellow cat or a black cat, a cat that catches mice is a good cat."

[2] The author's idea, developed while teaching at Tsinghua University.

[3] Mao (1991b).

A. Hu, *China: Innovative Green Development*, DOI 10.1007/978-3-642-54962-5_1,

and also their pioneering reclamation. China is the most populous country and the largest grain producer in the world, feeding one-fifth to one-fourth of the world's population with less than one-tenth of global arable land and water resources. The history of Chinese civilization also shows the Chinese people's struggle with nature. Despite being the country with the most detailed historical records of natural disasters and famines, we are ignoring the lessons of history by allowing a continuous expansion of our ecological deficit through overuse of ecological assets. Historically, over-population and a shortage of agricultural resources, in particular, a serious shortage of arable land, has been the focus of the productivity paradox of China's traditional agricultural society. The longer the contradictions of surplus agricultural labor and limited arable land continue, the sharper these problems become for society and the greater the damage to the environment.[4] It is a miracle that China has managed to feed the world's largest population, but there is no such thing as a free lunch. New land can be made available to agriculture through deforestation and land reclamation from lakes; however, this process continues to exacerbate the conflict between humanity and nature. The increasing ecological deficits being faced could prove to be the greatest problem for China's long-term development.

Since 1949 China's ecological environment has become extremely vulnerable. The clash between humanity and nature constitute one of the core contradictions within modern China's social productive forces. There are many factors responsible for the recent rapid expansion of the ecological deficit. First, the population in China has experienced a surge in the past 6 decades. In 1949 the population of mainland China was 540 million; today, that figure has passed 1.3 billion, and it will reach nearly 1.5 billion before 2030. Second, the area of land under cultivation in China expanded rapidly and reached its maximum extent in 1957; since then, the area under cultivation has been in continuous decline. This means that the annual area of new land reclaimed for cultivation is less than the area of land lost to cultivation. China's increasing grain production has become reliant on one "leg" (increasing yield) of the two "legs" available (expanding cultivated land and its yield), and increases in yield must therefore compensate for the ongoing fall in the amount of arable land.[5] Third, the scale and speed of deforestation, grassland degradation, soil erosion, and desertification have exceeded those of any other historical era. Fourth, rapid industrialization, urbanization, and modernization have led to unprecedented environmental pollution; various types of pollution are spreading rapidly across the country. Finally, the frequency of natural disasters and the associated direct and indirect economic losses are increasing every year. Such disasters affect crops, decrease food production, and cause many casualties. The resulting huge loss of natural assets has reduced or offset Chinese GDP and national wealth to a large extent; however, the huge ecological loss is mainly invisible, but the effects on GDP are visible in the national economic statistics. Therefore, like the industrialized developed countries, China has inevitably experienced a process of "protection after destruction," "treatment after pollution," "and reduction after emission." We

[4] Hu (1991).

[5] Hu et al. (1989).

are currently at the stage where the rapid expansion of the ecological deficit must be turned around and reduced, which is the next major challenge of China's industrialization, urbanization, and modernization process.[6]

In the next few decades, there will be dramatic changes in China in which the most important direction of development will be green modernization; we will gradually enter the era of ecological surplus. China will become the country with the world's largest forest surplus and supply of green energy.[7]

Green development is the only way to achieve China's future green modernization. The question of how to innovate and realize green development and achieve green goals has generated a brand new subject, a creative idea, and a grand strategy for the twenty-first century.

The purpose of this book is "to innovate the green development concept, build a Chinese green development theory, summarize green development practices, and design a green modernization blueprint for China."

Innovate the Green Development Concept Innovation is the source of human progress, and philosophy is a cornerstone of human development. The following green development concepts are incorporated in the book: first, it makes full use of the wisdom of the ancient Chinese concept of "the harmony of humanity and heaven"; second, it is based on the nineteenth century Marxist dialectics of nature; and third, it includes and exceeds the contemporary concept of sustainable development.

This approach boldly abandons traditional modern western philosophy, rather than reforming or overhauling it, and comprehensively and thoroughly overturns outdated and traditional concepts unsuited to human development. In the book, it is explained that the historical logic of human development is from agricultural civilization to industrial civilization, and then from industrial civilization to a new era of ecological civilization (green civilization). The book indicates a new concept for future human development and explains the philosophical basis, historical origin, basic ideas, developmental path, implementation methods, and future goals of green development.

Build a Chinese Green Development Theory Theory is the perspective by which humans understand the world, and the ideal to guide human practice. In this book, green development theory is drawn from the course of development of human civilization and Chinese green development practices. An analytical framework and theoretical system for green development is built with reference to, and integration of, different disciplines or schools of thought, with the green development concept as a guide, and with the direction of green development as the subject. Green development theory is a new perspective with which to observe the natural world and to recognize the role of our own social practices. It gives a new understanding and recognition of nature and the dynamics of extremely complex major contradictions and relationships inherent in human development in terms of natural, economic, and social systems.

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[6] Hu et al. (2005).

[7] Hu et al. (2011).

Summarize Green Development Practices True knowledge comes from practice, and true knowledge promotes new practice. By drawing extensively from history and applying a global perspective, the green development path is stated and understood based on a summary and combination of aspects of the green development road; the green development road in China corresponds to the green development path, and the green development path corresponds to the green development road. The green development road may be explained by the path, or the green development path may be extracted from the road.

Design a Green Modernization Blueprint for China In the twenty-first century, China's modernization is not crawling behind that of western countries, but is exceeding the traditional path of western development and creating a tunnel effect of green innovation to achieve green growth. Green growth is a fundamental change from the traditional "black model," which is characterized by high consumption, expenditure, and emissions; green growth constantly develops and innovates and forges a green road to modernization with characteristics of rational consumption, low expenditure, and low carbon emissions. This book depicts the grand goal of green modernization for the first half of the twenty-first century in a creative, bold, forward-looking manner and proposes a three-step strategy to design and promote green development.

1.2 International Background: the Continuously Expanding Gap Between Humanity and Nature

Early humans lived for a long time in hunter–gatherer societies,[8] and had limited effects on nature. About 10,000 or 20,000 years ago, mankind gradually entered the agricultural era[9] and became increasingly dependent on agricultural resources. Agriculture resulted in more and more destruction of nature, and many civilizations disappeared because of overexploitation of natural resources.[10] The first industrial revolution occurred during the second half of the eighteenth century, and as a result, human productivity levels rapidly increased. Marx and Engels summarized the situation in 1848 as follows: "The bourgeoisie, during its rule of scarce one hundred years, has created more massive and more colossal productive forces than have all preceding generations together. Subjection of Nature's forces to man, machinery, application of chemistry to industry and agriculture, steam-navigation, railways, electric telegraphs, clearing of whole continents for cultivation, canalisation of rivers, whole populations conjured out of the ground—what earlier century

[8] The gathering economy was from more than 10 million years ago to about 2 or 3 million years ago; the hunting economy began about 2 or 3 million years ago and ended about 10,000 or 20,000 years ago. Zhang (2005).

[9] Zhang Jianhua has divided agricultural economies into three types: primitive, slave, and feudal agriculture. Zhang (2005).

[10] Arnold (2001).

had even a presentiment that such productive forces slumbered in the lap of social labour?"[11]

For the 250 years since the industrial revolution humanity has undergone earth-shaking changes. The traditional agriculture of self-sufficiency, which lasted for thousands of years, has been gradually replaced by highly market-oriented industrial agriculture. This industrial agriculture is characterized by high levels of production (as the machine has replaced traditional manual labor) and become a pillar of mankind; with increasing income, a booming new wave of service industries such as finance, education, counseling, and transportation has become the new driving force for human development, and is gradually replacing the more traditional industries.

During this unprecedented phase of human development, the capitalist model has expanded worldwide, and capital has reached every corner of the world. The driving force of the capitalist development model is the single-minded pursuit of profit from capital, which relies on expanding the scale of access to natural resources and energy to achieve further expansion of production and thus obtain maximum profit. The capitalist development model, however, has a fundamental and irreconcilable contradiction between infinite capital expansion and limited natural resources. This contradiction was temporarily relieved in the early development of capitalism through western-oriented countries' continuous wars and colonial plunder. But with rapid advances in technology and completion of the global expansion of capital, traditional approaches have been unable to inject the new resources required by the ever-expanding capitalist system. After World War II, western societies entered a model based on consumerism in which the excessive growth of consumption drove high production and profit, resulting in higher consumption of natural resources, pollution, and emissions. This capitalist development model of excessive consumerism and the resulting high levels of consumption, pollution, and emissions is known in China as the black model of development.

In applying the capitalist development model, western countries have promoted the development of civilization and achieved some national success, but this model has led to huge and invisible costs for the whole world. This cost is mainly reflected in the following two ways: first, western countries have consumed energy and resources at rates several times higher than their proportion of the world's population, and second, these countries have emitted most of the greenhouse gases and pollution during their 250-year industrial history, becoming the biggest contributors to the expanding human ecological deficit. Faced with these problems, western countries are trying to correct the situation through a limited new concept—sustainable development; however, sustainable development can only passively adjust the mode of production under pressure of the natural crisis and not change the fundamental levels of consumption. The major result has been that resource consumption, pollution emissions, and greenhouse gas emissions have been transferred from the northern to the southern countries. Therefore, after more than 20 years, sustainable development has not effectively curbed the global environmental and ecological crisis, but has, in fact, become an increasingly serious threat to human security.

[11] Marx and Engels (1988).

The black model of development, after having advanced mankind over the past 200 years, has become the largest shackle on human development, resulting in a huge crisis for mankind, including environmental pollution, depleted energy resources, extreme climate change, global ecological crises, and a myriad of other difficulties.

To put environmental pollution into perspective, each year 2.7 million people die of respiratory diseases, cardiovascular diseases, and cancer caused by air pollution from industry, automotive emissions, and home fossil fuel combustion. Economic output is correspondingly reduced by lost productive labor. The incidence of waterborne diseases and loss of health linked to water pollution are also high; each year 25 million agricultural laborers in developing countries (11 million in Africa alone) are poisoned by pesticide and hundreds of thousands of people die.

In terms of energy resources, humans have sequestered 50% of the Earth's potential photosynthesis; human consumption is now three times what the entire planet can bear. At the same time, humans consume more and more forests: at least 10–12 million ha of forest disappears each year as a result of excessive logging and deforestation. Annually, a US$ 1–2 billion loss results from reduced tree growth, decreased soil and water conservation capacity, and impaired nitrogen uptake. In the ecological environment, climate change, invasive alien species, over-exploitation of species, pollution, and other problems have brought about a huge loss of biodiversity.

In the past few hundred years, the rate of extinctions caused by mankind's activities has increased to become more than 1,000 times the typical reference rate in Earth's history. Currently, approximately 12% of birds, 23% of mammals, and 25% of conifers are at risk of extinction.

In recent years, frequent extreme climate events caused by global warming have been an unprecedented challenge for mankind. According to an Intergovernmental Panel on Climate Change report, "Climate change will affect the basic life elements of global humanity—access to water, food production, health, and the environment." Countries worldwide have never felt the issues of climate change so keenly before, or been damaged so deeply; this issue has become the common developmental challenge for humanity. According to research of the World Meteorological Organization, the global carbon dioxide concentration in the atmosphere before the industrial revolution was about 280 ppm; this figure had risen to 385.2 ppm by 2008.[12] According to the latest research of the International Energy Agency (IEA), if humanity does not effectively control the long-term rise in the concentration of greenhouse gases in the atmosphere, it could rise to a level greater than 1,000 ppm of carbon dioxide equivalent, leading to a disastrous global temperature increase of 6 ℃ compared to that before the industrial revolution.

Western-style modernization seems successful, and is the pursuit of developing countries; however, western countries have paid huge and invisible costs—their consumption of energy and resources are several times higher than their proportion of the population in the world. Carbon dioxide emissions accumulate in the

[12] World Meteorological Organization: Greenhouse gas bulletin 2008, November 23, 2009.

atmosphere and have become a burden on the world after 250 years of industrialization. Therefore, this road is essentially unsuccessful and unrepeatable. The world crisis is, in its essence, the crisis of capitalism and excessive consumerism.

Essentially, the global ecological crisis means that it is unsustainable for the West to continue with the growth model of high input, high consumption, and high pollution emissions that has been followed since the first industrial revolution. This crisis also indicates that the model for human development must be consciously transformed through self-development; we must seek a new development model through a new green industrial revolution. The financial crisis triggered in the second half of 2008 by subprime mortgage lending in the United States has caused a ferocious global financial tsunami with strong impacts over a very wide area, resulting in economic recession, rising unemployment, and social unrest in many countries, as well as debt crisis. This fact proves that the capitalist mode of development is unsustainable; consumerism as a core value has led developed countries to become heavily dependent on fossil fuels and to take an increasingly "predatory" stance toward global ecological resources.

Humanity is now presented with an unprecedented opportunity for green development; we must proceed quickly into the fourth industrial revolution—the green industrial revolution. Now is the dawn of the green industrial revolution, and the traditional development model must be abandoned; if humanity wants to achieve common sustainable development, we must select and put into practice a new development paradigm—green development.

Since 1750, the industrial revolution led by western countries can be considered a "black industrial revolution," in which economic growth is accompanied by resource consumption, environmental pollution, and a corresponding increase in carbon emissions, the latter becoming the main human factor effecting global environmental change. In contrast to previous industrial revolutions, the green industrial revolution, in essence, represents a fundamental change from traditional and modern modes of development—it encompasses the green development model. In other words, economic growth will become fully decoupled from water consumption, fossil energy consumption, pollutant emissions, and carbon dioxide emissions; it will be characterized by substantial increases in resource productivity, decreases of pollution emission, and development of the circular economy and the low-carbon economy.[13]

Since the financial crisis some developed, and some newly industrialized countries, such as South Korea, Japan, the United States, and those in the European Union, have begun to explore the transformation of the mode of economic development, and tried to restore macro-economic development policy combined with green strategies, including environmental protection, growth pattern change,

[13] The so-called low-carbon economy is an economic development idea or form that pursues maximum output with the precondition of a reduction of greenhouse gas emissions. It is also one of the basic ways for humanity to respond to climate change, and one of the new basic trends of world economic development in the twenty-first century. Even developed countries are aware of this issue. In essence, the low-carbon economy is the reduction of carbon content, whether in the process of production or consumption, which means cleaner air and lower CO_2 emissions.

and carbon emission reductions. They have begun to develop a green economy and green growth strategies, and to provide policy support for green innovation, production, and consumption through legislation and national development planning, with the goal of gaining an advantage in the global green industrial revolution as the green economy becomes the global trend. Meanwhile, many international organizations, including the OECD and the UN, have also introduced related reports; green development will become an important global issue in the post-crisis era.[14]

1.3 The Domestic Background: Becoming the Innovators of Green Revolution

China is the only ancient civilization to have maintained continuity for more than 5,000 years. China was an innovator of agricultural civilization and, as a developed agricultural country, created a unique and brilliant civilization; it is ironic therefore, that China gave birth to the great philosophy of "harmony" while building up a large ecological deficit.

During the era of industrial civilization, there have been three industrial revolutions. Since early modern times, China has become marginalized and was a laggard and a beaten nation in terms of the industrialization launched and dominated by the West; until the third industrial revolution, China was always struggling to catch up.

From 1760 to 1840, western countries initiated and led the first industrial revolution—the steam engine revolution—leading to unprecedented explosive growth in western national productivity; the western countries held dominant positions in international competition and armed struggles. In China, there was a process of transformation and modernization during the era of the emperors Kangxi, Yongzheng, and Qianlong (1681–1796); however, this period marked the end of the era of feudal empires, and China lagged behind western countries in terms of economic, political, scientific, technological, and cultural development. At this time, China was arrogant and self-contained, and was either unaware of, or ignored, the earth-shaking industrial revolution in the West. It thus became marginalized in the first industrial revolution, and this planted the curse of backwardness, turmoil, and humiliation which marked the 100 years of early modern China.

[14] The World Economic and Social Survey Report by the United Nations Department of Economic and Social Affairs has called on countries around the world to promote and increase investment in green economic development. Over the next 30–40 years, therefore, global investment for development of the green economy needs to increase annually at a rate of US$ 1.9 trillion, of which developing countries need to contribute US$ 1 trillion, otherwise it will be difficult to avoid the disastrous effects of climate change and environmental degradation. Therefore, the United Nations called on its member governments to play leading roles in the green energy technology revolution. Poverty reduction and economic growth will synchronize with the implementation of appropriate investment and incentive policies in green energy. With acceleration of the innovation of green technologies and structural reform, sustainable production and consumption will be promoted.

From 1840 to 1950, western countries launched and led the second industrial revolution—the electricity and railway revolution—and rose again to global hegemony. To achieve economic expansion, they plundered global resources. In old China, after the collapse of the tumultuous Qing imperial regime (1644–1911), China fell into a period of political instability, frequent wars, poverty, weakness, division, and misery. The Chinese Empire became a trampled sheep, a place of plunder of resources and dumping of goods for the western powers; therefore, China's natural account fell into a rapidly increasing international deficit. China was not only a laggard, but was also the victim of aggression of the second industrial revolution.

From 1950 to 2000, the northern countries (Western countries and the former Soviet Union) launched and led the third industrial revolution that gave birth to new information industries and promoted service industries; these gradually became the leading industries of the developed economies, further improving their living standards. During the third industrial revolution, with the founding of New China the reforms, and the period of opening up, Chinese economic development went into overdrive, continuously shrinking the huge gap with western countries that opened up during the first and second industrial revolutions. China took the opportunity to participate in the third industrial revolution, with the initiative of opening up, but it was still following behind the northern countries. China is now the world's largest producer, consumer, and exporter of information and communications technology (ICT), and is the emerging global economic power. China was initially striving to catch up, but then it became an active participant of the third industrial revolution, and it will emerge the winner.

After the success of restoring the national economy in the early period of New China, it started to learn from the Soviet experience and implemented industrialization under the slogan "one industrialization, three reforms," in which the government launched industrialization but excluded the private sector (i.e., private capital and individual ownership), giving priority to the development of heavy industry and artificially depressing its costs, such as the price of capital, foreign exchange, energy, raw materials, agricultural products, and labor. The initial choice of China's route to industrialization set the direction of heavy industry for a long time and was focused on import substitution.

Since the reforms, China experienced the largest and most unprecedented period of population growth, industrialization, and urbanization in human history. China has become the world's largest industrial producer, topping the world ranking in the production of major industrial products, and China's industrial added value ranks second in the world.

From the 1950s, China has fed the largest population in the world with the most fragile ecological environment, undertaken the most unprecedented consumption of resources, and developed an impressive level of economic activity; it has also faced unparalleled ecological and environmental challenges. The result has been serious and massive degradation of land resources, aquatic ecosystems, and grasslands, and the forest deficit has widened; biodiversity is seriously under threat, and urban air pollution is a major problem. The number of devastating natural disasters and the level of direct economic losses have continued to rise. Now, China is the world's

largest emitter of carbon dioxide and organic wastewater discharge, as well as the nation with the largest annual loss of natural assets; it has become a veritable black cat. China is faced not only with enormous pressure from the international community to reduce greenhouse gas emissions, but also with very serious ecological challenges, including desertification, rocky desertification, serious soil erosion, and degradation of ecosystem functions.

China's industrialization, urbanization, and modernization process was thus accompanied by rapid expansion of the gap (and the increasingly prominent contradiction) between humans and nature. Based on the prevailing natural conditions, its limited supply of the world's resources, and current environmental load, China is being forced to discard the "black road" of development. It can no longer follow the former Soviet-style model of heavy industrialization with its high energy consumption, pollution emissions, and low resource efficiency; also, it cannot imitate the modern mode of high consumption, high expenditure of resources, and pollution emissions applied in western countries. The only viable way forward is be inventive and to innovate the path of green development.

As the twenty-first century continues, we clearly recognize that the world's fourth industrial revolution, the so-called green industrial revolution, has arrived, with its goals of substantially improving resource productivity, substantially reducing pollution emissions, and decoupling economic growth and carbon emissions (or even a decline in carbon emissions). Now we are at the dawn of this new industrial revolution, which is a period of great opportunity; this is both fortunate and unsettling at the same time. In the history of industrialization and modernization of the past 200 years, China lost the opportunity to participate in three industrial revolutions; even since the 1980s, we have just been playing catch-up, and by luck caught the last train of the information revolution. China has always been in the position of a "latecomer" and follower because of the opening up policy. Only now does China have a chance to stand on the same starting line and stay in the same camp as the United States and other developed western countries, with the opportunity to become the instigator, innovator, and leader of the fourth industrial revolution, the green industrial revolution.

"Although Zhou is an old state, its mission is reforming."[15] As the state with the oldest civilization and the largest population, and as a developing state with increasing prosperity and great influence, China cannot slavishly imitate the traditional path of modernization followed by the United States and other developed countries; China must go beyond the mainstream model and lay the road to green development. China must launch a green revolution, actively promote green development, lead the trend of green civilization, and become the pioneer, innovator, and leader of human development in the twenty-first century. It must provide southern countries with a new path leading to ecological civilization and development—the green development path. This is the "new mission for an old country" that must be borne by China; green development is the greatest strategic opportunity of the twenty-first century.

[15] The Book of Songs • Taiga • King Wen.

During the first decade of the twenty-first century, China became the instigator, and then a participant, innovator, and practitioner, of this global green industrial revolution. China took on board green development planning, implemented a green development strategy, and took a series of innovative measures to achieve the goal of green modernization. The Communist Party of China's (CPC's) 17th Congress report promised that "we shall help and promote environmental protection with each other and take joint care of mankind's planet for survival."[16] The 12th Five-Year Plan has become China's first green development plan and was published in 2011; it is the starting point of green modernization in the first half of the twenty-first century. First, the proportion of green indicators in the 12th Five-Year Plan has increased from 7 (accounting for 27.2% of the 11th Five-Year Plan) to 8 (accounting for 33.3%). Second, the plan clearly proposes, for the first time, to actively respond to global climate change; it includes quantitative indicators of 17% reduction in carbon dioxide emissions per unit of GDP by 2015 and other quantitative indicators such as increasing forest cover and reserves. Third, the plan also clearly proposes incentive and restraint mechanisms for green development and, for the first time, takes "rationalizing the price of resource-based products and strengthening environmental protection reform" as the direction of the plan. Finally, the plan further clarifies the strategy of the main functional areas to promote ecological protection and restoration: zones in which development is restricted or prohibited are set up with strict ecological protection, and special ecological restoration projects are implemented to protect the ecological environment in 9.6 million km^2 of territory. The overall aim of the plan is to leave a good green home for future generations to live in.

1.4 Research Issues and Framework

Because humanity is part of nature, and because humanity's survival and development are inseparable from nature, human civilization has always faced a fundamental problem, namely, how to deal with the relationship between humanity and nature. At the agricultural level of civilization, mankind's activities had an adverse effect on nature to some extent. Chinese philosophers have put forward the idea of the "harmony of humanity and heaven," which proposes the pursuit of a harmonious coexistence between humans and nature.

During the era of industrial civilization, mankind's activities have destroyed nature at a hundred, a thousand, or ten thousand times the speed and scale of that wrought by agricultural civilization. Recently, during the late phase of industrial civilization, western countries put forward the concept of "sustainable development" in an attempt to correct the traditional black model of development, but in

[16] Hu Jintao: Hold high the great banner of socialism with Chinese characteristics, to strive for new victories of building a moderately prosperous society in all aspects—report at the 17th CPC Congress, October 15, 2007.

general it has not been successful; the contradictions between humanity and nature have not been eased but exacerbated. The result has been unprecedented global ecological crises and the climate change crisis; however, these crises usher in an unprecedented opportunity for transformation, a chance to shift toward the new road of green development, which marks a fundamental departure from the traditional path of black development.

The third industrial revolution has peaked and will enter a period of decline. Humanity is at a new crossroads; it is the eve of the green industrial revolution that will usher in the dawn of green civilization. Just as Mao Zedong said in 1947, "The dawn is coming, and we shall be prepared!"[17]

In the new era of green civilization, humanity will need to completely change its philosophy, theory, and practice of development; as an amendment to the traditional mode of industrialization, sustainable development has proven unable to meet the needs of the new era; we have to supersede the prevalent western approach and propose a new concept of development, open up a new theory, and formulate new practices—the concept, theory, and practice of green development.

In this book there are several questions to be answered (with green development as the framework) and specific topics to study: what is the basic background of green development? What is the theoretical basis of green development? What areas are contained in green development? What stages are included in green development? What are the constraints and favorable factors of green development? How can the constraining factors be changed into favorable ones? How should China's green development path be understood? What is the logic behind it? What is its motivation? Where will China go? How will the goal of Chinese-led green development be achieved?

This book provides systematic explanations of the theory of green development and gives a profound critique of the limitations and negative externalities of the traditional western model of development. It also gives a comprehensive analysis of the crisis and the opportunities presented by green development, showing how humankind is at a period of transition from the traditional black industrial civilization to a modern green ecological civilization.

China's road for green development is reviewed from a broad historical perspective, in which the natural deficit that opened up as a result of agricultural civilization became the rapidly expanding deficit of the era of industrialization; the book then addresses how the deficit can be narrowed, and ultimately how a natural surplus can be established, marking a historical change in human development.

China must become an innovator, practitioner, and leader of green development, and green planning is an important means to establish green development. Local governments will become green innovation practitioners, and enterprises will become the main arena of green development.

This book is the culmination of the author's engagement in national studies, especially in green development studies, over the past 20 years; it is a green development textbook containing related scientific knowledge and important information

[17] Mao (1991a).

for decision-making presented in a concise, easy-to-understand form. The book is also a creative and innovative work that hopefully will contribute to the long-term development of humankind in general and China in particular.

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Chapter 2
The Theory of Green Development

> Making Green Development a Choice. [1] United Nations Development Programme (2002)
>
> China's economic development mode must shift from traditional "black development" to "green development.", from ecological over-exploitations to ecological restoration, and from ecological deficit to ecological surplus. [2] Hu (2002)

The basis of human civilization has transformed from hunting to agriculture and then to modern industry; now a new ecological civilization, or green civilization, is needed.[3] Although industrial civilization has achieved great things with "more massive and more colossal productive forces than … all preceding generations,"[4] it has also adversely impacted nature more than all preceding generations, and the dissonance between humanity and nature is larger than ever. What is the biggest challenge for human development in the twenty-first century? We face unprecedented and serious natural crises, extreme climate change, unprecedented shortages of resources and energy, and continuing degradation of the global ecological environment. The question is one of survival as human development reaches a new crossroads: Which path will the world follow? What role will China play? The only correct answer is to resolutely develop an ecological civilization.

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[1] UNDP: China Human Development Report 2002: Making Green Development a Choice, UNDP, 2002.

[2] Research Center for Contemporary China of Tsinghua University et al. (2005).

[3] The Research Group of Chinese Sustainable Development for Forestry Strategy in 2002 stated that the twenty-first century is the century of ecological civilization. Primitive civilization lasted about 1 million years, agricultural civilization has been with us for nearly 10,000 years, while industrial civilization has existed for only 300 years; the twenty-first century will be the century of ecological civilization. "Ecological civilization refers to an ideal civilization characterized by virtuous interactions between mankind and nature, one that follows harmonious social development, is developed from mankind's spiritual and technological innovations, and which is in accordance with the inherent rules governing the functioning of both nature and society. The main objective of ecological civilization is to optimize and operate natural ecosystems and social–ecological systems to achieve ecologically, economically, and socially sustainable development.

Research Group of Chinese Sustainable Development for Forestry Strategy (2002).

[4] The Communist Manifesto.

A. Hu, *China: Innovative Green Development,* DOI 10.1007/978-3-642-54962-5_2,

As Engels said, "Major historical disasters are always mitigated by tremendous historical progress."[5] Every great crisis of human civilization contains the seed of the vitality that will follow at the next level of civilization. Industrial civilization, or what is referred to in China as "black civilization," has resulted in the cumulative emission of greenhouse gases based on the burning of fossil energy and is creating an unprecedented "black crisis." Therefore, a new civilization based on green energy is needed, with ecological civilization decoupling from ever-increasing carbon emissions. A new development theory is also needed that makes use of historical self-reflection, academic consciousness, innovation, and global vision. This new green development theory will ultimately guide green development practices.

The questions to be addressed in this chapter include:

- What does "green development" mean?
- What is the theoretical basis of green development?
- What is the practical basis of green development?
- What is its relationship with sustainable development?
- What does the green industrial revolution mean and how should it be interpreted?
- What kinds of systems and wealth are included in green development, and how are they measured?
- What stages are involved in green development?
- What is the meaning of the innovation of green development?
- Why the concept of green development is, in its essence, the same as the Scientific Outlook on Development proposed by the Chinese Communist Party (CCP)?

This chapter proposes the concept of green development and describes the theoretical system of green development in a systematic manner. It acts as a guide to the following chapters, which are based on the practice and empirical analysis established in this chapter. Green development will become the next major innovation and is intended to supersede the concept of sustainable development in human development theory. Green development will guide tremendous changes in human society in this new century, and scholars should consciously and confidently strive to contribute to the research and practice of the concept.

2.1 The Three Sources of the Theory of Green Development

There are three sources of the theory of green development: (1) the concept of "unity of nature and humanity" in traditional Chinese philosophy that has developed over thousands of years; (2) the Marxist dialectics of nature, which were developed more than 100 years ago; and (3) the contemporary theory of sustainable

[5] Marx and Engels Collected Works, volume 39, page 149.

development. These sources represent current theoretical peaks and constitute the sources and bases of green development theory. Green development is essentially the integration and re-focusing of these powerful ideas and theories.

2.1.1 The Unity of Nature and Humanity in Traditional Chinese Philosophy

The unity of nature and humanity in traditional Chinese philosophy was first proposed by Zhuangzi (or Chuang Chou, 369–286 BC);[6] it was then developed as a philosophical system by Dong Honshu (179–104 BC), a thinker and Yin-Yang scholar of the Han Dynasty, and became a fundamental tenet of traditional Chinese culture.[7]

The philosophy has three basic tenets. First, according to the unity of nature and humanity, nature and humanity are inseparable, rather than opposites. For example, Zhang Zai's idea of the unity of nature and the Earth proposes that humanity and everything else constitute an organic intertwined system in which humanity is simply a part of the universe. The relationship between humanity and nature is not a master/servant or a conqueror/conquered relationship, but an equal and harmonious relationship.

Second, the unity of nature and humanity argues that humanity should be in harmony with nature. A reasonable approach to life is to follow and practice "destiny," which is explained by Yi Zhuan as "the way of heaven changes constantly, during which everything has a destiny"; "destiny" is not only a modern natural law, but is the "cosmic law of nature" that must be followed in life.

Finally, as an important part of the unity of nature and humanity, the simple idea of the conservation of nature was put forward by the ancient Chinese: Mencius (372–289 BC) stated "if farming is done in the right season, corn will fill up the barn… if people cut down trees with axes at the right time, the trees cannot be exhausted"[8]; Xunzi (ca. 312–230 BC) had similar views, "as the grass and trees are growing, people shall not bring their axes into the forest and destroy their growth;… fishing shall be banned in dirty pools, deep marshes and lakes, so people have more fish and turtles; tree cutting shall be done at the right time, so the green forests provide people with more wood than ever before."[9]

The unity of nature and humanity means harmony between humanity and nature, complying with the laws of nature, self-discipline in the use of natural resources, and long-term coexistence between humanity and nature. It is different from many western philosophies that view nature and humanity as being in opposition, and

[6] Zhuangzi, Qiwu Theory: "Nature and earth coexist with me and everything on earth is harmonious with me."

[7] Ren (1985).

[8] Mencius, King Hui of Liang 1.

[9] Xunzi, Li Theory.

which attempt to justify nature being permanently under human control, resulting in the plunder and destruction of natural resources. In contrast, Chinese philosophy has proposed since ancient times that mankind should not violate nature, but should strive to integrate with nature.[10]

Chinese culture is traditionally in awe of and close to nature, influenced by a traditional wisdom that extols the pursuit of the long-lasting and eternal over the short-term.

Ancient Chinese philosophy of the unity of nature and humanity is still a simple view of nature that does not take on board the subjective activity of humans in their relationship with nature. Rao Zongyi a famous scholar of ancient Chinese civilization, developed the philosophy. He proposed the learning of wisdom from ancient culture, the avoidance of mutual harm to nature and humanity, and the setting up of an environment for the mutual benefit of nature and humanity. His philosophy is based fundamentally on a reciprocal relation between nature and humanity.[11] In the interactions between humanity and nature, people play a more active role, and so should strive to follow nature and cherish nature. This is the modern concept of the unity of humanity and nature in which human beings come from, follow, benefit, and nurture nature. Therefore, humanity should strive to form a symbiotic relationship with nature, a relationship of coexistence and common prosperity. In essence, this is the only way forward for mankind.

The unity of nature and humanity provides not only a source of traditional wisdom for innovative green development, but also a rich historical and cultural bedrock for the Chinese conceptualization and practice of green development in the twenty-first century.[12] If the concept of sustainable development proposed by western scholars is a reflection and correction of unsustainable capitalist production and consumption since the industrial revolution, the unity of nature and humanity is the source of the theory of innovative green development and the source of innovative human development for the twenty-first century and beyond.

2.1.2 Dialectics of Nature in Marxist Philosophy

The dialectics of nature in Marxist philosophy was first put forward by Engels,[13] and it developed into the Marxist view of nature and natural science. The dialectics

[10] Mu (1990).

[11] Unity of humanity and nature, and their mutual benefit, Nanfang Daily, November 18, 2009.

[12] Qian Mu said in his last article: "'The unity of humanity and nature' is the real destination of traditional Chinese culture, and I am convinced that Chinese culture's contribution to the survival of mankind lies in it." Mu (1990).

[13] In fact, *Dialectics of Nature*, an unfinished book by Engels, is a summary of the natural science research that Engels undertook over the years. In the book, Engels appraised the main achievements of natural science in the mid-nineteenth century using the method of dialectical materialism; he criticized metaphysics and idealism in natural science. *Dialectics of Nature* was not published during Engels' lifetime; however, the article "Labor's Role in the Transformation from Ape to

of nature embody the unity of world outlook, epistemology, and methodology of Marxist philosophy and constitutes an integral part of it.

This approach has three main aspects. First, in the dialectics of nature, nature is the source and basis of human life. From the perspective of historical materialism, Marx thought of human history as a continuation of natural history, and "history itself was natural, namely, nature became a real part of this process."[14] At the same time, Marx also believed that human beings must depend on nature, "The life of the species, both in man and in animals, consists physically in the fact that man (like the animal) lives on organic nature; and the more universal man (or the animal) is, the more universal is the sphere of inorganic nature on which he lives."[15]

Second, in the dialectics of nature, the relationship between humanity and nature is a unity of opposites. Humans can understand and transform nature; in the relationship between humanity and nature, humanity is the subject and nature is the object; humans may change nature through practice-driven initiatives.[16]

Finally, in the dialectics of nature, humanity must respect and follow the laws of nature, and in that way we are able to transform nature. Engels pointed out that "…at every step we are reminded that we by no means rule over nature like a conqueror over a foreign people, like someone standing outside nature—but that we, with flesh, blood, and brain, belong to nature, and exist in its midst, and that all our mastery of it consists in the fact that we have the advantage over all other beings of being able to know and correctly apply its laws."[17]

The Marxist dialectics of nature systematically understood the relationship between humanity and nature for the first time in the history of western philosophy. It clarified how humanity should correctly understand and handle its relationship with nature and strongly criticized the plundering of nature by western countries since the start of the industrial revolution. As a reflection and critique on capitalist production, Engels gave his famous warning: "Let us not, however, flatter ourselves overmuch on account of our human conquest over nature. For each such conquest takes its revenge on us. Each of them, it is true, has in the first place the consequences on which we counted, but in the second and third places it has quite different, unforeseen effects which only too often cancel out the first."[18] One hundred years after this was written, it became clear that continuous emission and accumulation of carbon dioxide and other greenhouse gases, mainly from western industry, had directly led to abnormal changes in global climate that could all too easily lead to global ecological disaster; global warming has become the largest development crisis of the twenty-first century.

Man" was published in 1896 after his death, and another article "Natural Science in the Spirit World" was published in 1898. *Marx and Engels Library* was published in the German and Russian translation until 1925 in the former Soviet Union.

[14] Engels (1972a).

[15] Marx: 1844—Philosophical Manuscripts.

[16] Engels (1972b).

[17] Engels (1995).

[18] Engels (1995).

The dialectics of nature proposed the correct approach to the relationship between humanity and nature for the first time in the history of western philosophy,[19] i.e., an approach leading ultimately toward the harmony of humanity and nature through advanced human technology and development. As Marx stated in his Economic and Philosophy Manuscripts of 1844: "This communism, as fully developed naturalism, equals humanism, and as fully developed humanism equals naturalism; it is the genuine resolution of the conflict between man and nature and between man and man—the true resolution of the strife between existence and essence, between objectification and self-confirmation, between freedom and necessity, between the individual and the species."[20] This approach has common ground with the "unity of humanity and nature" and the "harmonious world" of Chinese philosophy, and has the aim of achieving harmony, coexistence, and symbiosis between humanity and nature.

Although Marx and Engels proposed the innovative dialectics of nature, they did not propose specific ways to resolve the conflict and to narrow the gap between humanity and nature. Only in the practice of Marxism in China has the dialectics of nature undergone further development and innovation.

In the summer of 1998, China experienced flooding on a massive scale. Jiang Zemin, then President of the People's Republic of China, said, "The floods caused severe damage, and incurred high costs; the natural disaster was a bad thing, but people struggling with it can deepen their understanding and grasp of the laws of nature, draw useful conclusions, and thus use nature to serve their own lives and social development more scientifically. This was the dialectic between humanity and nature. We must consciously recognize and correctly grasp the laws of nature and learn to act according to the laws of nature in order to facilitate our economic construction and social undertakings and achieve coordinated development of economic construction and the ecological environment."[21]

The theory of the dialectics of nature provides a profound theoretical basis and methodology for green development, based on which the relationship between humanity and nature can be divided into three historical stages.[22] In the first stage, humanity is a passive natural slave to nature, and all activities are subject to natural control. In the second stage, humanity tries to become the master of nature to obtain resources from it; therefore, this stage includes the golden era of industrialization, urbanization, and modernization. This stage sees an ever-expanding gap between humanity (demand and consumption) and nature (carrying capacity and supply),

[19] In ancient Greek philosophy, humanity was always seen as a part of nature. The highest aims and ideals of humanity were seen as being not to exercise control over nature, but rather to wait and see how things developed, and to delve deep into nature as a part of nature and to understand the mysteries and vitality of nature.

[20] Marx (1985).

[21] Zemin (2006a).

[22] In 1994, Hu Angang, with Liu Dongsheng, academician of the Chinese Academy of Sciences (winner of the 2003 State Supreme Science and Technology Award and director of Guiyang Geochemistry of Chinese Academy of Sciences) and five other academicians went to Guizhou to carry out some investigation. Liu Dongsheng had talked about "three stages," therefore the author (Hu Angang) was inspired to further discussion. Hu et al. (1977).

as well as the prominent conflict between the environment and development, i.e., a typical "pollution first, treatment later" mode of development. In the third stage, humanity is no longer the master of nature, but is a friend to nature. Natural ecosystems and socio-economic systems form a virtuous cycle on the new green road of development with harmony between humanity and nature.

2.1.3 The Theory of Sustainable Development in Modern Times

Sustainable development was the first reaction to, and fight against, the enormous crisis in the natural environment in the second half of the twentieth century; a global consensus quickly formed around the rallying cry of sustainable development.

In 1962, the book *Silent Spring* marked the start of human reflection on ecological and environmental problems; the book posed such questions as "where are the spring birds? Why leave a silence?"[23] In 1972 the Club of Rome issued its famous report entitled *The Limits to Growth*, which led to increasing concern regarding environmental issues. In the same year, the first United Nations Human Environment Conference held in Stockholm, Sweden, adopted the Declaration on the Human Environment. Environmental issues have been included in the international agenda since then; humanity began to realize the link between the environment and development, and to call for national cooperation to solve environmental issues. The concept of sustainable development was first proposed in the United Nations General Assembly in 1980. The report *Our Common Future* of the World Commission on Sustainable Development in 1987 defined the concept: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." In essence, sustainable development is a response to the human ecological environmental challenges created by modern industrial society; international social and political consensus rapidly formed around this concept. It holds up capitalist production to global examination and makes a limited revision of the traditional development path.

However, sustainable development represents a passive, unconscious modification of unfettered development. It also makes it clear that since the industrial revolution, modern development, with consumerism as a driving force, has been characterized by excessive resource and energy consumption, pollution emissions, and ecological damage; after the crisis has occurred, sustainable development tries to fix it. Figuratively speaking, normal development under industrial civilization is to "kill the goose that lays the golden egg" or to "drain the pond to catch all the fish."; Although sustainable development mode calls for less damage to the well-being of future generations, it has not changed and cannot change the fundamental characteristics of western capitalist development—high consumption, over-consumption, and high emissions. The theoretical origins of sustainable development are still anthropocentrism, emphasizing the correctness of human control over nature, rather

[23] Carson (2007).

than permanent harmony between humanity and nature. Therefore human practice under the ideology of sustainable development entails only passive adjustment of production. Under pressure from the deepening natural crisis, western countries have in effect transferred resource consumption, pollution emissions, and greenhouse gas emissions to southern countries through economic globalization, transfer of industrial production, and trade. Over the past few decades, evidence has shown that efforts to modify development to make it more sustainable have not succeeded; world development has become more unsustainable. With the prominent problem of climate change, humanity has been exposed to an unprecedented ecological crisis.

In June 1992, the Heads of State Summit (attended by the leaders of 178 countries) was held by the United Nations in Rio de Janeiro, Brazil, and China's Premier Li Peng attended the meeting and signed the Environment and Development Declaration on behalf of the Chinese government. In July 1992, led by the State Planning Commission and the National Science and Technology Commission, 52 departments, institutions, and social groups prepared China's Agenda 21—White Paper on China's Population, Environment, and Development in the Twenty-First Century (hereinafter referred to as The Agenda). On March 25, 1994, the 16th Executive Meeting of the State Council discussed and adopted The Agenda, and formulated China's priority programs to promote the implementation of The Agenda. In 1995, China took sustainable development as a major national strategy and the country was called upon to actively participate in this great endeavor.[24] Jiang Zemin also emphasized that, "We must effectively protect resources and the environment. We must not only organize current development, but also make arrangements for future generations we must not take the path of wasting resources or 'pollution first, treatment later.'"[25] In China's implementation of sustainable development, we not only fully absorbed the concept of sustainable development from an international perspective, but also fully reflected factors specific to China. We gradually began to highlight Chinese innovation in practice, and especially put forward a guide to the establishment of sustainable consumption patterns for the first time. This has touched on the fundamental limitations of capitalist development, indicating that China's sustainable development practices have gradually moved beyond the western concept of sustainable development.Since 2003, the Communist Party of China (CPC) Central Committee has followed the scientific outlook of development in which the ideal of harmonious development of humanity and nature formed the basis of production and consumption patterns beneficial to resource conservation and pollution reduction. The aim is to build a resource-saving, ecology-protecting society to further deepen understanding of the relationship between humanity and nature.

The sustainable development theory has so far made great progress in promoting human environmental protection, but it still has fundamental limitations. The

[24] Jiang Zemin pointed out in his speech at the Fifth Plenary Session of the 14th Central Committee of the CPC: "in modernization, we must take sustainable development as an important strategy and give population control, resource conservation, and environmental protection an important position, so that population growth is suitable to the social development of the productive forces, and economic construction is harmonious with resources and the environment to achieve a virtuous circle." Zemin (2006b).

[25] Zemin (2006c).

passive sustainable development concept has lagged behind the needs of human development; in the twenty-first century, human development is at a historic crossroads, and humanity needs to make fundamental changes to deal with the serious challenges we face after 200 years of industrial expansion. Similarly, we need to make further breakthroughs to overcome the limitations of sustainable development as a development model, and innovatively use the green development concept according to China's scientific outlook of development. We need to move from sustainable development to green development, and gradually open up a modern path of development with Chinese characteristics.

Panel 2.1 China's Agenda 21 (March 1994)

China's Agenda 21, also known as the White Paper on China's Population, Environment, and Development in the Twenty-First Century, is an overall strategy and policy measure that proposes promotion of mutually coordinated and sustainable development of the economy, society, resources, the environment, the population, and education. It is a guiding document and long-term plan for China's national economic and social development.

The agenda contains 24 chapters, 78 program areas, and more than 200,000 words. It has four parts: an overall strategy of sustainable development, sustainable social development, sustainable economic development, and rational use of resources and environmental protection.

The short-term goals of China's Agenda 21 (1994–2000) included: focus on the prominent conflict between the environment and development, take emergency action and lay a solid foundation for long-term sustainable development of major initiatives; stop the deterioration of China's environmental quality, quality of life, and resource inventory and make local improvements consistent with a moderate rate of economic growth; and strengthen capacity building for sustainable development.

Medium-term goals (2000–2010) included: take a series of sustainable development actions to change the mode of development and consumption; improve management systems, economic and industrial policies, technology systems, and social norms for sustainable development.

Long-term goals (2010–) include: restore and improve the regulatory capacity of China's economic–social–ecological system; keep China's economic and social development within the capacity of the environment and resources; find an efficient, harmonious, and modern path of sustainable development suited to China's national conditions; and make appropriate contributions to the global sustainable development process.

Priority programs of China's Agenda 21 address protection of resources and the environment; global environmental problems; population control and socially sustainable development; sustainable development capacity building; and sustainable development of industrial traffic, agriculture, and energy production and consumption.

2.2 The Meaning of Green Development

Green development is based on three concepts: first, the unity of nature and humanity found in traditional Chinese philosophy, which calls for mankind's respect and coexistence with nature to achieve the mutual benefits of the nature and the humanity and maintain a green environment for human beings; second, the Marxist dialectics of nature, which have evolved to become modern materialist dialectics; and third, sustainable development, which has become the development concept of modern industrial civilization. These three concepts, which represent a distillation of ancient human wisdom and the essence of eastern and western civilizations, are blended to create a green philosophy, encompassing nature, history, and development. Green development, in essence, is the scientific outlook of development; it is "…people-oriented and embodies the establishment of a comprehensive, coordinated, and sustainable development concept to promote economic, social, and comprehensive human development."[26]

What is green development? What is the meaning of green development in economic terms? How can it be accurately defined? First, I will disentangle "economic development" from "sustainable development," then I will emphasize the different meanings of "scientific development" and "comprehensive development," and finally I will define green development as scientific development.

Economic development is how nations emerge out of poverty and backwardness in a process of modernization of economic and social life. Economic development means not only expanding the scale of a national economy, but also improving the quality of economic and social life. Economic development has nothing to say about protection of the environment or sustainable development.

Sustainable development means "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[27] Figuratively speaking, sustainable developmentmeans not "killing the goose that lays the golden egg,"[28] i.e., contemporary human development must not leave behind degraded ecological assets or leave it to future generations to clean up its mess. Sustainable development, however, does not reflect the concept of leaving enhanced ecological assets for future generations, i.e., it does not adhere to the idea that "earlier generations plant trees, while later generations enjoy the shade."

Comprehensive development means the transformation of society as a whole in a process that moves a variety of traditional relations, ways of thinking, and production methods in a more "modern" direction. The task of development in the twenty-first century is to promote social transformation and human development,

[26] The decision of the CPC Central Committee on issues concerning improvement of the socialist market economic system (adopted at the Third Plenary Session of the 16th Central Committee of the Communist Party of China on October 14, 2003).

[27] World Environment and Development Committee: Our Common Future, 1987.

[28] Jiang Zemin pointed out: "So-called sustainable development must take into account the current needs of development, but also the needs of future development; it must not sacrifice the interests of future generations to meet the interests of sustainable development of the current generation." Zemin (2006d).

not only raising levels of GDP per capita, but improving the quality of life in terms of health, education, and cultural level. It also encompasses eradication of absolute poverty, improvement of the ecological environment, and the promotion of sustainable human development.[29]

Green development was proposed by the United Nations Development Programme in the *China Human Development Report 2002: Making Green Development a Choice*. The report describes the challenges faced by China in establishing the road to sustainable development. China's development plays a decisive role in maintaining global stability, and the speed of China's urbanization is unprecedented in human history. Green development goals face great challenges and need a set of policies and practices to help implement them; the grand scale and complexity of the task are unprecedented in human history. Although there is awareness of, and a clear commitment to, green development, we need to make correct choices on the road to achieving green development.[30]

The Scientific Outlook of Development In 2003, the Chinese Communist Party proposed at the Third Plenary Session of the 16th CPC Central Committee to "adhere to a people-oriented approach and establish comprehensive, coordinated, and sustainable development and promote economic and social development." Five balanced strategies were proposed, balancing development between urban and rural areas, between different regions, between economic and social undertakings, between humanity and nature, and between domestic development and opening up to the world.[31] The scientific outlook of development means to balance development between humanity and nature by use of the historical dialectical materialist theory based on the reality of China's socialist modernization. The Report to the 17th National Congress of the CPC takes the scientific outlook: "The first prerequisite is development, its core is people-oriented, the basic requirement is overall coordination, and the fundamental approach is holistic."[32] Based on the guiding ideology of the scientific outlook of development, the Chinese government formulated and implemented the 11th Five-Year Plan (2006–2010) and formulated the 12th Five-Year Plan (2011–2015), establishing the largest green development program in history. The scientific outlook of development encompasses the contemporary Marxist dialectics of nature and also the contemporary development of the concept of Marxism. It aims, for the first time, to consciously and correctly understand and deal with the relationship between humanity and nature.

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[29] October 19, 1998, Joseph Stiglitz, Vice President and Chief Economist of the World Bank, in an address to the United Nations Conference on Trade and Development Conference held in Geneva.

[30] United Nations Development Programme: Human Development Report of China in 2002: Green Development To Be an Option, UNDP, 2002.

[31] Decision of the Central Committee of the CPC on Some Issues Concerning the Improvement of the Socialist Market Economy System (adopted at the Third Plenary Session of 16th Central Committee of the Communist Party of China on October 14, 2003).

[32] Hu Jintao: Hold High the Great Banner of Socialism with Chinese Characteristics and Strive for New Victories in Building a Moderately Prosperous Society in all Respects—Report to the Seventeenth National Congress of the Communist Party of China (October 15, 2007).

Column 2.2 Hu Jintao's View on the Relationship Between Humanity and Nature

A large number of facts show that the disharmony between humanity and nature tends to affect the relationships between individuals and between individuals and society. If a seriously damaged ecological environment causes deterioration of people's productivity and living environment, and if resources and energy supplies are overstretched, and if economic development is in conflict with natural resources and energy supplies, it's hard to achieve harmony between individuals and between individuals and society. Now, China's ecological environment is very grim, and some local environmental pollution problems are quite serious. With an increased population and improved living standards, the contradictions of economic and social development and resources and the environment will become more prominent. If humanity cannot effectively protect the ecological environment, we will not achieve sustainable economic and social development, and people will not be able to drink clean water, breathe clean air, and eat safe food, which will inevitably lead to serious social problems. We shall strive to scientifically understand and correctly apply the laws of nature, learn to act in accordance with them, and use nature to serve people's lives and social development in a more scientific manner, and resolutely prohibit the predatory destruction of nature.

(Speech at the Provincial and Ministerial Leading Cadres Seminar to Improve and Build a Harmonious Socialist Society, February 19, 2005)

Green development is a new form of development that uses an integrated approach toward economics, society, and ecology. It is characterized by increasingly rational consumption, low consumption, low emissions, and preserving ecological capital. Based on green innovation, its fundamental aim is the accumulation of green wealth and improved human welfare to achieve harmony between humanity and nature. In essence, green development is the logical result of the scientific outlook of development.

Green development constitutes a profound criticism of, and fundamental break with, traditional "black" development, and inherits and transcends the concept of sustainable development. Sustainable development, as a correction to the excesses of more than 200 years of capitalist industrialization, cannot address the fundamental essence of this developmental paradigm, and so cannot fundamentally change it. The pattern of high consumption and over-consumption is rigidly locked into the social fabric of developed countries, making it very difficult to reduce per capita resource consumption and pollution emissions. However, by adopting green development, developing countries may find a new way to achieve green innovation and avoid repeating the mistakes of the traditional form of development.

Sustainable development requires people to passively adapt to the constraints of nature, whereas green development requires humanity to seize the initiative and launch programs that are in harmony with nature. Sustainable development is based

on anthropocentrism, whereas green development is an integrated system of humanity and nature; sustainable development is based on convergence, whereas green development can support expansion. Sustainable development means not passing on a depleted environment to future generations, but green development means "planting trees now to provide shade for future generations," i.e., adding more inputs and passing on enriched ecological assets.

The implementation of green development depends on several different factors. First, green development needs to create a road leading to an ecology-oriented civilization. Traditional western-style development, characterized by high consumption, pollution, and emissions, is fundamentally driven by capital and built on free competition and self-interested markets; sustainable development is a partial amendment of this traditional form of development, whereas green development marks a fundamental change from the traditional developmental paradigm. Green development is characterized by self-discipline and based on a green market and reasonable consumption. Therefore, traditional paths of development, whether based on the doctrines of Adam Smith, Keynesianism, or monetarism, still focus on adjustments to government and the market. In contrast, green development lies outside the traditional model of development and focuses on the processes of humanity and nature, moving from a wantonly predatory approach to nature to harmony and self-discipline, and from previous economic centrism and the primacy of pure economic interests to comprehensive eco-socio-economic integration and respect for society, humanity, and nature. The Report to the Seventeenth Party Congress of the CPC first proposed that the path of ecological civilization should "stick to the development of production, an affluent life, and a sound ecological environment while following a civilized development road."[33] Thus, economic, social, and natural systems form a united and coordinated trinity on this road to development.

Green development is based on green system theory, i.e., the interdependence and mutual influence of humanity and nature. First, green production theory means saving and investing in resources, improving utilization efficiency, clean production, and the repeated use and recycling of materials. Second, green consumption theory means developed countries moving from over-consumption to moderate consumption, and developing countries moving from low consumption to reasonable and green consumption. Third, green development theory means the promotion of comprehensive and coordinated development between humanity and nature, and between people, as well as permanent and fair human development. Equity is the core value of green development, not just in one area, but comprehensively, including at least four main areas: economic, social, natural, and international equity. International inequity, the largest inequity, has historically exacerbated the other three areas, a fact that has been intentionally ignored and neglected by western countries.

Second, the green path of development is a new path instigated by China. In traditional "black" development, international developments are led by western countries. If China were to go along this road, copying, imitating, and following ev-

[33] Hu Jintao: Hold High the Great Banner of Socialism with Chinese Characteristics and Strive for New Victories in Building a Moderately Prosperous Society in all Respects—Report to the Seventeenth National Congress of the Communist Party of China (October 15, 2007).

ery step, it would overextend not only national resources but also global resources; even several Earths would not be able to meet the huge demand. Therefore, China must be innovative and take the green development path; it must become an advocate, innovator, and leader to provide southern countries with inspiration and demonstrate how the new development path can be followed.

Third, green development is a road of innovation and leaping ahead. Traditional "black" development relies mainly on predatory resource consumption, wanton pollution, and emission of greenhouse gases. It is characterized by pollution first, treatment later; destruction first, repair later; and emissions first, reduction later, and is locked into rigid patterns of excessive consumption, waste, and abandonment. In contrast, green development gives full play to people's initiative; it harnesses the macro-guidance of national strategy, the enthusiasm of local innovation, and the subjectivity of enterprise-level innovation. It accelerates the transformation of economic development and changes the original development path to one that tunnels through Kuznets' curve to achieve a society characterized by high income per capita and low inequity. Green development aims to achieve development decoupled from non-renewable resource consumption, pollutant emissions, and greenhouse gas emissions and to substantially reduce resource, environment, and ecology costs, thereby establishing a new era of sustainable development.

Finally, in essence, green development entails a new set of values and a new development philosophy based on the scientific outlook of development. Modern western economic theory is based on an individual making rational decisions; it pursues increases in the speed and volume of material production in terms of value and derives economic strategies and policies based on consumerism, which leads inevitably to development characterized by high consumption, depletion, and emissions. Over the past 200 years, the industrial revolution guided by western economic concepts has greatly enhanced human material life; however, it has also caused great harm to the living environment. The green development concept, in contrast to the traditional "black" development concept, is a blend of eastern and western cultures, and represents a new developmental paradigm. The green development concept does not focus on the pursuit of rapid material development and boosting volumes and values, it focuses on the quality and cost of development, ecological construction, environmental protection, ecological asset values, and carbon decoupling.

2.3 Green Industrial Revolution: From the First to the Fourth industrial revolutions

2.3.1 Economic Perspective of Green Industrial Revolution

During the development of human society, scientific and technological progress and economic changes go through a "revolutionary" period that has profound effects on human society, the economy, politics, and culture, and these ultimately drive

the advance of human civilization as a whole. Since the mid-eighteenth century, as a result of three industrial revolutions, human society has developed toward industrialization and modernization. Zhang Peigang wrote an article in 1949 titled *Agriculture and Industrialization: Exploration of Industrialization Issues of an Agricultural Country* in which he stated that through "combinations of changes in a range of essential production functions"[34] in the national economy, industrialization can be launched to promote long-term sustained economic growth and changes in social productivity, thus fundamentally changing the socio-economic structure.

Different types of industrial revolutions result from different combinations of strategic production functions. It is commonly accepted that there have been three industrial revolutions, in which the new combinations of strategic production functions involved changes in the following: population size, composition, and geographical distribution; major resources and energy; social system; production technology; and cultivation of entrepreneurial innovation.[35] Therefore, to launch a new industrial revolution, we must promote changes in the strategic production functions.

The first industrial revolution created the "steam age" (1760–1840) and marked the transition from agricultural to industrial civilization; it was a major turning point in the history of human development. Industrialization is, in essence, a qualitative change in the combination of strategic production functions, which initially used coal, rather than muscle power, as the major energy source, thus starting the process of carbon emissions and global warming. Thereafter, in the "electric age" of the second industrial revolution (1840–1950), heavy industries such as electricity, steel, railways, chemicals, and automotive arose and used oil as the new energy source. This revolution promoted the rapid development of transportation, both within and between countries, and a globalized international political and economic system gradually emerged. After two world wars, the third industrial revolution gave rise to the "information age" (1950–2000). Global exchange of information and resources became more rapid and most countries and regions were involved in this globalization process. With further maturing of global political and economic structures, an unprecedented level of development of human civilization was achieved.

However, over the course of more than 200 years, humanity has undertaken unprecedented plunder and destruction of natural resources. In the previous three industrial revolutions, technological innovations continued to promote changes in the combination of strategic production functions, but the mechanism did not reflect equity between humanity and nature or between countries. On the contrary, because of "market failure" caused by externalities, natural resource exploitation and the economic exploitation of southern countries by northern countries have become increasingly serious as technology has advanced. This process has ultimately led to a global economic crisis and the double crises of the ecological environment and climate change.

We are now entering the fourth industrial revolution, the green industrial revolution (Table 2.1). Inspired by Zhang Peigang, I define the green industrial revolu-

[34] Zhang (1984).

[35] Zhang (1984).

Table 2.1 Main features of the four industrial revolutions (1750–2050)

	First	Second	Third	Fourth
Period	1750–1850	1850–1950	1950–2000	2000–2050
Total world population (billion)	0.8–1.1	1.1–2.5	2.5–6.1	6.1–9.3
World GDP (trillion USD)	0.5–0.7	0.7–5.3	5.3–36.7	36.7
Leading countries	United Kingdom	United States, United Kingdom, former Soviet Union	United States, Japan, Europe, former Soviet Union	China, the United States, European Union, Japan, India
Following countries	United States, France, Germany	France, Japan, Australia, Taiwan, South Korea, Hong Kong, and Singapore	China, India Taiwan, South Korea, Hong Kong, and Singapore	Other developed countries
Leading industries	A substantial increase in agricultural productivity, rapid development in manufacturing	Manufacturing, communications, transportation	Rise of the information economy and a dominant service sector	Rise of service sector, knowledge economy, and green economy
Main technologies	Steam engine, cotton textiles, iron, and porcelain	Variety of new products and consumer goods	ICT and nuclear technology	Green energy, technology, building, and transportation
Economic organizations	Emergence of commercial companies	Emergence of large enterprises, international economy began close cooperation	Rapid development of multinational companies and SMEs	Multinational companies, SMEs, network companies, virtual companies
Main energy	Coal	Oil, natural gas	Oil, natural gas, nuclear energy	Rapidly rising proportion of non-fossil energy, declining share of fossil energy
Energy utilization rate	Low	A small increase	Increasing	Significantly increasing
Consumption pattern	Consumption growth	Consumption growth	High and excessive consumption	Moderate and rational consumption
Quality of the environment	Beginning to deteriorate	Continued deterioration	Serious deterioration	Beginning to improve
Carbon emissions	Beginning to grow	Continued growth	Rapid growth	Beginning to decouple or even decline
The gap between humanity and nature	Beginning to expand	Continued expansion	Rapid expansion	Beginning to narrow

tion as follows: a series of strategic production functions[36] undergoes a transition process from natural to green input elements, in which green production gradually becomes dominant and permeates all of society. The consequence of this process is that economic development becomes gradual and is decoupled from natural elements. The green revolution involves the following processes.

Green industrial revolution is a process in which green elements replace traditional "black" elements, and green processes arise from combinations of these elements. From the first to the fourth industrial revolutions, the input elements have changed and become recombined. The new elements supersede traditional elements, and the green industrial revolution simply introduces green production elements (including physical capital and technological capital) into strategic production functions to achieve a substitution of natural elements and the greening of element combinations. The substitution of natural elements and the gradual achievement of a dominant position by green production elements will ultimately result in the decoupling of economic growth from the consumption of natural elements.

The green industrial revolution starts with a green revolution in the strategic production functions of some leading sectors, and this induces the greening of production functions in other sectors. The changes in these leading sectors then gradually spread to the whole of society, and ultimately all elements will be replaced with green alternatives. This means that the strategic production function will mutate into a completely new form, and green processes will become the new paradigm.

The green industrial revolution is a process in which many quantitative changes lead to a partial qualitative change, and then a big shift (i.e., a mutation) occurs. Changes in strategic production functions include both continuous variation (quantitative) and gradual changes (quantitative changes become partial qualitative changes), and finally, rapid "mutation" (complete qualitative change). The strategic production function is in a state of continuous change, step by step, from low to intermediate and to advanced levels, which means that green industrial revolution cannot be said to occur at a specific point in time, but is, in fact, a gradual evolutionary process, with specific performance parameters improving in a long-term continuous process.

The green industrial revolution involves generating and limiting factors. In the process of change, the same elements can come together in different combinations, and the environment may contain "generating" or "limiting" factors with respect to the industrial revolution. Momentum for fundamental growth comes from changes in the system and in technology, which means that innovations in green technology and in the system start a series of continuous changes in combinations of the strategic production function, and such changes will exceed the limiting factors of population growth and scarcity of resources and become dominant. However, technology and systems may have both positive and negative roles, and can change from being generating to limiting factors depending on our awareness and manifestation of green development as it carries out specific institutional functions and creates new technology.

[36] The author refers to the definition of industrialization by Zhang Peigang. Zhang Peigang: The agriculture and industrialization: exploration of the industrialization issues of an agricultural country (Chinese edition), pp. 70–71, Wuhan, Central China Institute of Technology Press, 1984.

From a global perspective, green development and the green industrial revolution will be a fundamental long-term trend in which various factors of production become green or undergo green combination or diversification. From the perspective of production, the green industry will grow rapidly, green energy will provide new sources of power, and the green economy will become a new source of growth; together these factors will combine to create a new industrial paradigm. From the perspective of consumption, developed countries go from over-consumption to reasonable consumption, developing countries go from low consumption to reasonable consumption, and the least-developed countries enhance their consumption. Although the green industrial revolution is currently in its gestation period or infancy, it will soon enter a period of explosive growth, large-scale application, and expansion.

Source of data on the previous three industrial revolutions: Thomas K. McCraw: *Modern Capitalism: Winners of the Previous Three Industrial Revolutions*, Chinese version, Nanjing, Jiangsu People's Publishing House, 2006; Data for the fourth industrial revolution were supplied by the author.

The source of world population data: United Nations Population Database: http://esa.un.org/unpd/wpp/unpp/p2k0data.asp;

The data sources for world GDP (1990, USD): Angus Maddison Database: Historical Statistics of the World Economy: 1–2008 AD, http://www.ggdc.net/maddison/Maddison.htm.

2.3.2 Main Features of the Green Industrial Revolution

Although the third industrial revolution led by western countries was still a "black" industrial revolution, some positive amendments and adjustments did occur in terms of the impact on nature; however, the relationship between humanity and nature is still deteriorating (Table 2.1). The fourth industrial revolution will forge new combinations of strategic production functions, and this means fundamental change compared with the previous three revolutions.

The fundamental distinction is the improvement of the relationship between humanity and nature: in the hunting and agricultural periods of civilization, humanity was, in effect, a slave of nature, but in the era of industrial civilization, humanity, as the "master" of nature, has failed to understand the endless harm it has inflicted by the predatory destruction of natural assets. Nature's "revenge" is becoming increasingly serious; the challenges of global environmental crises must result in humanity embarking on a process of self-reflection, and this creates opportunities for green industrial revolution.

The three previous industrial revolutions set up the mechanism for mankind's plundering of nature. Under the existing international economic order, developed countries plunder developing countries; through the establishment of a global supply chain, highly polluting and energy-intensive industries and production methods have been transferred to developing countries to support the high energy consumption patterns of residents of developed countries. The global financial tsunami

(following the debt crises in the US and Europe) and the climate change crisis constitute dual economic and environmental challenges indicating that the traditional model of development is unsustainable. The gaps between countries and between humanity and nature still continue to expand. Simply relying on the sustainable development concept to make limited amendments is not sufficient to fundamentally reverse this trend; the green industrial revolution is the only path that supports ongoing human development.

I will now discuss the various features of the green industrial revolution from eight perspectives. First, a limited number of countries participated in the previous three industrial revolutions, but the fourth industrial revolution requires the participation of all countries and regions: one reason for this is that the accumulation of greenhouse gases is a global problem, and reducing carbon emissions needs global cooperation and collective action. Because the future growth of carbon emissions will mainly occur in developing countries undergoing rapid economic growth as they try to alleviate poverty, it will be necessary to provide technical and financial assistance to these countries to facilitate a changeover to low-carbon growth to resolve the issue of adverse global changes. In this process, as the largest developing country, China will lead an industrial revolution for the first time.

Second, the combinations of key input elements to the strategic production function will undergo constant change. Leading industries will have to undergo rapid technological innovation, hopefully driven by major breakthroughs in basic theory. Each industrial revolution has different driving forces, typical forms of industry, and representative products. In the first industrial revolution, improvements in the steam engine and its wide use affected key technical parameters of the production function; in the second industrial revolution, key drivers included progress in electrical technology and rail transport; in the third industrial revolution, ICT products and technologies were paramount. Green industrial revolution entails fundamental changes in many wide-ranging fields, including low-power green industries, the greening of "black" industry, the development and utilization of new energy technologies, and development and promotion of various energy-saving and emission-reduction technologies. Green technologies, such as information technology and nuclear technology (which began development in the third industrial revolution), will be more widely used in the green industrial revolution; "black" or "brown" technology, such as the electrical technology that emerged in the second industrial revolution, may become greener as the revolution proceeds. In this process, research and development (R&D) investment accumulates to a certain extent and can promote fundamental changes in the structure of industry. According to the report *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication* released by the United Nations Environment Programme in 2011, investing 2% of GDP in the greening of the global economy could transform the highly polluting, low efficiency "brown" economy into a green economy.

Third, various types of economic organizations will participate in the green industrial revolution; these include traditional economic organizations (such as multinational corporations and SMEs) and also emerging organizations such as network companies and virtual companies. In addition, many non-profit social organizations

will play an important role in the green industrial revolution. At the same time, various social organizations, as well as the state system itself, may promote or obstruct green industrial revolution: those organizations in "green" industries will promote the green revolution, but those in "black" industries may hinder it. Under national institutional structures, it is possible that government decision-making will be "hijacked" by big interest groups that represent "black" industry, and this will pose problems for the green industrial revolution. In the United States, for instance, despite strong physical capital, technological strength, and a pool of talented individuals, and despite government leaders such as former Vice President Al Gore and President Barack Obama who are committed to the promotion of green economic development, slow progress is being made in saving energy and new energy development due to the lobbying power of interest groups sponsored by the oil and coal giants.

Fourth, in the previous three industrial revolutions, exploitation of coal, oil, and other "black" energy sources led to serious greenhouse gas emissions and the global climate change crisis. The fourth industrial revolution is a response to this challenge: it will promote significant fundamental changes in the structure of the energy industry, leading to substantial increases in the proportion of non-fossil energy and a rapid decline in the proportion of fossil fuels. It will also promote rapid progress in, and the wide use of, clean and renewable energy technologies.

Fifth, in building a globalized market, the use of pricing information is increasingly important for resource allocation, and should lead to the generation of advanced resource-saving technologies and improved efficiency in resource use. However, three industrial revolutions have not overcome the inequality and inequity between countries and between humanity and nature; there are obvious regional differences in resource use efficiency, leading to continuous growth in the rate and volume of global resource consumption. The green industrial revolution will significantly and fundamentally improve global efficiency of resource use, not only through technological revolution and innovation, but also through changes in global economic structures and institutional innovation.

Sixth, in the previous three industrial revolutions, the consumption associated with capitalist development has grown exponentially to reach excessive levels; the growth in resource-use and energy efficiency lags far behind the rapid expansion of human consumption. However, the fourth industrial revolution will fundamentally reverse this trend and attain a self-regulating consumption pattern based on introspection to achieve moderate and reasonable consumption.

Seventh, the previous three industrial revolutions directly led to deterioration of the global ecological environment on an ever-increasing scale. In the steam age that emerged in the first industrial revolution, coal burning not only resulted in huge carbon emissions, but also caused serious air pollution. In the electricity age that was fostered by the second industrial revolution, use of oil and natural gas resulted in a relative increase in air quality, but this was offset by rapid increases in production and consumption that continued to increase pressure on the ecological environment. The third industrial revolution gave birth to a new information industry and led to a major readjustment of industrial structures in northern countries, in which low-emission and low-pollution services have become the leading industries. However,

this process also resulted in the deepening and extension of the global industrial supply chain; as a result, northern countries transferred large amounts of industry to the South. Awareness of, and attention to, environmental issues in southern countries lagged far behind those in the North, finally leading to a serious globalization of pollution and the ecological consequences of environmental damage. In the fourth industrial revolution, southern countries will become more clearly aware of the value of ecological assets and be committed to improving the environment. The extensive use of resource recycling, clean production mechanisms, and other new modes of production in southern countries will further enhance the efficiencies of resource and energy use and substantially reduce pollution levels, with countries going from high emissions to low emissions, with zero emissions as the ultimate goal.

Eighth, the previous three industrial revolutions brought about a rapid increase in economic growth and also caused a rapid increase in carbon emissions. The accumulation of these emissions is leading to global climate change, the increasing frequency of natural disasters, and other challenges. The core objective of the fourth green industrial revolution is to promote decoupling between economic growth and carbon emissions and to work toward reducing absolute levels of carbon emissions so as to achieve a global temperature increase of less than 2 °C.

2.3.3 The Most Important Goal of the Green Industrial Revolution: Full Decoupling

As a result of the previous three industrial revolutions, humanity has, in fact, already reached the "limit" of the use of natural assets; economic growth has led to increasingly prominent problems such as the continuous decline of global green welfare, inequalities in resource utilization, and liabilities and costs for pollution of the ecological environment.

Unlike previous revolutions, the green industrial revolution entails a conscious transcendence of the capitalist form of development in an attempt to fundamentally solve the conflicts between human development and natural resources/the ecological environment. We have to change the economic development mode and road map used by mankind since 1750 and attain decoupling between economic growth and carbon emissions. It is also necessary to promote "full decoupling" between economic growth and ecological capital consumption and to narrow the gap between humanity and nature, between people, and between humanity and nations.

The goal of decoupling the green industrial revolution means the adoption of "conscious innovation," rather than "blind innovation" that is only concerned about economic income and is ignorant of the eco-environmental costs incurred by the previous three industrial revolutions. We must take the initiative and respond to the serious conflict/crisis between humanity and nature, minimize humanity's dependence on nature in future development, and eliminate the antagonism between economic development and natural assets.

In terms of carbon emissions, according to estimates of the International Energy Agency (IEA),[37] if greenhouse gas concentrations in the atmosphere are to be stabilized at 450 ppm carbon dioxide equivalent (the so-called "450 scenario program"), global carbon dioxide emissions must peak at 30.7 billion t/year (carbon equivalent) by 2020 and drop to 24–26 billion t/year (carbon equivalent) by 2030 and to 10 billion t/year (carbon equivalent) by 2050, equal to half the amount in 1990 (20.9 billion t/year carbon equivalent). This is a bold global emission reduction target and emission reduction roadmap proposed by an international organization; in other words, if the greenhouse gas concentration in the atmosphere is controlled at 450 ppm, the temperature rise will be constrained to 2 °C and the global climate will remain stable in the long term, thus avoiding dramatic climate change and ecological disaster.[38]

However, if humanity does not fundamentally change the current approach to industrial production and consumption patterns and remains locked into the "black" development pattern, by 2017 the industrial infrastructure will use up all the carbon dioxide emissions allowed in the 450 scenario program.[39] Therefore, the green industrial revolution is the active response to real challenges; its core objective of promoting decoupling between economic growth and carbon emissions can help achieve peak carbon emissions in 2020, followed by a quick and significant drop.

The core decoupling objective of the green industrial revolution involves three aspects: first, to promote the greening of existing "black" or "brown" energy sources, i.e., to decrease pollution intensity per unit of energy consumption, to lower power consumption, and find cleaner ways of using fossil fuels; second, to promote decoupling between fossil energy use and economic output by minimizing the proportion of fossil energy in economic production and consumption; third, to promote substantial increases in the production of non-fossil energy, renewable energy, and green energy until they become dominant.

In addition to the decoupling of carbon emissions, the green industrial revolution also needs to promote full decoupling of the relevant elements of ecological capital, including land, water, and ecological environment resources. To achieve this goal, first the efficiency of resource use must be improved by the combined effects of factors such as technology, institutions, organizations, and investment in physical capital. Then the peak use of various types of resources must be reached as soon as possible, so that declining use can be achieved and finally a "surplus" of eco-capital elements can be established.

From the perspective of North–South differences, in the previous three industrial revolutions, the northern countries plundered the southern countries not only in

[37] IEA: World Energy Outlook 2009, Paris, IEA.

[38] According to the latest Oxfam study, the average number of people affected by global climate change was 278 million in 1997–2008, and will reach 375 million, or a 45 % increase, by 2015. This will pose serious challenges to the global humanitarian response system. An IPCC report also stated that in the next 10 years at least 200 million people will lack drinking water in Latin America, Asia, and Africa. By the mid-twenty-first century, there will be another 130 million people under threat of starvation in Asia. By 2100, crop revenues in Africa will be reduced by 90 %.

[39] IEA: World Energy Outlook 2009, Paris, IEA.

economic terms but also in terms of the ecological environment. As a result, southern countries find themselves at the bottom of the global industrial supply chain and have to accept industry and pollution transfer from the North. At the same time, because of the globalized nature of climate change and the ecological crisis, the South is the first region to suffer its adverse consequences. Taking climate change as an example, the least-developed countries and members of the Alliance of Small Island States (AOSIS) have suffered the worst effects of climate change and have the most urgent need for a global carbon emissions reduction agreement, but their voices are likely to be ignored in the existing global political and economic landscape.

Therefore, the role of the green industrial revolution, especially for developing countries, is to innovate a new model of human development and avoid repeating the mistakes of traditional "black" development carried out by western countries over the past 250 years. Additionally, the gap between the countries of the South and the North and the gap between humanity and nature should be reduced. From the perspective of key specific measures, the green industrial revolution needs to develop green energy, green industrial products, and green consumption patterns; to decouple the strategic production function and carbon emissions; and ultimately to achieve full decoupling between ecological capital and economic development.

2.3.4 The Results of the Green Industrial Revolution: Toward an Era of Green Civilization

The first industrial revolution propelled humanity from agricultural civilization into the era of industrial civilization, and the second and the third industrial revolutions developed industrial civilization, but the green industrial revolution takes humanity into a new green ecological civilization.

Green civilization, a new form of civilization, takes as its basic values the unity of humanity and nature and their mutual benefit. It embodies harmony with nature and it maximizes human net green benefits as its development goal by greening of the economic means, political systems, social life, and cultural values.

A green civilization is inherently fair. The Earth is the mother of humanity, and nature is inseparable from humanity. Human nature is basically kind, and kindness leads to the common prosperity of society; social ideals can expand to encompass all of humanity, but the "unity of humanity and nature" and "green culture" can expand to cover the entire biosphere. With the expanding scale of human civilization, humanity needs a more open mind to embrace the whole of nature; if this does not happen, humanity will not continue to develop, and may not be able to survive.[40]

A green civilization is the correct route for human development in the twenty-first century. Green development is the new master of human exploration for natural, economic, and social laws. Dao (The Way) follows nature"; "The Way" of nature is the only correct way for mankind, and green development is just a "Way"

[40] Toynbee (2001).

for the respect, following of, benefiting from, and protection of nature. The road of economic development is the process of continuous variations of the strategic production function, some of which can lead to qualitative changes or "mutations." The road of green development is the process in which the "black" elements of the strategic production function transition into green elements, as well as the mechanism for transformation and development of the human economy. The process also involves social development, which will move toward a fair, stateless world of common prosperity; green development is the road of poverty eradication, improvement of people's livelihood, and increased green welfare.

2.4 The Three Major Systems of Green Development: Social, Economic, and Natural

Green development is a complex system. Ma Shijun and Wang Rusong pointed out in 1984 that the social, economic, and natural systems have different characteristics, but the survival and development of each system are subject to the other systems' constraints of structure and function; thus, they are considered to constitute a composite system. Ma Shijun and Wang Rusong called it the social–economic–natural complex ecosystem, and it forms social, economic, and natural ecosystems in a given area through synergy with humanity as the subject.[41] This is a holistic system theory proposed by Chinese scholars. Since the beginning of the twenty-first century, this system theory has been used to analyze sustainable development, which is considered to be the intersection of the sustainable economy, the ecological environment, and society. However this picture does not bring out the deeper communication, alternativeness, entirety, dynamism, and scalability of the three components. We put forward the theory of the green development system on the basis that it is a social–economic–natural complex ecosystem.

The green development system is based on the economic, natural, and social systems and emphasizes the full, fair, harmonious, and sustainable development of the three systems. Going from "black" to green development entails the comprehensive transformation of the economic–natural–social system, with the economic system moving from "black" to green growth, the natural system moving from ecological deficit to surplus, and the social system moving from unfairness to fairness. Green development is the intersection and union of two or all three aspects, i.e., of green growth, green benefits, and green wealth, and the ever-expanding process represents continuous green development (Fig. 2.1). This is called the three circles model of green development.

In the green development system, the green economy, green benefits, and green wealth are not isolated and fragmented, but are interrelated, mutually restrained, and interpenetrating. The green development system is dynamic and includes the creativity of the economic system, the vigor of the social system, and the vitality

[41] Ma and Wang (1984).

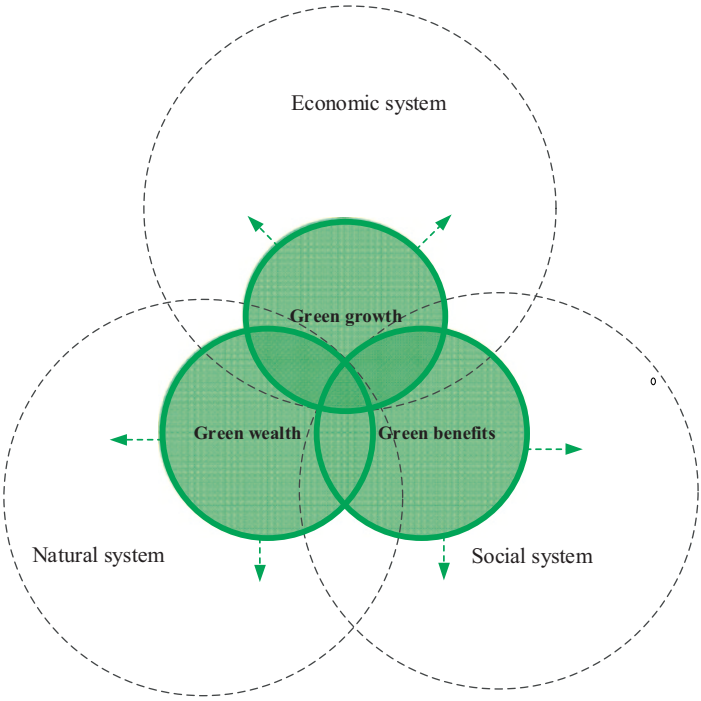

Fig. 2.1 Three circles model of green development

of the natural system. Green development is an open system, and it maintains close contact with the outside world through material and information flows; it mutually interacts with the huge positive externality of the outside world. The green development system pursues the three main objectives described in Panel 2.2.

Panel 2.2 Three Systems and Targets of Green Development

The green development goal of **the natural system** is to move from ecological deficit to surplus. [42] In the natural system, the parts closely related to human production and everyday life include sunlight, air, rivers, minerals, plants, animals, microorganisms, and wealth; these constitute so-called natural capital and exist objectively in nature. They are affected by substance and energy cycles within the natural system as well as by human production and activities.

[42] Ecological capital is material and life wealth by nature to human, in which natural ecological capital refers to the part closely related to human activities objectively existing in nature, including sunlight, air, rivers, minerals, plants, animals, and microorganisms.

In traditional "black" development, rapid development of the human economic system depends on uncontrolled use of resources obtained from the natural system. This leads to the emission of large quantities of pollutants, leading to the ecological deficit of the natural system, i.e., the rate of material and energy loss in the ecosystem is higher than can be borne by ecological self-healing and repair, and this results in the decay of natural capital. In green development, the growth of the human economic system is completely decoupled from resource consumption and pollution emissions. At the same time, humanity invests in natural capital by ecological planning, pollution control, forestry, and water conservation, among others, to establish an ecological surplus, i.e., the rate of loss of material and energy in the ecosystem is lower than that of ecological self-healing and repair. This process results in a continuous increase of natural capital, which is usually reflected by improved ecological environment indicators.

The green development goal for **the economic system** is to change the aim of development from maximizing growth to maximizing net welfare. In the early stages of economic development, there is too much emphasis on expansion of the scale of the economy, but this ignores the quality of growth and its development costs. In the later stages, the development goal does not simply focus on the scale of growth, but considers the quality of growth and its development costs. The development goal becomes maximizing the net welfare of the economic system, i.e., maximizing growth in terms of green GDP, which includes both the quantity and quality of growth, with deduction of various development costs (such as resource, ecological, and social costs.)

The goal for **the social system** is to move to a system of human development based on fairness rather than unfairness, a system in which humanity is both the driving force and the purpose of development. Traditionally, there have been fairness issues in development of the social system—contemporary development has been at the expense of the development of future generations, and development within the current generation has been seriously uneven. In the green development system, social development will focus on the care of vulnerable groups and on equity—equity between contemporary and future generations, and within the current generation. Progress can by indicated by a human development index (HDI) that is adjusted for unfairness,[43] and HDI multiplied by the total population is equal to the generalized human development index (GHDI).

The ultimate goal of green development is the overall greening of the natural, economic, and social systems, i.e., achieving positive welfare values in these systems. Specifically, the ultimate goal of green development is to gradually shift these three systems from an ecological deficit into an ecological surplus; at the same time, the economic system gradually shifts from

[43] The United Nations Development Programme: Human Development Report 2010.

maximizing growth to maximizing net welfare, the social system shifts from inequity to equity, and social welfare is no longer maximized for part of the population but for the entire population.

Progress in green development will need to be measured. Based on its theoretical system framework, we will achieve green growth, green welfare, and green wealth (corresponding to the economic–social–natural system), which require the establishment of a green economy index, a green welfare index, and a green wealth index.

The **green economy** refers to a new market-oriented economic form (based on the traditional industrial economy) with the purpose of economic and environmental harmony as part of overall green development. It constitutes a form of development in which industrial economy is adapted to human environmental and health needs. The term "green economy" can be applied to a small specific economic unit, the economy of an entire country, or even the global economy as a whole. "Green economy" contains two meanings: first, the greening of the entire economic system, i.e., the reduction of energy and resource consumption, pollution emissions, and carbon emissions, ultimately to achieve decoupling of economic activity from pollution emissions and resource consumption; second, the increasing proportion of green economy in the overall economy, i.e., the relative amounts of green technology, green energy, and capital-driven low-power industry increase to adapt to human health and environmental protection throughout the entire economic system.

Green welfare refers to continuously improving human health, security, and quality of life achieved as part of overall green development. The development of the social system is, in essence, the development of humanity. Humanity is the driving force and the purpose of development. Green welfare is fundamentally the pursuit of human development. Specifically, it includes three aspects: first, the development of human security refers to an individual's freedom to make choices free from external pressure or the threat of violence. This requires improvement of the relationship between humanity and nature, which will enhance our ability to resist natural disasters, reduce the frequency of natural disasters (and the associated personal losses and losses of human capital), as well as to maintain social stability under the framework of democracy and the rule of law. National public power will need to be constrained to avoid the possibility of social violence and to protect personal fundamental freedoms and rights. Second, the development of human health requires a healthy and stable society, in which the population has adequate food and water, enjoys sanitation and wealth, and is free to achieve self-growth and personal development. To realize this, the natural environment will need to be protected, environmental pollution and human disease will need to be reduced, poverty eradicated, employment created, and investment in human resources enhanced. Third, overall human development means an improved and developed quality of life in an equitable environment. Specifically, it includes fair horizontal development within the current generation, and fair vertical development between current and future generations. This entails

care for vulnerable groups through improvement of social distribution systems and welfare systems within the social system, adherence to equity and justice in social philosophy, continuous reduction of social inequity, and achievement of common development, prosperity, and wealth to maximize social welfare.

Green wealth refers to aspects of the natural system that are closely related to human production and activities; these include sunlight, air, rivers, minerals, plants, animals, and microorganisms. Compared to economic benefits, green wealth is an invisible but more precious material basis for human survival, production, and living, and it can also be considered a part of human wealth. However, because of its hidden nature, green wealth in the traditional development mode is neglected in the long term. The dominant growth of the human economy is often at the expense of invisible losses of green wealth, and these losses may cause a decline in overall levels of wealth. Green wealth can be accumulated in two ways: one is the full decoupling of economic growth from non-renewable resource consumption and pollutant emissions (this means reducing excessive resource depletion to facilitate a natural system of self-repair); the other is to nurture nature by functional regional planning and in other ways, and to exchange physical and technology capital investment for ecological capital, thereby increasing green wealth.

2.5 The Wealth of Green Development: From Nominal GDP to Green GDP

What is wealth? In a Chinese dictionary, wealth is defined as "things with value." In the *Dictionary of Modern Economics* edited by the famous British economist David W. Pearce, wealth is defined as "anything with market value to be used to exchange money or goods, including substance, physical assets, financial assets, and personal skills to generate income, which are considered wealth as they are exchanged for goods or money in the market. Wealth can be divided into two main types: tangible wealth refers to capital or non-human wealth; intangible wealth is human capital. All wealth has a basic property of generating income, and income is a benefit of wealth. Therefore, wealth is a stock concept, but income is a flow concept in which the present value of the flow income constitutes the stock value of wealth."[44] Usually we also divide wealth into personal wealth and the sum of all household wealth, or the total wealth of the nation or society.

Despite the constant pursuit of wealth and the creation of wealth, it is still not clear exactly what wealth is. How should it be measured? How is it created? Its meaning is not entirely clear in terms of the three important green indicators and green systems. During the 1930s and 1940s, Simon Kuznets (1901–1985) led research on national income accounting for the US Commerce Department and created the GNP indicator and its accounting system. The United Nations' *System of*

[44] David W. Pierce: Dictionary of Modern Economics, 1981, Macmillan, revised in 1983.

National Accounts 1993 has now become the blueprint of the world's official statistics, in which GDP is used as the yardstick. GDP has become the greatest invention of the twentieth century to measure economic wealth, but it has great defects and its use is questionable. In the 1990s, the United Nations Development Programme (UNDP) took on board the human development thinking of Amartya Sen (winner of the Nobel Memorial Prize in Economic Sciences in 1998 and a most distinguished economist and philosopher) and created the human development index (HDI), which goes beyond the economic wealth represented by GDP to include a wide range of human factors such as health and education; the annual *Human Development Report* publishes each nation's HDI. As a measure of the total welfare of human development, I define the total global value of human development (GHDI) by multiplying HDI by the total population.[45] In the late 1990s, the World Bank first put forward the genuine domestic savings concept and its method of calculation, an accounting method for green GDP. This is an indicator accounting for the total value of newly created genuine national wealth with a deduction of the natural capital cost, and is the second major innovation of GDP. Even with these new measures, however, the understanding and measurement of human wealth are still asymmetric and incomplete in terms of information, understanding, and knowledge.

In fact, the total wealth of humanity is not only economic wealth, but includes social and ecological wealth. Strictly speaking, GDP only represents economic wealth. HDI represents social wealth; in particular, HDI adjusted for inequality represents social equity.[46] Human wealth includes natural wealth, but so far a natural wealth account has not been built to clearly express and measure it. Therefore, total human wealth includes the sum of continuously accumulating wealth in the development processes of the economy, society, and nature.

The accumulation of human wealth is not only additive but subtractive, because development "is not a free lunch": different modes of development have different costs, thus leading to different net incomes. From the perspective of net welfare, net human wealth is represented by the following formula:

$$\begin{aligned}\text{Net human wealth} &= (\text{economic wealth} - \text{economic costs}) \\ &\quad + (\text{social wealth} - \text{social costs}) \\ &\quad + (\text{natural wealth} - \text{natural losses}) \\ &= \text{total wealth of mankind} - \text{total costs}\end{aligned} \tag{2.1}$$

There are three types of total costs: (1) economic costs, the dominant cost is usually calculated through the system of national accounts; (2) social costs, the implicit cost is difficult to calculate because it includes such factors as social injustice, social conflict, poverty, and corruption; and (3) natural costs, such as ecological destruction, environmental pollution, losses resulting from natural disasters, and climate change impacts. Therefore, the development objective function is not only to maxi-

[45] Hu (2007).

[46] UNDP: Human Development Report 2010, UNDP.

mize development gains, but also to minimize development costs. Calculation and measurement of human wealth include addition and subtraction, with economic costs, social costs, and natural loss being deducted.

Net human wealth has a simple formula, but it is actually difficult to measure. We propose three different concepts and key indicators for use by national economic accounting systems:

First, nominal GDP comes from the United Nations' System of National Accounts. Nominal GDP does not take into account natural costs, and in this sense, it really is the *nominal* GDP. Thus, Agenda 21, adopted at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, highlighted the limitations of nominal GDP and required nations to "expand existing systems of national accounts in order to integrate environmental and social issues to the accounting framework."

Second, genuine GDP was proposed by the World Bank in 1997 based on the system of green national accounts.[47] It refers to a nation's genuine savings rate with deduction of natural resource depletion (especially non-renewable resources) and environmental pollution according to the following formula:

$$\begin{aligned}\text{Genuine GDP} = {} & \text{nominal GDP} - \text{natural asset depletion} \\ & \left(\text{energy depletion} + \text{forest depletion} + \text{mineral depletion}\right. \\ & \left. + \text{emissions of particulate matter} + \text{CO}_2\text{emissions}\right) \\ & + \text{education expenditure}\end{aligned} \tag{2.2}$$

The accounting system of the World Bank requires measurement of the genuine savings rate for the first time, and also considers natural assets losses, i.e., depletion of natural assets;[48] it also takes into account the substitution of natural capital by human capital (expenditure on education). The genuine savings rate calculated based on Eq. 2.2 is less than the nominal savings rate, thus showing for the first time how "invisible natural loss" has offset traditional economic wealth; raising the genuine GDP means decreasing the loss of natural assets and/or increasing investment in human capital.

Third, green GDP summarizes the author's understanding of the theory of green development and human wealth and makes an important supplement to the World Bank's genuine GDP.[49] The measurement of green GDP adds four key indicators:

[47] World Bank: Expanding the Measure of Wealth: Indicators of Environmentally Sustainable Development, the Environment Department, the World Bank, 1997.

[48] Natural resource depletion includes energy depletion, mineral depletion, net forest depletion, and particulate emissions damage. Depletion of natural resources is measured based on the rental value of mining and natural resources, which is the difference between the producer price and the total production cost based on world prices, including depreciation of fixed assets and return on capital.

[49] The author believes that under the opening-up environment, domestic and international resources may increase the external natural capital input (net import of primary products). (Hu and Wang 2005).

$$\begin{aligned}\text{Green GDP} = {} & \text{nominal GDP} - \text{natural losses} + \text{investment in human capital} \\ & + \text{green investment} + \text{external natural capital input}\end{aligned} \tag{2.3}$$

Specifically, the formula can be expressed as:

$$\begin{aligned}\text{Green GDP} = {} & \text{nominal GDP} - \text{natural asset losses (energy depletion} \\ & + \text{forest depletion} + \text{mineral depletion} + \text{particulate matter emissions} \\ & + \text{CO}_2\text{emissions)} - \text{natural disasters losses} \\ & + \text{investment in human capital} \\ & \text{(education expenditure} + \text{health expenditure} + \text{R \& D expenditure)} \\ & + \text{green investment (eco - construction} + \text{environmental protection} \\ & + \text{energy saving)} + \text{external natural capital input} \\ & \text{(net imports of primary products)}\end{aligned} \tag{2.4}$$

The first new item is natural disasters losses and this reflects a core indicator in the *National Disaster Prevention and Mitigation Plan (2011–2015)*, namely, that the average annual direct economic losses caused by natural disasters as a proportion of GDP should be controlled to less than 1.5%. This figure was based on losses in the period covered by the Eleventh Five-Year Plan (2006–2010), which amounted to 1.6% of GDP. The implication is that, to a certain extent, disaster reduction means an increase in green GDP.

The second new item is the human capital indicator, which reflects a proposal of the *National Long-term Talent Development Plan* (2010–2020).[50] The human capital indicator includes three factors: expenditure on education, expenditure on health, and expenditure on R&D. The Plan also clearly states that investment in human capital as a proportion of GDP should increase from 10.75% in 2010 to 15% in 2020,[51] which constitutes the total human capital investment of China, reflecting national intellectual capital investment to some extent and helping to increase green wealth.

The third new item is green investment, which refers to increased investment in natural capital. It includes three indicators: (1) investment in ecological construction, such as forestry, soil erosion governance, and water conservancy construction, which means more ecological capital; (2) investment in environmental protection,[52] which means less discharge of pollutants; and (3) investment in energy saving,[53]

[50] The author directly participated in the design of plan objectives and indicators.

[51] National Long-term Talent Development Plan (2010–2020) (June 6, 2010).

[52] Vice Premier Li Keqiang pointed out in the Seventh National Environmental Protection Conference that "It is expected that the output value of the energy-saving environmental protection industry will reach 12 trillion Yuan in the 12th Five-Year period, a significant increase over that in the Eleventh Five-Year period." Xinhua News, Beijing, December 20, 2011.

[53] According to data provided by the Zero2IPO Research Center, Chinese investment in clean energy grew 30% to US$ 51.1 billion in 2010, the largest amount invested inglobal clean energy

which means increased energy efficiency and reduced greenhouse gas emissions. The total physical capital investment mentioned above is an alternative to natural capital, and thus increases the flow and stock of natural capital.

The fourth new item is the import of external natural capital. Based on the openness of the green development system and the reality of the shortage of resources in China, the increased net imports of primary products add natural capital from the outside; under the opening-up environment, the change from the use of domestic resources at domestic prices (domestic market equilibrium price) to the use of world resources at international prices (world market equilibrium price) will greatly improve the utilization of domestic resources and will directly reduce energy resource depletion, representing an increase of domestic green GDP.

Physical investment in human capital and the ecological environment is an alternative to domestic natural capital, which reflects the fact that green human development will not deplete nature but will nurture and benefit it. Taking into account the input of external resources from the world market, green GDP calculated by the new formula can be greater than the genuine GDP. The formula makes up for the shortcomings of the World Bank's accounting system, which does not consider human capital, green investment, and external natural capital input under open conditions.

The green GDP formula has practical significance and policy implications. First, it increases the importance of losses from natural disasters in two respects, i.e., the depletion of natural assets and natural losses. This means that it is important to increase comprehensive disaster prevention and mitigation investment and to significantly reduce natural disaster losses. Second, the increase in human capital investment may improve resource use efficiency, improve the ecological environment, and enhance innovation in green technology. Third, the increase in ecological environment investment may directly increase domestic natural capital. Fourth, the increase in external natural capital investment may promote the international trade of different primary products, which would help to increase not only scarce domestic natural capital, but also increase the world's natural capital and its utilization efficiency.

In fact, the formula for green GDP means not only the simple accumulation of several types of capital, but also the profound logic of intercombination and intersubstitution of elements. According to the theory of green development, it is easy to identify minimal GDP (physical capital) and natural, human, and external natural capital inputs (international capital). These items belong to the economic, social, and natural systems and have strong connectivity; therefore, they may be mutually substituted and converted, which ultimately is shown as the conversion and recombination of elements.

The significance of green GDP lies not only in the calculated "invisible" natural losses (including loss of natural assets and natural disaster losses), but also in

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by any country.

http://www.chinabidding.com.cn/zbw/zxzx/zxzx_show.jsp?record_id=7057118

The National Energy Administration stated in The Emerging Strategic Industries Plan: from 2011 to 2020, the Chinese new energy industry will increase cumulative investment to RMB 5 trillion. China Economic Herald, December 31, 2011.

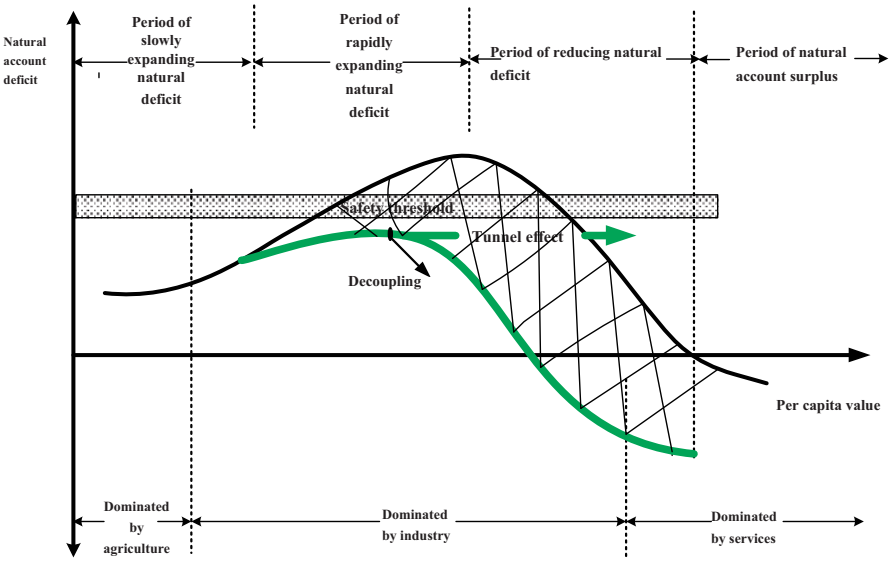

Fig. 2.2 From natural deficit to surplus

"visible" physical and human capital investment. This approach should lead to an increase in natural capital and help change the natural system from an ecological deficit to an ecological surplus, an important milestone on the road to green development.

2.6 Stages of Green Development: From Ecological Deficit to Surplus

Nature is the cradle of life and the basis for human survival and development. Nature, as a special asset, offers a variety of services to humanity, including life-support systems to maintain human survival and development. The evolution of the relationship between humanity and nature is a very long historical process, and also a very complex process of understanding and development.

The various stages of economic development are determined according to per capita income and GDP, and per capita income is divided into low, lower-middle, upper-middle, and high income brackets. According to the Engel coefficient, the stages are absolute poverty, provision of basic food and clothing, well-off, wealthy, and wealthier. Based on HDI, the stages of human development are defined as low, middle, upper-middle, and high. However, these economic and social indicators cannot fully reflect the green development stage. According to green development theory, we generally divide the relationship between humanity and nature into four periods (Fig. 2.2).

The first period is when the ecological deficit is expanding slowly. It is the stage of primitive agricultural civilization, in which people worked hard to maintain a self-sufficient life-style based on small-scale production. During this period, with population growth, humanity started to destroy the natural system as the economic and social systems slowly expanded.

The second period is when the ecological deficit expanded rapidly. It is the stage of industrial civilization, with large-scale machine production replacing subsistence farming and handcraft workshops. The ever-changing modes of production and the improved relations of production greatly promoted the development of the productive forces and the rapid expansion of economic and social systems. However, at the same time, the development of excess consumption and the throw-away society also led to major ecological crises and rapid expansion of the ecological deficit.

The third period is when the ecological deficit begins to narrow in the late stage of industrial civilization. With the worsening of the human ecological crisis, humanity has begun to modify its approach to development and has taken the initiative to narrow the gap between humanity and nature. The ecological deficit is gradually being reduced and the vicious circle of "mutual harm of humanity and nature" has been broken.

The fourth period is when the ecological deficit is turned into an ecological surplus. This represents the ecological civilization stage of human development, when humanity seizes the initiative to narrow the gap between humanity and nature, leading to balanced ecological accounts and the achievement of the unity of humanity and nature. This is the realm of coexistence, prosperity, and harmony when humanity intuitively nurtures nature, creating eco-account surpluses to the mutual benefit of humanity and nature.

The changing relationship between humanity and nature depends on the period and the level of human development, but is also greatly affected by the form that development takes and the path that is follows. If the traditional development path is followed, i.e., "black" development, humanity will reach peak ecological deficits with high levels of per capita income late in industrial civilization. Thereafter, humanity may gradually modify the development mode and rely on advances in technology and production methods to achieve gradual economic development, reduced resource consumption, and decoupled pollution emissions, thus entering a period of narrowing ecological deficit. However, the traditional development path allows extremely limited tolerance and accommodation of natural systems. The cumulative environmental load built up over thousands of years of human civilization, and, in particular, over the 200 years of industrial civilization, has resulted in our living on a ravaged planet. If humanity continues to follow the traditional development path, the safety thresholds of natural systems may be exceeded, resulting in unimaginable disaster for humanity and the world. Following the path of green development is a way to avoid this disaster.

The green development path aims to achieve peak ecological deficits as soon as possible at the stage of relatively low per capita income, and then to rapidly reduce the ecological deficit and "tunnel through" Kuznets' curve to achieve a society characterized by high per capita income and low inequity. The deficit peak

should appear earlier under green development; in addition, the peak should have a relatively smaller amplitude and result in reduced accumulated system losses.[54] Thus, the conflict between humanity and nature will be eased earlier, and the era of decreasing ecological deficit will be achieved before the safety thresholds of natural systems are reached.

Specifically, the tunneling effect of green development allows full decoupling of economic development from the consumption of natural wealth, and humanity will progress from local to overall ecological surplus, fundamentally reversing the trend of deterioration of the ecological environment. The specific areas in which decoupling is anticipated and their benefits include: (a) a significantly improved ecological environment, with total coal consumption reaching a peak and decoupled from economic growth; (b) the effective protection of water resources, with decoupling of total water consumption from economic growth; (c) the slower growth of carbon dioxide emissions, leading to decoupling of carbon dioxide emissions from economic growth; (d) basically unchanged arable land area, leading to decoupling of new arable land occupation and economic growth; (e) reduced ecological degradation, including soil erosion, desertification, rocky desertification, and destruction of vegetation; and (f) comprehensive improvement of environmental quality resulting from continuously decreasing industrial and domestic pollutant emissions and waste generation, with levels finally falling within the limits of environmental self-purification, thus ensuring that future generations can enjoy blue skies, clean water, and green mountains.

Green development will give full play to the subjective initiative of the populace through political will, institutional arrangements, cultural training, international cooperation, and other means. Green development will mark a huge change from the traditional path of development that relies solely on material accumulation and technological progress to promote the progress of human civilization. For the first time in the history of human civilization, we will change from blind to conscious development and from irrational to intellectual development; humanity will stride on to a new stage of ecological development. This development path is essential to achieve green policies and promote green technology and to enter the new stage of green human civilization as soon as possible, before any more damage is done.

Objectively speaking, economic development and human development are historical processes that can be divided into different stages according to various indicators. In this way, people are made aware of the different characteristics of the various stages, but the development and stages are incomplete, so only the embedded relationship between humanity and nature may correspond to the four stages of green development. Of course, the high-income stage or high human development stage may facilitate access to the stage of narrowing ecological deficits or ecological surplus. A developing country can choose from alternative development strategies and enter the stage of narrowing ecological deficit or ecological surplus

[54] As shown in Fig. 2.2, the area under the green development curve is much smaller than that under the "black" development curve. The shaded area is the difference and represents the different cumulative losses of natural systems resulting from "black" and green development.

ahead of developed countries while at a relatively low stage of economic and human development. China will be able to achieve this goal through implementing green development and innovation.

2.7 Green Innovation and the Tunneling Effect

How can the transformation from "black" to green development be achieved? How can the green tunneling effect be achieved? What methods are needed to achieve green development? What approaches are included in green development?

Specifically, there are three methods to promote green development, i.e., green innovation, green institutional arrangements, and green cooperation; of these, green innovation is the fundamental factor. Because green innovative elements can act as alternatives to natural elements, economic development may become decoupled from natural consumption, and a green tunneling effect may result. Green institutional arrangements constitute the motivating factor, and only reasonable institutional arrangements can provide effective system incentives and promote the transition to green development from "black" development. Under the opening-up policy, green cooperation is a major international factor in the promotion of green development.

Green innovation is the fundamental driving force for promoting green development: it contains three component parts. The first part is green concept innovation, which is essential for introduction of the concept of green development beyond the traditional industrialized approach of "pollution first, treatment later." The idea is for developing countries to enter the stage of green development while still in the period of low per capita income. Green concepts can help people change their thinking about "pollution first and treatment later," leading to self-regulation of economic system production and consumption and environmental protection, as well as improved ecological protection concepts and awareness. Green concepts require not only political consensus, but also wide acceptance among the general public. The second part is green technological innovation that will improve the production quality of the economic system, enhance the efficiency of resource utilization, and boost the environmental governance capacity of natural systems. Green technological development will be achieved through enhanced human wisdom and innovation, and thus investment in human capital is the key to green technological development. Green technological development is still market-oriented, but strong government support contributes to further development of green technology. The green industrial revolution brought about by application of green technology can be speeded up by use of both domestic and foreign resources; countries should strive to maintain self-reliance while actively introducing advanced foreign technology to achieve substantial breakthroughs in new sources of energy and materials. The third part is green market innovation, in which green low-carbon lifestyles and consumption patterns are encouraged and promoted. Resource conservation, pollution reduction, and recycling will be required; these will be guided by government policies, with enterprises as the actors, and be driven by the market. In the future, China will

become the world's largest green market and the largest producer, consumer, and exporter of green products and services.

Green institutional arrangements. As a core way to achieve green growth, green policies and systems can affect the combination of elements contributing to development. Green institutional arrangements constitute the basic method for element polymerization to provide positive incentives for green development. These arrangements fall into three areas: (a) *the constraint system* implements policies, including the core financial and regulatory environment, to encourage efficient use of natural resources and to increase pollution costs, thereby maximizing the efficiency of resource allocation as a part of proper design and implementation. The policies include price-based instruments and other policy instruments such as taxation and competition policy that can effectively improve the efficiency of element allocation to avoid under-emphasizing nature during policy formation, and curb the tendency to excessive consumption and use. (b) *The innovation system* works at the level of technological innovation and provides positive incentives to green development, including improvement of the efficiency of resource use and reductions in pollution emissions. (c) *The green industry system* refers to the generalized framework of industrial development to promote economic growth and protect natural capital. To encourage the expansion of green industries, the economic policy agenda must focus on both environmental and economic benefits. Through policies and institutions, China should fully use the advantages of its socialist system, i.e., alignment of central and local governments and alignment of the state and the market, to constrain traditional "black" development and to stimulate green transformation.

Green co-operation is an important impetus for green development. Green development represents an open framework in which the systems are closely connected by flows of goods, pollution, personnel, and technology. This means that green development is not only a regional or national phenomenon, but must become a common global trend. No nation or region can solve the problems of environmental degradation on its own. Green development is not for the regional public good; its reach must be global. The problems that green development must tackle are trans-regional (e.g., environmental pollution) and must be resolved by co-operation. Green co-operation can help ensure adequate flows between elements and improve the efficiency of green development for all of humanity and the planet as a whole. China, with its vast territory and huge population, and as a permanent member of the UN, should promote inter-regional cooperation and coordinate support for the green development path. China must take the initiative to promote green international cooperation, lead the world green trend, and become a pioneer and leader in green human development.

2.8 The Contents and Pathways of Green Development

What are the main concepts and approaches relating to green development? These are matters that I am concerned about and have extensively researched. In 1989, the National Situation Research Group, Chinese Academy of Sciences, of which I was a

part, believed that China's road to modernization could only be a new development mode adapted to China's prevailing national conditions; the Group sought a unique way to develop the productive forces of socialist China. I call this the "non-traditional modern development mode," and its core idea was to implement a production system based on low consumption of resources, with lifestyles consistent with moderate consumption, an economy pursuing steady economic growth, and continuous improvement of economic benefits. The social system was intended to ensure social innovation and equity; the technology application system was intended to continuously innovate and fully absorb new technologies, processes, and methods; the more open trade and non-trade international economic system was intended to promote close contact with the world market and to promote the rational utilization of resources to prevent pollution and protect the ecological balance.[55] This latter point turned out to be the earliest source of the idea of green development.

How do I think about and try to promote the path of green development more than 20 years later? Based on the contents and description of China's 12th Five-Year Plan,[56] I will introduce the contents and methods of "Chinese-style" green development.

Vigorously Develop Green Industry Development of green industries, such as forestry, may create employment, increase farmers' income, and increase forest coverage and carbon sink capacity. Other important aspects are fostering the development of new energy, renewable resources, new energy sources for vehicles, new materials, energy saving and environmental protection, and other emerging strategic industries. It is also important to accelerate the elimination of outdated technologies, products, businesses, and industries; high energy consumption; and pollution. Finally, the development of modern services, especially information-, knowledge-, and employment-intensive services, must be fostered to form a new low-carbon, green modern industrial system led by a modern service industry.

Build Green Production Systems With the aim at improving the efficiency of resource outputs, and following the principles of "reduce, reuse and recycle," we will promote the development of a circular economy of production, distribution, and consumption and build a resource recycling system covering the whole of society. We will also implement recycling-based production methods, greatly enhance resource utilization, accelerate the implementation of cleaner production, promote eco-design, and improve comprehensive resource utilization. We will need to improve the resource recycling system, involving such aspects as renewable resources, remanufacturing, garbage recycling, kitchen waste utilization and safe disposal, and an "urban mineral" demonstration base to dispose of waste metal, electrical and electronic products, paper, plastics, and other renewable resources, with both large-scale and high-value usage. This involves encouraging businesses and industrial parks to develop a recycling economy. It is also important to

[55] National Situation Research Group, Chinese Academy of Sciences, Hu Angang, Wang Yi: Survival and Development, Beijing, Science Publishing House, 1989.

[56] Zhang (2011).

eliminate by law high energy consumption, high-energy products, and high-energy production capacity and to strictly limit the development of major high-energy-consuming industries (e.g., iron and steel, building materials, non-metallic mining, and the chemical and petrochemical industries).[57] Overall, we must continue to reduce energy consumption per unit GDP and water consumption per unit of industrial added value and control total energy consumption, water resources, and groundwater.

Develop Green Technology and Standards To innovate and develop green technologies, it is necessary to implement technological innovation under green standards; to encourage the introduction and use of all aspects of green technology; and to develop green technologies through original innovation, assimilation, absorption, re-innovation, and integrated innovation. These will apply to agricultural, industrial, construction, water-saving, and ecological environment-protection technologies. We must also develop and enforce all kinds of standards and designated systems of green, low-carbon, energy-saving, emission-reducing, and environmental protection technology. Another important aspect involves establishing and improving the statistics and accounting systems for energy production and consumption and greenhouse gas emissions.

Actively Promote Green Consumption Governments and public institutions will take the lead in energy saving, emissions reduction, and green procurement. They will also promote green food and medicine, smart energy-efficient appliances, energy-saving environmentally friendly vehicles, energy-efficient lighting products, energy- and land-conserving housing, and green buildings.[58] It will also be important to create green businesses, schools, and communities; build green cities; and give priority to the development of urban public transportation systems, the development and popularization of hybrid cars, alternative fuels, and electric vehicles. The development of national and regional intelligent transportation systems will also be encouraged.

Encourage Green Investment and Credit Public investment will give priority to ecological construction, environmental protection, energy-saving, emissions reduction, and disaster prevention and mitigation. Non-governmental sector investment in the above areas will be encouraged by tax reduction, financial discounts, and other incentive policies. Full play will be given to "green finance," the active

[57] High energy-consuming industries are defined as those in which the proportion of energy consumption with respect to total industrial consumption is more than 1.5 times the proportion of their industrial output with respect to total industrial output. For example, the three major sectors of China (iron and steel, building materials and non-metallic mining, and the chemical and petrochemical industries) accounted for only 1/5 of industrial added value in 2005, but their energy consumptions accounted for 2/3 of total industrial energy consumption. (IEA 2007)

[58] Green buildings are those in which green processes are used throughout the whole lifecycle of the building, i.e., maximized energy and resource savings, promotion of the use of renewable energy, protection of the environment and reduction of pollution, and the provision of a comfortable, healthy, suitable, and efficient space in harmony with nature.

implementation of the "equator principles,"[59] the guidance of capital flow into industries that focus on resource-saving technological development and ecological environment protection, and the guidance of consumers' conception of green consumption.

Develop Green Energy It is necessary to continuously improve the proportion of renewable energy, significantly reduce the proportion of high-carbon energy, limit total coal consumption, enforce the clean use coal and the desulfurization and denitrification of coal-fired units, and continue to reduce the proportion of coal consumption and the emissions intensity of coal carbon and sulfur. It is also important to impose energy consumption reduction indicators on per-unit product output of high-energy industries on average every five years. These will act as industry standards and market access thresholds for energy consumption reduction.

Build Green Ecological Systems Necessary ecological construction includes protection of natural forests, restoration of farmland and grazing land to forest, sandstorm source control, soil erosion control, wetland protection, and control of desertification. All of these and more will be required to effectively curb the trend toward ecological deterioration and to increase the nation's natural capital.

Implement Green Policies and Reforms We must establish, develop, and enforce the "polluter pays" system and increase the standards and rates levied for sewerage and garbage disposal. It is also important that we design and implement green fiscal reforms, rationalize the tax burden on resources (levied at the ad valorem rate), and introduce environmental taxes, pollution taxes, and a carbon tax. On top of this, we must continue to implement green price reforms, promote water and electricity price reforms, implement tiered prices for residential water and electricity, adjust the tariff system to charge different prices at different times of day (to reducing peaks and fill valleys in the demand curve), and promote oil price marketization. Further reforms include improving the policy, evaluation, legal, and compensation systems conductive to resource saving and environmental protection; the introduction of market mechanisms to establish and improve mining rights; the enforcement of payments to use emission permits; and the establishment of an emissions trading system, including a carbon emissions trading market.

Implement Green Trade To develop and promote green trade, it is necessary to actively expand the import of primary products, increase the nation's natural capital, take full advantage of new technology for energy saving and environmental protection, vigorously develop products for export in compliance with international environmental standards, and prevent the transfer of pollutants. We must also actively participate in international cooperation and abide by international environmental conventions so as to greatly improve the global environment.

[59] The "equator principles" require financial institutions to assess projects that may affect the environment and society, and to use financial leverage to promote the project's active role in environmental protection and harmonious development.

Green International Cooperation It is important to actively participate in, and take the initiative in, promoting global energy and climate governance, as well as championing international green cooperation. The scope includes actively participating in global energy governance, strengthening the dialogue mechanisms associated with energy strategy and security, and participating in the formulation of international rules. Under the principle of "common but differentiated responsibilities," we must take the lead in global compliance with international conventions; perform measured, reportable, and verifiable mitigation actions; increase information transparency; actively participate in international mechanisms to tackle global climate change [such as the United Nations Clean Development Mechanism (CDM) projects][60]; and not only fight for space for development and safeguard national interests, but also take the initiative in reducing emissions and maintaining the nation's international image. It is also necessary to support and help measures leading to emission reductions in developing countries, such as funding for the United Nations Global Environment Facility and provision of official assistance to fragile states (e.g., some African countries, the least-developed countries, small islands, and other adversely affected countries) to help them improve their ability to adapt to climate change. Finally, we must encourage Chinese enterprises to help develop the low-carbon economy abroad.

In short, green development is a new form of development that lacks off-the-shelf solutions and a body of experience to draw from; it requires bold and science-based innovation. It also fundamentally changes the relationship between humanity and nature: "black" development means increased conflict between economic development and environmental protection, but green development is a win–win for economic development and environmental protection; "black" development is a dead-end for human development and nature, but green development is a win–win for human development and nature. In addition, China, a nation with a huge population, has highly uneven regional development; therefore, China needs to innovate on at least three levels: (1) national innovation, in particular the formulation of national development planning, the determination of a national green development strategy, and design of a green development blueprint to guide national green innovation; (2) local innovation, to innovate different green development modes according to local conditions and to achieve the major objectives in the local economic, social, and natural systems; (3) enterprise-level innovation, to innovate green technologies and to develop green market-based products based on market competition at home and abroad. I will discuss these three levels of development in more detail in Chaps. 5 and 6.

[60] By the end of 2010, the Chinese government had approved 2846 CDM projects, of which 1186 projects had been successfully registered with the United Nations Clean Development Mechanism Executive Board, accounting for 42.7% of all global projects. The annual certified issuance emission reduction is about 2.7 t for the registered projects, accounting for 62.4% of the total global amount. Zhang Ping: Guidance Book of the People's Republic of China 12th Five-Year Plan on National Economic and Social Development, Beijing, People's Publishing House, 2011.

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Chapter 3
Global Ecological Crisis

> The human propensity for creating civilization can be attributed to its fight to meet the challenges in particularly difficult situations, and these challenges have greatly stimulated unprecedented efforts.[1] (Arnold J. Toynbee 2010)

> Current ecological problems are closely linked with global economic and social activities, and as the twenty-first century advances such problems will become a central issue of human survival and development. China is seriously affected by global environmental changes, and it will in turn also have a great impact on the world environment.[2] (Angang Hu 1989)

Dickens once offered an excellent portrayal of the human situation: "It was the best of times, it was the worst of times…it was the spring of hope, it was the winter of despair,"[3] Humans currently face unprecedented challenges, such as the global energy crisis, environmental crises, ecological crises, and climate change, and human exposure to these challenges is of the same magnitude as the threat of nuclear war. If people are unable to deal effectively with these problems, a large-scale eradication of economic wealth will result, which will force huge numbers of people to live in poverty. These problems may further cause the degeneration of human civilization.

At the same time, "human's difficulties have greatly stimulated unprecedented efforts",[4] and these have engendered a spirit of extraordinary vitality in terms of the creation of a new green civilization and a green industrial revolution. The green industrial revolution essentially amounts to replacing conventional industrial functions and elements with environment-friendly processes, thereby leading to a dominantly green economy. This revolution also signifies a decoupling of economic growth from carbon emissions and the development of green energy, green industrial products, green consumption, and other aspects of a green economy by means of technological progress and green innovation. These efforts are intended

[1] Toynbee (2010).

[2] The author, Wang Yi, and Niu Wenyuan wrote *Ecological deficit: the biggest crisis in the next period of the Chinese nationality survival–analysis of China Ecological Environmental Conditions* for the early warning team of the Ecological Environment Research Center of Chinese Academy of Science, August 1989 and it appeared in the Chinese science newspaper: *National Conditions and Decision-Making*, page 186, Beijing, Beijing Press, 1990.

[3] Dickens (2003).

[4] Toynbee (2010).

A. Hu, *China: Innovative Green Development,* DOI 10.1007/978-3-642-54962-5_3,

to reverse the "black" mode of development that has existed since the first industrial revolution and represent a fundamental change in the relationship between humans and nature. With the development of the green industrial revolution, creating a green economy has become an inevitable choice for the countries of the world.

This chapter will address the following questions. Why do we need to re-examine the industrial revolutions that have occurred during the 200 years since the mid-eighteenth century? How do these industrial revolutions create material wealth, consume considerable resources, and emit large amounts of pollution and greenhouse gases? How do we calculate the huge invisible natural and development costs of these industrial revolutions? How should we best reflect on the characteristics of excessive consumption, depletions, and emissions in industrial civilization? How are we to recognize the global ecological crisis? How should we best understand the opportunities presented by global green development? What kind of position should we adopt with respect to the challenges posed by the global ecological crisis, and how should we initiate and develop the fourth, green industrial revolution? How can China become the initiator, innovator, and leader in this revolution?

This chapter addresses the concepts of "challenge" and "acceptance" in terms of an analytical framework. This is because humans are often slow at identifying challenges and they respond passively to such challenges; however, they also act intelligently by converting crises and challenges into opportunities. I will first review and reflect on the development of black industrial civilization through the course of the last two centuries, and I will then analyze the current unprecedented global crisis with respect to environmental pollution, energy resources, extreme climate change, and ecology.

With the global financial crisis at the beginning of the twenty-first century combined with pressure from the global ecological crisis, an unprecedented green industrial revolution has begun. This is evident in the rapid rise of the green economy, greener industrial structures, the rapid development of green energy, accelerating green scientific and technological innovation, and the swift expansion of international trade. With the green industrial revolution and the dawn of green ecological civilization, China and other southern countries need to develop this revolution in coordination with northern countries so as to reap the benefits of the future green economy, energy, and technology. As the world's largest developing country, China is also the biggest emitter of carbon and the biggest nation affected by the ecological crisis. It therefore needs to take full advantage of the opportunity to be a dominant force in the green industrial revolution by encouraging green innovation to ensure green economic development. This is the international background and these are the opportunities presented by green development.

3.1 Development Model of Black Industrial Civilization

From hunting and gathering societies to the development of agricultural civilization, human progress has reflected changes in the human response to available natural resources. This response evolved from a simple acceptance of those resources to an initial remodeling of them and gradually resulted in the cultivation of various

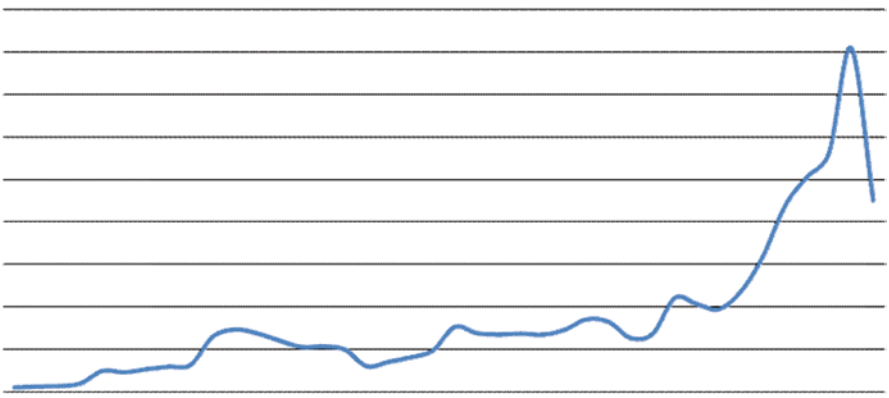

Fig. 3.1 Change in the net depletion index of the world's natural capital (1970–2009). (Source: Open Database of the World Bank http://data.worldbank.org.cn/indicator/all; 1970 = 100)

crops and domestication of livestock through an understanding of the laws of plant and animal growth. This resulted in enormous material and spiritual wealth and formed the basis for the great diversity of human civilization over the world.

In this process and with the growth of human knowledge, strategic production has changed. For thousands of years, agricultural civilization was always subject to the vagaries of natural conditions, and historically the disappearance of many civilizations around the world can be closely linked to changes in the natural environment. With the first industrial revolution, humans made the great historical step from agricultural to industrial civilization. The benefits of this appeared in the form of the great liberation of the capitalist mode of productivity, which was superior to the pre-capitalist mode of development. However, since success and failure are two sides of the same coin, the huge costs of the capitalist development model are often invisible.

3.1.1 Huge Invisible Natural Capital Depletion and Development Costs

The development model introduced by Western industrial civilization has wreaked terrible damage on the world's natural environment on an unprecedented scale. According to data provided by the World Bank, compared with the figure for 1970, the net depletion of the world's natural capital showed a rapid 19.5-fold increase by 2020 and an 81-fold increase by 2008; there was, however, a significant decrease caused by the global recession triggered by the recent international financial crisis (Fig. 3.1). This situation reflects the increasingly prominent conflict between global economic systems and natural systems that has taken place over the past 40 years; it points to the widening gap between humanity and nature, with the depletion of natural capital being faster than economic growth. This development model

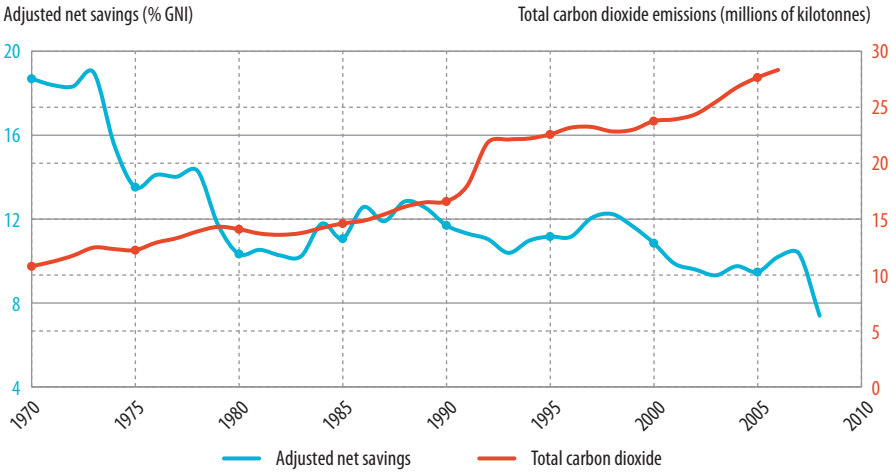

Fig. 3.2 The world is becoming less sustainable: Trends in key measures of sustainability, 1970–2010. Adjusted net savings excludes particulate emissions damage. (Source: World Bank 2010g)

is essentially an unsustainable one since it has at its core the natural capital predation and natural capital depletion.

From a global perspective, the genuine savings rate with deducted natural capital depletion shows a downward trend: from 19% in 1970, it dropped to 7% in 2008, which amounted to a 12% decrease and doubling of carbon emissions (Fig. 3.2). This reflects the fact that increasing GDP is achieved at the depletion of natural assets. Such depletion substantially offset the growth in economic wealth, as stated in a report by the United Nations Development Programme report: the world has become increasingly unsustainable.[5]

In global terms since 1970, the proportionate net depletion of natural assets in northern countries has shown a decreasing trend, but such depletion in southern countries has displayed an upward trend (Table 3.1). This also reflects the fact that southern countries have higher growth rates and greater depletion of natural assets since those countries are undergoing rapid industrialization and urbanization, whereas northern countries have entered a postindustrial era, with a service-oriented industrial structure. Faster-than-ever economic globalization, the transfer of production, manufacturing, and exports, and the transfer of resource consumption, pollution emissions, and natural asset depletion from northern to southern countries reflect the inequality and injustice that exist in terms of income and cost between northern and southern countries. As a victim of this major global transfer, China *has undergone a continually rising proportionate net depletion of natural capital: it surpassed the EU in 2005, the United States in 2008, and Russia in 2009. China now has the highest level in the world.*

[5] UNDP (2010).

Table 3.1 Proportionate net depletion of the natural capital of northern and southern countries on a global scale (1970–2009) Unit: %. (Source: World Bank Open Database http://data.worldbank.org.cn/indicator/all)

	1970	1980	1990	2000	2005	2008	2009
Northern countries	60.4	39.2	25.7	29.6	26.2	24.0	22.1
EU	11.4	7.2	8.3	9.4	6.9	5.5	5.9
U.S.	37.7	25.4	12.1	12.1	10.9	10.7	8.7
Japan	3.6	0.6	1.0	0.9	0.5	0.3	0.6
Southern countries	39.6	60.8	74.3	70.4	73.8	76.0	77.9
China	6.8	6.7	6.7	5.7	7.9	11.4	12.7
India	3.8	1.5	2.5	2.4	2.4	3.1	4.1
Russia	–	–	13.4	9.8	12.4	11.9	11.0
Brazil	0.9	0.6	1.0	1.5	2.1	2.5	3.1

Northern countries refers to the advanced economies defined by the IMF in 2010, and it includes 34 countries and regions; southern countries refers to countries other than northern countries. The net depletion of natural capital = carbon dioxide damage + mineral resource depletion + energy depletion + net depletion of forest resources + particulate emissions damage

3.1.2 Excessive Consumption, Expenditure, and Emissions

Historically, northern countries have been characterized by excessive consumption, depletion, and pollution emissions, and these have led to global climate change—the product of over 200 years of accumulated carbon dioxide emissions. During the period of the first industrial revolution in 1751 to 1800, the vast majority of global cumulative emissions of carbon dioxide derived from northern countries—more precisely, from European countries. According to figures from the U.S. Department of Energy database, from 1800 to 1900 northern countries were responsible for over 90% of global carbon dioxide emissions; of that proportion, 70% was due to European countries, and the United States accounted for 23.6%. From 1900 to 2000, northern countries were responsible for 50–90% of global carbon dioxide emissions. The United States was the world's largest emitter during this period, though its emissions decreased after 1960, and it accounted for 28.8% of emissions in 2000. Over that 100-year period, the proportion of EU countries decreased from 70 to 20% (Table 3.2). As the greatest producer of global carbon dioxide emissions, northern countries should clearly bear the greatest responsibility in reducing such emissions. They therefore need to undergo a fundamental shift in their modes of production from high-level to low-level emissions and move from a high-carbon to a low-carbon economy.

After World War II and the third industrial revolution, southern countries rapidly increased their carbon dioxide emissions, with the proportion of cumulative emissions rising from 28.3% in 1950 to 43.3% in 2000 and further to 46.7% in 2010 (Table 3.1). In the near future, their emissions may exceed those of northern countries. Among southern countries, the cumulative carbon emissions of China have continued to rise. China's emissions increased from 0.8% in 1950 to 3.7% in 1980; with 7.0% in 2000, China's emissions were 1.9-fold higher than those of Japan. China's emissions *increased to 9.8% in 2010, which ranked the country second in*

Table 3.2 Proportion of world cumulative carbon dioxide emissions (1750–2010) Unit: %. (Source: Carbon Dioxide Information Analysis Center, 18 January 2011)

	1800	1900	1950	1960	1970	1980	1990	2000	2010
Northern countries	98.0	91.5	71.7	68.0	63.7	59.7	55.6	56.7	53.3
United States	0.0	23.6	39.8	38.6	36.3	33.4	30.7	28.8	25.0
European Union	98.0	70.0	31.7	28.4	25.6	23.1	20.9	22.6	20.4
Japan	0.0	0.0	0.0	0.6	1.5	2.6	3.2	3.7	3.4
Southern countries	2.0	8.5	28.3	32.0	36.3	40.3	44.4	43.3	46.7
China	0.0	0.0	0.8	1.7	2.4	3.7	5.2	7.0	9.8
Brazil	0.0	0.0	0.2	0.2	0.3	0.5	0.6	0.7	0.8
India	0.0	0.3	1.0	1.0	1.1	1.3	1.6	2.1	2.8
Russia	–	–	–	–	–	–	–	1.4	2.2

Carbon dioxide emissions refer to those from burning fossil fuel and cement production, including carbon dioxide consumed with solid, liquid, and gaseous fuels and in gas flaring
For Russia, figures are available only for the years 2000 and 2010

the world behind the United States. The annual carbon emissions of China have thus rapidly increased over the past decade, and as the country with the highest level of manufacturing in the world, China has exerted a great impact on global climate change.

Since 1800, the accumulative carbon dioxide emission per capita in northern countries has been much higher than the world average. Likewise, the consumption of energy and resources per capita by these countries has been much higher than the world average over the same period. Since 1950, the proportion of accumulative carbon dioxide emission per capita in southern countries has shown a continuing rise—from 37% in 1950 to 55% in 2010 (Table 3.3). The energy and resource consumption per capita in these countries is much lower than the global average. Therefore, although they are at different stages of development and have different levels of resource consumption, both northern and southern countries need to undergo changes with respect to their environmental impact. This represents a huge challenge for northern countries: they need to shift from high consumption, depletion of resources, and excessive emissions to low consumption and low emissions; however, owing to their wealth, this will be marked by high costs and an overall unwillingness to reform and reduce consumption. At the same, this signifies a major opportunity for southern countries to leapfrog northern countries by reducing their consumption, depletion of resources, and emissions. *Thus, as the world's most populous and largest developing country, China needs to be inventive in innovating green development among southern countries.*

3.1.3 High Ecological Footprints and Huge Natural Resource Rents

All humans have an equal right to make use of the resources of nature. If historical debts with respect to carbon emissions among nations were to be settled northern countries would have a 2.7-fold carbon footprint debt to pay, and the United States

Table 3.3 Cumulative emissions per capita in northern and southern countries compared with the world average (1800–2010) Units: the world level = 1.00. (Source: Carbon Dioxide Information Analysis Center, 18 January 2011; total population from Angus Maddison, Historical Statistics for the World Economy: 1-2008AD)

	1800	1900	1950	1960	1970	1980	1990	2000	2010
Northern countries	5.08	3.64	2.96	2.99	3.04	3.15	3.27	3.59	3.59
United States	0.03	4.84	6.61	6.51	6.53	6.52	6.46	6.20	5.51
European Union	11.97	4.86	2.55	2.49	2.51	2.58	2.70	3.24	3.17
Japan	–	–	0.01	0.18	0.52	1.00	1.38	1.77	1.84
Southern countries	0.03	0.11	0.37	0.41	0.46	0.50	0.53	0.51	0.55
China	–	0.00	0.04	0.08	0.11	0.17	0.24	0.34	0.50
Brazil	–	–	0.07	0.10	0.12	0.17	0.21	0.25	0.28
India	–	0.02	0.07	0.07	0.08	0.08	0.10	0.13	0.16
Russia	–	–	–	–	–	–	–	0.58	1.09

For Russia, figures are available only for the years 2000 and 2010

would have a 4.6-fold debt to pay; southern countries such as China would receive the compensation for this carbon consumption. This settlement excludes other natural resources, ecological resources, and the footprint for other pollutant emissions.

With respect to natural resource rent as a percentage of GDP since 1970, the proportion for northern countries has been far lower than that for southern countries. This indicates that northern countries have a relatively optimized industrial structure and make less use of their own domestic natural resources. In the 1970s and 1980s, southern countries showed a rapid increase in this proportion, which was followed by a decline; after 2000, this proportion increased once again but then went into decline as a result of the global financial crisis (Table 3.4).

This analysis also shows that northern countries, with one-seventh of the world's population and with long-term prosperity, base their economies on excessive consumption, pollution emissions, and depletion of natural resources. Southern countries, on the other hand, with six-sevenths of the world's population and a long-term lower income, have less consumption, deplete fewer resources, and are responsible for fewer emissions. As the culprits behind the destruction of nature, northern countries should take the initiative by acknowledging their responsibility and decreasing their consumption, depletion of natural resources, and release of emissions. For their part, *southern countries, which later caused the destruction of nature, should exercise self-discipline and self-restraint in development in order not to repeat the failure of northern countries. Southern countries should open up a new path of green development that will offer bright new prospects for the future of humanity.*

3.2 Unprecedented Global Crisis

Over 200 years of black industrial civilization have led to a serious global environmental crisis and will present unprecedented challenges for future human development. The ecological environment has to be regarded as a global public good. The

Table 3.4 Natural resource rent as a percentage of GDP (1970–2009) Unit: %. (Source: World Bank Open Database http://data.worldbank.org.cn/indicator/all)

	1970	1980	1990	2000	2005	2008	2009
Northern countries	1.0	3.6	1.1	1.1	1.7	2.5	1.3
United States	0.3	1.4	0.6	0.7	0.8	0.9	0.5
European Union	1.3	5.8	1.3	1.0	1.5	2.2	0.9
Japan	0.26	0.16	0.04	0.02	0.04	0.05	0.03
Southern countries	3.8	21.4	11.3	10.2	15.4	17.7	9.6
China	2.5	19.4	8.2	3.3	3.8	3.8	2.0
India	2.1	4.0	3.6	3.2	3.8	5.8	4.0
Russia	–	–	19.2	45.3	39.1	31.0	20.7
Brazil	2.7	3.3	2.5	3.2	6.0	7.2	5.0
The world	1.6	7.6	2.8	2.8	4.6	6.9	3.7

Northern countries refers to the OECD countries, and southern countries refers to countries other than northern countries. Total natural resource rent is the sum of oil, natural gas, coal (hard coal and soft coal) and mineral and forest rents; oil rent is the difference between crude oil production value and production cost calculated by international prices; natural gas rent is the difference between natural gas production value and production cost calculated by international prices; mineral rent is the difference between production value and production cost of mineral stock calculated by international prices; coal rent is the difference between production value and production cost of hard and soft coal calculated by international prices; forest rent is the amount multiplied by logs felled product and average price according to region-specific rental rates

sustainable development of the planet has been greatly challenged through global warming, water shortages, and severe pollution problems; all of these present a serious threat to human survival. The current global ecological crisis also includes the difficulties caused by environmental pollution, energy resources, and climatic extremes.

3.2.1 Global Environmental Pollution Crisis

According to a 2001[6] report by the World Bank, the pursuit of short-term economic growth by countries around the world leads to improvements in their national welfare through the excessive exploitation of forests, fish and mineral resources, and pollution of the air and water. This has resulted in great destruction of the natural capital in addition to ecological and environmental problems at the global level.

According to recent estimates, premature death and disease caused by excessive environmental damage account for about one-fifth of the total disease burden in developing countries. The result is such major environmental hazards as a lack of clean water, inadequate sanitation, indoor air pollution, urban air pollution, malaria, and excessive runoff of agricultural chemicals and waste. Some 14% of the total disease burden is due to the scarcity of clean water, inadequate sanitation, and indoor air pollution, which mainly affects children and women in poor families.

[6] World Bank (2001).

Deaths caused by air pollution due to industrial and automotive emissions as well as the domestic combustion of fossil fuels each year cause more than 2.7 million deaths as a result of respiratory diseases, lung and heart disease, and cancer. Among those premature deaths, 2.2 million occurred in poor rural families, who suffer from indoor air pollution as a result of burning traditional fuels. Air pollution leads to the loss of productive labor time, which in turn reduces economic output. There are considerable health costs through unsanitary drinking water as a result of water-borne diseases and water pollution; in 1992, over 2 million children under the age of five died from diseases caused by contaminated water. Table 3.2 reports the findings of health loss due to the lack of clean water, sanitation, and pollution. As with air pollution, the poor are the biggest victims with water pollution. Every year, pesticides poison 25 million agricultural laborers in developing countries (11 million in Africa alone), and lead to the deaths of hundreds of thousands.

3.2.2 Crisis of Global Energy and Resources

The increasing global demand for energy has raised tensions regarding the supply and demand for traditional fossil fuels. Against this background, the demand for mineral resources in emerging countries has gradually risen. Competition for resources has increased, and this has pushed up the prices of crude oil, coal, and other resources. The International Energy Agency predicts that the average import price of crude oil will reach US$ 100 a barrel in 2020 and US$ 115 in 2030. Thus, the nominal price of crude oil per barrel on the international market will rise to US$ 198 in 2030,[7] thereby putting additional pressure on the transfer to green energy.

In terms of overall development, humanity uses 50 % of the Earth's potential photosynthesis, and it consumes three times more than the planet can tolerate. Clearly, economic growth is not likely to continue. The greatest obstacle to development does not lie so much in mineral resources, however; it exists mainly in ecological problems, which have now reached an alarming level. The entire ecosystem is near collapse. This is a crisis of the Earth, not just of ecology, and it is almost certain to lead to serious social and political crises.

3.2.3 Extreme Climate Change

Climate change is becoming the most significant factor in many environmental problems. The global atmospheric carbon dioxide equivalent (CO_2e) has reached a concentration of 380 PPM, and it now surpasses the natural range that has existed over the past 650,000 years. Since the industrial age began, the average global temperature has risen by about 0.7 ℃, and that trend is worsening. Every 10 years, the average global temperature rises by 0.2 ℃; in the course of the twenty-first

[7] International Energy Agency, World energy outlook 2009, 2011, pp 64.

century, average global temperatures may rise over 5℃, which is equivalent to the temperature changes that have taken place since the last Ice Age.[8] Most climate scientists believe that it would be better to limit future climate change to within 2℃.[9] They maintain that breaking this threshold will produce a number of disastrous consequences, including ocean warming, reduction of rain forests, and melting of ice sheets, which would lead to considerable biodiversity damage and cause irreversible harm to ecosystems. At the same time, the complexity of related carbon feedback effects will accelerate climate change. If current trends continue, human emissions of greenhouse gases will approach this limit.

If humans continue the development path that has been maintained since the first industrial revolution began in 1750, the world's carbon emissions will continue to grow; this will cause further worsening of the global climate and bring about a disastrous loss to all mankind. According to a report by the United Nations Development Programme, "We have less than 10 years to ensure that the doors of opportunity remain open."[10] The carbon crisis exists in the present, but the effects of not making carbon reductions will be long lasting. In the twenty-first century, climate change will be a decisive factor in the prospects for human development.

The intensification of global climate change will bring about a deterioration in human development in addition to more frequent droughts and floods, especially in low-elevation coastal areas, more outbreaks of infectious disease, and acceleration of forest loss. Climate change will also reduce agricultural output in developing countries; this will threaten global food security and present a significant danger to human health and safety (Table 3.5). The cost to the global economy as a result of climate warming may amount to US$ 550 billion a year, and it is likely that developing countries will bear an unequal proportion of the burden.

The increasingly serious global ecological situation essentially signifies that the growth mode that has been in place since the first industrial revolution—characterized by high input, consumption, and pollution emissions—is unsustainable. During the period of industrialization, the large-scale use of fossil fuels has resulted in ever more emissions of greenhouse gases into the atmosphere. The industrial emissions of greenhouse gases produced by developed countries account for 85% of the cumulative amount of such gases since 1850. The rise in global temperatures is an indisputable fact, and it will result in large-scale ecological disasters, and these will have a major effect on future human development.

It has to be emphasized that developed and developing countries bear an inverse proportion of the responsibility for, and vulnerability to, climate change. Developed countries are more vulnerable to climate change than developing countries; however, in terms of greenhouse gas emissions, though developed countries account for only 15% of the total world population, they produce more than half of all carbon dioxide emissions.

[8] United Nations Development Programme (2007/2008a).

[9] Including ISSC 2005; the European Union 2007b; den Elzenand Meinshausen 2005; Schellnhuber 2006; Government of France 2006.

[10] United Nations Development Programme (2007/2008b).

Table 3.5 Five major impacts on human development as a result of climate change

Impact	Affecting mechanism	Consequences for human development
Decreased agricultural productivity	Drought and rainfall changes will greatly reduce grain yields	It is expected that by 2060, the dry lands of sub-Saharan Africa will lose 25 % of their revenue, amounting to a total loss of US$ 26 billion; by the 2080s, the number of severely malnourished people will increase to 600 million relative to no climate impact (Warren et al. 2006)
Exacerbation of water problems	Melting glaciers will cause reduced flow of major river systems	By 2080, the water shortages produced by climate change will affect 1.8 billion people (Warren et al. 2006)
Increasingly frequent coastal flooding and extreme weather	Intensified tropical cyclones, increased droughts and floods	Sea-level rises and worsening tropical storms will affect 1.8 to 2.3 billion people as a result of coastal flooding (Anthoff et al. 2006)
Collapse of ecosystems	Rising ocean temperatures will destroy coral reef ecosystems, and thus affect the entire marine ecosystem	If global temperatures exceed the 2 ℃ threshold, the extinction rate of all species will increase; if the temperature rise reaches 3 ℃, 20 to 30 % of species will be at a high-risk danger of extinction (IPCC 2007). Large-scale loss of biodiversity and ecosystem services will occur
Increased health risks	Increased risk of infectious disease outbreaks	Global malaria-infected population will increase to 220–400 million. The risk-free rate in sub-Saharan Africa will be increased by 16−28 % and the death will account for about 90 % of the total (IPCC 2007)

At present, millions of the world's poorest people in many developing countries have to face the severe impact of climate change. From 2000 to 2004, about 262 million people suffered as a result of climate disasters; more than 98 % of these people were from the developing world. The citizens of OECD countries have a 1:1,500 chance of being subject to a climate catastrophe, but the comparable figure for people in developing countries is 1:19. In other words, the risk of

Table 3.6 Proportion of endangered species in the world. Unit: % (Source: World Bank, WDI (2010))

Region	Endangered plant species	Endangered fish species	Endangered mammal species	Endangered bird species
World	8,457	1,275	1,141	1,222
U.S.	244	164	37	74
China	446	70	74	85
Russia	7	32	33	51
Brazil	382	64	82	122
India	246	40	96	76
Proportion				
U.S.	2.9	12.9	3.2	6.1
China	5.3	5.5	6.5	7.0
Russia	0.1	2.5	2.9	4.2
Brazil	4.5	5.0	7.2	10.0
India	2.9	3.1	8.4	6.2

exposure to climate disasters in developing countries is 79 times greater than in developed countries.[11]

3.2.4 Global Ecological Crisis

The following findings are contained in the Millennium Ecosystem Assessment released by the United Nations. Human activities have caused rapid irreversible changes in the Earth's biodiversity; they have resulted in a reduction of forest cover; large areas of land have been converted to arable land; there have been rapid increases in the storage capacity of reservoirs. These and other human activities have led to dramatic changes in the ecosystem. About 20% of coral reefs have been destroyed as a result of climate change, and another 20% are subject to ongoing damage.

In combination with other factors, climate change, invasive alien species, the over-use of particular species, and pollution have produced a loss in biodiversity. Over the past few hundred years, the extinction rate caused by humans has been 1,000 times higher than at other times in the Earth's history. At present, approximately 12% of bird species, 23% of mammal species, and 25% of conifer species are in danger of extinction (Table 3.6).

With growth in the world's population, economic development, productivity and per capita consumption, human consumption of ecosystem services will continue to increase. With the current pattern of energy consumption, fossil fuel use will have to expand to meet consumption demand, and this will put increasing pressure on ecosystems and biodiversity.

[11] United Nations Development Programme (2007/2008c).

Table 3.7 Level of desertification around the world (1996) Unit: million km^2. (Source: UNEP)

Region	Dry land area	Desertification area	Degree of desertification			
			Mild	Moderate	Severe	Extremely severe
Africa	1,286.0	1,000.0	118.0	127.2	70.7	3.5
North America	732.4	79.5	13.4	58.8	7.3	–
South America	516.0	79.1	41.8	31.1	6.2	–
Australia	663.3	87.5	83.6	2.4	1.1	0.4
Europe	299.7	99.4	13.8	80.7	1.8	3.1
Asian	1671.8	1400.0	156.7	170.1	43.0	0.5
World	5169.2	3618.4	427.3	470.3	130.1	7.5

By the end of the twenty-first century, climate change and its impacts will become the greatest direct driver behind global biodiversity loss and changes in ecosystem services. From 1950 to 2000, there was an almost seven-fold growth in global economic activities. It is predicted that by 2050, 10 to 20% of the world's grassland and forest will have been converted for agricultural purposes. This will further exacerbate desertification (Table 3.7) and together with the impact of climate change will place severe pressure on biodiversity and ecosystems.

Soil degradation is also a global problem, especially in Asia and Africa. The cost of this problem to China amounts to 5% of its GDP, and the direct consequences of desertification annually cost the country US$ 42 billion in loss of agricultural productivity.

In addition, at least 1,000–1,200 million ha of forest land disappear worldwide every year as a result excessive logging and deforestation. The annual global economic loss through the reduction in tree growth, decreased soil and water conservation capacity, and impaired nitrogen uptake amounts to US$ 1–2 billion.

3.3 Green Development Opportunities

The financial crisis triggered by the U.S. subprime mortgage crisis in the second half of 2008 had global repercussions. Among the numerous and widespread effects were economic recession, rising unemployment, and social unrest in many countries as well as a subsequent series of debt crises. The global impact of this financial tsunami has exposed the vulnerability and inequality of the international financial system. In addition, it has revealed the unsustainability of the capitalist mode of development, which is dominated by developed countries and places at its core the values of consumerism, heavy dependence on fossil fuels, and the predatory consumption of global ecological resources. The financial and debt crises are essentially a crisis of the capitalist mode of development, and their resolution demands changing patterns of growth and seeking new development through a new green industrial revolution.

3.3.1 Rapid Growth of the Green Economy

In view of the world situation following the financial crisis, some developed and newly industrialized countries have in fact begun to explore ways of transforming their mode of economic development. They have attempted a combination of macroeconomic policy to restore economic development and increased green strategies to protect the environment, adjusted modes of growth, and reduction of carbon emissions. In the future, traditional modes of development will have to be abandoned if there is to be sustainable human development. It will be necessary to follow a new course of development—green development.

The report *Towards a Green Economy—Ways to Achieve Sustainable Development and Eradicate Poverty* was published by the United Nations Development Programme (UNEP) in November 2011. The report states that a **common feature of** the energy, food, financial, and climate crises that have occurred over the past decade is *overall capital misallocation, and it proposes that a green economic development vision be developed: "2% of global GDP invested in 10 green core economy sectors would change the mode of development and promote the use of public and private capital for a low-carbon economy and resource efficiency."* (Box 3.1)[12]

The South Korean government has proposed to use 2% of its annual GDP for green growth projects. In the first half of 2010 in the United States, 25% of venture capital was invested in green technology; the proportion of energy-efficient and renewable-energy technologies in the government's energy R&D budget increased to 26% from 13% in 1990. The EU plans to achieve an "intelligent, sustainable and inclusive economy strategy by 2020, as part of which it has set up a monitoring system for macroeconomic factors and reforms to improve growth and public finance. The United Kingdom plans to invest GBP3 billion of public funds in starting a green investment bank to finance low-carbon projects by the end of 2012. In Germany, clean energy development is evident in the fact that almost 17% of its electricity came from renewable energy sources in 2010; this surpassed the original target of 12.5%. Denmark has signed a green growth pact to develop the green economy for its agriculture and food industry. New Zealand has established an advisory group to the private sector under the auspices of the Ministry of Finance, Ministry of Economic Development, and Ministry of Environment; the aim is to help small and medium-sized enterprises improve their energy efficiency and promote exports of industrial value-added products through clean technology and other green innovations. Japan has established a national green innovation strategy project with plans to create an environment-related market plan worth approximately JPY 50 trillion and create 1.4 million new environment-related jobs.

[12] UNEP (2011).

Box 3.1. The World's Emerging Green Economy

In agriculture, the green economy means farming in ways that are conducive to the environment, without destruction of ecosystems and causing harm to human health. A world population of 9 billion will have to be supported by 2050. It is estimated that around the world, there are about 525 million small farmers, of whom 404 million have less than 2 ha of land[13]. It is necessary to achieve the green economy at the small-scale farming level and effectively increase production through the promotion and dissemination of sustainable farming techniques. It is also necessary to change agricultural practices from being the main source of greenhouse gas emissions to being net neutral, or even creating greenhouse gas sinks.

The green economy is mainly reflected in investments in improving clean energy sources and increasing energy efficiency in the energy sector as an alternative to carbon-intensive energy investments. From 2002 to mid-2009, worldwide the total investment in renewable energy increased at a compound annual growth rate of 33 % annually.[14] Despite the global economic recession, this sector is booming. In 2008 and 2009, new investments in clean energy amounted, respectively, to US$ 173 billion and US$ 162 billion; it is estimated that they attained US$ 180 billion to US$ 200 billion in 2010.[15]

One-third of the world's energy end use occurs in the construction industry, which also consumes one-third of global material resources. The green transformation of this sector would therefore save energy as well as reducing indoor air pollution, increasing efficient use of materials, land, and water, and reduce waste and the risk of harmful substances. According to the McKinsey Global Institute research, together with the development of renewable energy supplies, existing green technology could reduce 3.5 billion t of carbon dioxide emissions at a cost of US$ 35 per t.[16]

In the area of water resources, the conventional development model will lead to a huge gap between supply and demand in global water supplies. At an annual investment of US$ 100 –300 billion from 2010–2050, the green transformation of water resources would lead to a one-fifth decrease in water demand; this would reduce the short-term and long-term demands on underground and surface water resources.

The development of forestry is also part of the green economy, and to curb the current global trend of deforestation would also be a very beneficial green investment. Reducing global deforestation by just half would

[13] Irz et al. (2001).

[14] UNEP (2010a).

[15] UNEP (2010b).

[16] McKinsey Global Institute (2009).

lead to double the climate regulation revenue of the cost.[17] The greening of the manufacturing industry, which originally gave rise to the "black" economy, will involve redesigning products and recycling old materials so as to extend the life cycle of products and ultimately achieve a circular economy. The reprocessing of used products alone could amount to annual savings of approximately 1,070 barrels of oil[18]. If green investments were made in terms of energy efficiency, industrial energy consumption would be almost halved over the next 40 years.

In the field of waste utilization, only 25% of garbage is recycled or reused, even though the total garbage market around the world (from collection to reuse) has an annual valuation of up to US$ 410 billion.[19] If improvements were made in the green economy, the level of e-waste recycling could be increased from the current 15% to almost 100% by 2050, and the amount of landfill waste could be reduced by at least 85%. Such moves could also have benefits for the global climate: it is estimated that by 2030 landfill methane emissions could be decreased by 20–30% through negative costs, which would amount to a reduction of up to US$ 20/t of carbon dioxide equivalent each year.[20] In the green economy market, the amount of energy that can be derived from waste amounts to US$ 20 billion, and this is expected to increase by 30% by 2014.[21]

In addition, green tourism is booming: the annual growth rate of ecotourism is 20%, which is about six times higher than that of industry as a whole.[22]

The transport industry consumes more than half of all the liquid fossil fuels in the world, and it accounts for nearly a quarter of global energy-related carbon dioxide emissions. The environmental and social costs that result from air pollution, traffic accidents, and traffic congestion may amount to or exceed 10% of a country's or region's GDP.[23] Innovative low-carbon transport, the integration of land use and transportation planning, the development of public and non-motorized transport services, and improved vehicle technology and fuel technology could be used to effect a greening of the transport sector, which would bring substantial economic and environmental benefits. Source: UNEP, 2011: *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication—A Synthesis for Policy Makers.*

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[17] Eliasch (2008).

[18] Steinhilper (1998).

[19] Chalmin and Gaillochet (2009).

[20] Bogner et al. (2007).

[21] Argus Research Company, 2010: Independent International Investment Research Plc and Pipal Research Group.

[22] TEEB (2009).

[23] Creutzig and He (2009).

3.3.2 Greener Industrial Structure

Industry around the world is increasingly moving in a green direction, and this involves three aspects. First, the proportion of global service industries with low pollution, emissions, and power consumption will significantly increase, and this will lead to a greening of the entire economic structure. Second, green manufacturing is being implemented by the promotion of clean production techniques, moves toward a circular economy, and the introduction of production technologies to further reduce energy and resource consumption to create a cleaner manufacturing sector. Third, there will be improved industrial added value, especially for southern countries, and the greater proportion of high value-added industries will make the economic structure greener and more efficient.

With the advent of the fourth industrial revolution, developing countries will also have to upgrade and make adjustments to their industrial structure and this will lead to changes in industrial structure at the global level. By 2030, agriculture will account for 2.1 % of global GDP, industry for 20 % (manufacturing for 11.2 %), and the service sector for 77.9 %.[24]

With continuing adjustment to the global industrial structure, the number of people employed in agriculture will decline further as agriculture becomes increasingly modernized with substantial increases in land productivity. This will be accompanied by greater agricultural diversification as well as refinement and deep processing of agricultural products. Within the international trading system, the total trade in agricultural products has increased in line with the rapid development of agricultural technology and a wider range of applications of existing agricultural technology. There will be further increases in agricultural productivity and exports. Increasingly, agriculture will be combined with food processing services to ensure food safety.

With the ongoing development of the information industry and global transport infrastructure, the services trade ratio will increase. In terms of restructuring, the industries of mature, developed economies will be more resistant to change, and so the existing industrial structure will tend to remain in place; the dominance of the service sector will continue, and it will become even stronger. Emerging economies are currently having to make profound changes to their industrial structure; their service industry, tourism, transportation, information and communications, and financial and insurance services will make the biggest contributions to their growth rate. The international trade in services will also continue apace. Rapid development of the knowledge service industry, which first took place in northern countries, is a power for long-term national growth, and it allows a country to make the

[24] From 2010 to 2030, the average annual growth rates will be as follows: agricultural productivity 2 %, industrial productivity 2 %, and manufacturing productivity 3 %. Source: World Bank, World Development Indicator 2011. Center for China National Studies, Tsinghua University, Hu Angang, Yan Yilong, Wei Xing: *2030 China: Towards a Common Prosperity*, p 31, Beijing, China Renmin University Press, 2011.

transition to a knowledge economy and society. Southern countries need to close the existing gap with northern countries in this area to ensure that they are well placed for the green industrial revolution.

In the green industrial revolution, the industrial structure of emerging countries will undergo dramatic change. Areas of their agriculture and industry that are capital intensive and have high levels of energy consumption, water consumption, resource consumption, and serious pollution will be significantly reduced. Likewise, areas of their industry that are labor and knowledge intensive and the energy-conservation service industry will significantly increase. Emerging countries will make the transition from an industry-led to a service-led system. In these countries, a rapidly increasing proportion of their emerging strategic industries will be in manufacturing; they will have greater incentive to engage in international competition. The least developed countries, such as those of sub-Saharan Africa, will become major areas of labor-intensive industrial transfer, and this will see their industrial proportion being substantially increased.

3.3.3 Rapid Development of Green Energy

With rising fossil-energy prices, increasing global primary energy demand, and changes in the consumption structure, the fourth industrial revolution will be a period of adjustment, and it will mark the beginning of green energy transformation. Green energy signifies the following: the cleaning of traditional energy; renewable energy; and efficient use of energy. As industries undergo restructuring, the development of the service sector will be conducive to saving energy.

According to forecasts by the International Energy Agency, the following changes will have taken place in global primary energy demand structure by 2030 compared with 2007: coal will increase; oil will decline; other primary energy sources will show a stable consumption ratio. The proportion of coal consumption will increase from 22.9 % in 2000 to 29.1 % in 2030; the proportion of oil consumption will decrease from 36.5 % in 2000 to 29.8 % in 2030; nuclear, hydro, biomass, and other renewable energy sources will show stable levels of consumption (Table 3.8).

Southern countries will be relatively more competitive than northern countries in developing green energy. First, the fossil-energy industry of southern countries does not have strong interest groups as is the case in northern countries, and this will prove less of a hindrance to the development of green energy. Second, southern countries can take full advantage of relatively mature green energy technologies to reduce the sinking costs of the development process. Finally, the pressure on southern countries to meet their huge energy needs will be an important motivating factor.

Table 3.8 Demand structure for global primary energy sources (1980–2030) Unit: %. (Source: International Energy Agency, World Energy Outlook 2009, 2011)

	1980	2000	2007	2015	2020	2030
Coal	24.8	22.9	26.5	28.4	28.9	29.1
Oil	43.0	36.5	34.1	31.4	30.5	29.8
Natural gas	17.1	20.8	20.9	20.8	20.8	21.2
Nuclear energy	2.6	6.7	5.9	6.0	5.9	5.7
Hydro	2.0	2.2	2.2	2.4	2.4	2.4
Bio-energy and recycling	10.4	10.3	9.8	9.9	9.9	9.6
Other renewable energy	0.2	0.5	0.6	1.2	1.6	2.2

Data of 2020 is estimated by the author according to IEA model

3.3.4 Accelerating Green Technology Innovation

Green technology innovation will become an important driving force in the fourth green industrial revolution. This will see participating countries substantially increase the sharing, diffusion, and application of technology, and this development will be faster and more extensive than was the case with the past three industrial revolutions.

It is evident that *global scientific and technological innovation is an extremely active area, and the output of international scientific papers and patents is rapidly increasing. By 2020, it is* expected that the number of international scientific papers published annually will amount to 1.67 million, while that of international patent applications will be 1.47 million; by 2030, those two indicators will reach, respectively, 2.31 million and 1.97 million. International cooperation in science and technology will increase in prominence and frequency. Cross-border cooperation in scientific research and the depth and breadth of knowledge and technology transactions will greatly improve. It is of note here that the number of patents for renewable-energy technologies increased 24% from 1999 to 2009, those for electricity and hybrid vehicle technology by 20%, and those for buildings and lighting energy efficiency by 11%. The gap between northern and southern countries in scientific and technological development is much greater than that for economic development. However, the speed of convergence is much higher with science and technology than with the economy.

Compared with northern countries, those of the south have a strong latecomer advantage with respect to developing green innovation. From the leapfrog theory and sunk costs, southern countries can take full advantage of global public knowledge of basic theories. This will bring significant cost savings in terms of green innovation and will allow southern countries to jump to a high stage of development. Southern countries are less encumbered by black industry interest groups than northern countries, and this will result in lower resistance to green innovation. Southern countries will in effect be able to begin on a clean slate.

3.4 Embracing the Forthcoming Green Civilization

The fourth industrial revolution—the green industrial revolution—is both the call of an era and a historical necessity. This revolution will mean taking on the challenge of dealing with a severe global climate and ecological crisis. From a historical perspective, the goal of this revolution will be to fundamentally change capitalist means of production, distribution, and consumption and build a new path for the future development of the world. The fundamental goal of the green revolution is to make a real adjustment in the relationship between humanity and nature, narrowing the existing gap to ensure the long-term harmony between them. However, to achieve these goals, humans have to completely change the existing model of development.

The fourth industrial revolution will not amount simply to a technological revolution. The deepening of global cooperation will produce a break in the barriers that exist between northern and southern countries. Unfairness and inequality among countries will be eliminated; instead, the establishment of a global cooperation mechanism will be promoted, allowing all of humankind to share the benefits of the green industrial revolution. Many countries have already begun to develop a green economy and growth strategy; they have formulated national development planning by means of legislation to provide policy support for green innovations, production, and consumption. These countries have seized the initiative in moving toward the global green industrial revolution. At the same time, many international organizations, including the OECD and UN, have published a number of reports on this topic, indicating that green development will become an important global issue in the post-crisis era.

For southern countries, the existing resource constraints make it impossible for them to copy the past development modes used by developed countries. Only by fully using the opportunity presented by the green industrial revolution—adjusting their economic structure, bringing about a greening of their industrial structure, and profoundly transforming their economic development in ways that are conducive to improving domestic economic, social, and ecological development—will they be in a favorable position in the future global economic landscape.

China is the world's largest developing country, the biggest emitter of carbon, and a victim of the ecological crisis. In the face of severe challenges, both at home and abroad, China has a profound understanding of the importance in transforming its manner of development. China has to follow the world trend in green development planning, investing in green industry, and encouraging green innovation. With previous industrial revolutions, China missed out on the first two and it became something of a backward country. However, it managed to catch up in the third industrial revolution and made remarkable achievements. The fourth industrial revolution presents China with a huge strategic opportunity: it needs to become a front-runner and leader in this industrial revolution. How to seize this important opportunity and assume its international responsibilities are major challenges for the country.

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Chapter 4
Green Developments in China

> To win countrywide victory is only the first step in a long march of 10,000. Even if this step is worthy of pride, it is comparatively tiny; what will be more worthy of pride is yet to come. After several decades, the victory of the Chinese people's democratic revolution, viewed in retrospect, will seem like only a brief prologue to a long drama. A drama begins with a prologue, but the prologue is not the climax.[1] (Zedong 1949)

> In the twenty-first century, the core of the world's development will be human development whose theme is green development.[2] (Hu 2005)

Since ancient times in China there has been a unity of nature and humanity. Having respect for nature, protecting nature, and conforming to the laws of nature have long been mainstream elements of traditional Chinese culture. However, the agricultural civilization of China is actually dependent on the weather. With China's expanding population, the ecological deficit in traditional agricultural production has increased. In this regard, the recent forest deficit has been the greatest in the 5,000-year history of Chinese civilization. China has gone from being a richly forested nation to a poorly forested nation, with the level of forestation dropping to 8 % in 1948, the lowest in the nation's history.

After the new China came into being as the world's fastest-growing economy and with the world's biggest population, the country has been undergoing the greatest urbanization and industrialization in human history. The ultra-high-speed growth of China's economy and the development of resources have placed enormous pressure on the country's fragile environment. Not only will this situation place a constraint on domestic development, it will also make China increasingly susceptible to international pressure.

We need to address the following questions.

- How can we recognize green development in China?
- How can China make the change from black development to green development?

[1] Zedong (1991).

[2] Research Center for Contemporary China et al. (2005).

A. Hu, *China: Innovative Green Development,* DOI 10.1007/978-3-642-54962-5_4,

- How can China achieve the transformation from traditional industrialization to new industrialization?
- How can the country make the shift from an energy-consuming to a green-energy nation?
- How can it go from being a greenhouse gas emitter to a low-carbon country?
- How can China change from being a pollution emitter to a nation of reduced emissions?
- How can China alter its character from being a country of ecological damage to one of ecological construction?
- How can a green China be created?
- How can the country move along the road toward green modernization?
- How can China be a leader of green development and make a contribution in this area?

This chapter will systematically analyze China's development from slow to rapid expansion of the natural deficit and then further to extreme expansion before shrinking to the level of local surplus and finally changing to the path of green development, which is characterized by ample surplus.

4.1 Historical Trajectory: From Natural Deficit to Surplus

"The great Tao flows everywhere. All things are born from it, yet it doesn't create them. It pours itself into its work, yet it makes no claim".[3] Mother Nature has the ability to feed humans, and humans have come to believe that nature's feeding ability is inexhaustible. The biosphere in which humans are able to survive is actually just a fragile layer covering the surface of the Earth. However, the biosphere has been operating at an ever-widening deficit ever since the first industrial revolution. Development has come at a great price, and humanity quickly needs to turn this deficit into a natural surplus.

Green development in China can be divided into four stages. The first stage is that of a period of slowly expanding natural deficit and environmental issues; it covers the 5,000 years of China's agricultural history and extends to the modern era and the early founding of the new China on October 1, 1949. The second stage is characterized by the rapid expansion of the natural deficit in the industrial era; this covers the economic growth that has occurred since the founding of the new China and the greatest urbanization and industrialization in human history. The third stage is marked by the narrowing of the natural deficit; in the mid-1990s, China controlled pollution emissions and energy-intensive development, and it promoted ecological construction. The fourth stage is the natural surplus period, which is marked by a further decline in environmental pollution, continuously improved ecological

[3] Mitchell (2009).

environment, moderate consumption leading to a decline in environmental issues, and achieving harmony between humanity and nature. In the first decade of the twenty-first century, China began to produce a natural surplus, and it will enter full surplus by 2020.

4.2 Agricultural Civilization—Slowly Expanding Natural Deficit

In remote ancient times (up to about 2070 BC), China was undeveloped and sparsely populated, with fewer than 1.4 million people. It had lush forests, an excellent ecological environment, and 60–64 % forest coverage. The Yellow River Valley, the cradle of Chinese civilization, was characterized by a mild climate and extensive vegetation.

In the course of the next 2,300 years as the Yellow River Valley civilization developed and grew, China's population underwent a period of slow increase: it rose to 20 million by 221 BC, with the forest coverage rate having dropped to 46 %. At this time, the lower reaches of the Yellow River were characterized by plains, hills, and lakes with a humid climate, dense vegetation, and little resettlement. Horqin and other areas of Inner Mongolia featured extensive grasslands and a large number of lakes; the deserts were not as widespread as they are today, and they contained lush oases, a large number of lakes, pristine forests, and deserts not yet grown as large as they are today.

The first eco-environmental degradation occurred during the Qin and Han dynasties, following which there were few forests in the Guanzhong area, though there were serious problems of soil erosion and flooding. The population doubled from 10 to 20 million during the Qin Dynasty (including the Warring States Period) to 60 million in the second year of the Western Han Emperor Ping Yuanshi (AD 2), which marked the beginnings of feudal society. The emperors that followed largely followed a policy of promoting the spread of agriculture while frequently engaging in war. They also encouraged immigration to frontier areas of the empire, and undertook large-scale land reclamation and irrigation. The area of arable was considerably extended to the northwest, and this formed a kind of transition zone between the vast inland areas of agriculture farming and nomadic regions. However, large-scale reclamation in the middle reaches of the Yellow River resulted in the destruction of forests, grasslands, and other areas of natural vegetation. This led to a major loss of forests in the Guanzhong region and serious soil erosion. The tributaries of the Yellow River suffered from excessive turbidity, while the mainstream was badly affected by siltation. Siltation of the riverbed was particularly extensive in downstream areas, which were subjected to frequent flooding. During this period, widespread felling and appropriation of forestry land led to China's forest coverage rate being reduced to 41 %.

During over 300 years from the Eastern Han to the Sui Dynasty, the population greatly diminished, and there was relative recovery of the ecological environment.

This was the result of extensive areas of barren arable lands, reduced farming along the middle sections of the Yellow River, an expansion of grasslands, less severe destruction of forests, insignificant soil erosion, and relatively problem-free flow in the downstream reaches of the Yellow River.

During the Sui and Tang dynasties, China's population stood at around 60 million. An expansion of agriculture took place from north to south, but this was subject to natural restraints. In the more than 700 years from the Tang to the Yuan dynasty, the total population rose by at least 30 million. This period was characterized by aggravated soil erosion, increased desertification, siltation of lakes, and frequent flooding of the Yellow River. This was the second period of deterioration of the ecological environment in Chinese history. By the end of the Tang dynasty, China's forest coverage was only 30%, which was less than half of what it had been in ancient times.

After the Ming dynasty, China's ecological environment deteriorated sharply. There was devastation of forests along the middle reaches of the Yellow River, which was subject to 60–70% sediment concentration. After 1849, the population reached 41.299 million with large-scale reclamation. There was considerable population growth after the Ming dynasty: the Chinese population increased from less than 100 million in the late Ming and early Qing dynasties to 300 million after the Kangxi-Qianglong period; it rose to over 400 million in 1840. Along with this growth in the population, there was agricultural expansion, and there was a population spread to peripheral areas of the country: initially to the northeast, then to the Qinghai-Tibet Plateau (with half-tillage and half-pastoral areas), and subsequently northwest of the Tian Shan mountain range (with tillage and pastoral areas), fused with agricultural areas of central areas. In the wake of extensive destruction of forests, most of the upland areas of the Loess Plateau became denuded though excessive soil erosion. The silt content of the Yellow River increased from 60% in Ming dynasty times to 70% during the Qing dynasty. In addition, each historical period experienced greater breaching frequency than the one before. There were also frequent droughts and floods as well as unprecedented destruction of natural ecosystems.

The 5,000 years of China's civilization have come at a tremendous ecological cost as the nation has been transformed from a forested to an unforested one. According to the research information provided by the project, the massive destruction to the natural environment over the 4,000–5,000 years before the founding of the new China, the country's forests have been considerably reduced, with the lowest point having been reached during the days of the Republic of China (1911–1949), when the level of forestation stood at only 12.5–15.9% (Table 4.1).

Chinese emperors have always implemented the policies of physiocracy and encouraged forest land reclamation. However, because of the increase in the national population and the relative paucity of arable land, the increase in food production has been slow. Compared with the situation during the Warring States period, 2,000 years later in the mid-Qing dynasty the productivity of the country had increased only by 70%. To solve the food-supply problem, successive rulers adopted the approach of ravaging the country's ecology, such as by encouraging deforestation,

Table 4.1 Total population, area of arable land, and forest coverage throughout China's history. (Source: [a]refers to previous forestry census data; other figures derive from the project team *Sustainable Development of Forestry Strategy Research of China*, *The Strategy Research on Sustainable Development of Forestry of China • General (1)*, volume 1, pp. 36–37, August 2002)

Age	Total population (10,000)	Arable land (100 million acres)	Forest coverage (%)
Prehistoric times (about 1.8 million years ago—2070 BC)	Less than 140		64–60
Ancient times (2069–221 BC)	140–2,000		60–46
Late warring states period		0.90	
Qin dynasty (221 BC–AD 220)	2,000–6,500		46–41
Wei–Jin south–north period (220–589)	3,800–5,000		41–37
Sui and Tang dynasties (589–907)	5,000–8,300	2.11	37–33
Five dynasties and Song, Liao and Jin Xia (907–1279)	3,000–13,000	4.15	33–27
Yuan dynasty (1279–1368)	6,000–10,400		27–26
Ming dynasty (1368–1644)	6,500–15,000	4.65	26–21
Early Qing dynasty (1644–1840)	8,164–41,281		21–17
Mid-Qing dynasty		7.27	
Late Qing dynasty (1840–1911)	37,200–43,189		17–15
Republic of China (1911–1949)	37,408–54,167	13.5	15–12.5
People's Republic of China (1949–2010)	54,167–134,100	13.2–18.18	8.6–20.36 (including a large number of plantations)[a]

Arable land areas from Wu Hui: research of grain per *mu* of China, page 195, page 199, page 216. Arable land area in 2010 from the National Bureau of Statistics

destroying grasslands, converting lakes to farmlands,[4] expanding the areas of arable land, and increasing food production. The result is that there is little forest and considerable ecological damage in China.

[4] According to historical records, the year 1153, the Taihu Tian Wei shore up to 145 years, Wai Tian up to 1489. Yangtze River Water Resources Planning Office: "A Brief History of the Yangtze River Water Resources", Water Publishing, 114.

4.3 Industrialization—Rapidly Expanding Natural Deficit

Between the founding of the new China in 1949, which marked the beginning of the country's economic rise, and 1978, China basically achieved its initial goals of industrialization that were advanced in the 1950s and 1960s. The country established an independent and relatively complete industrial and economic system, laying the foundation for the development of industrialization and achieved the highest economic growth in history. According to data provided by the National Bureau of Statistics, at constant prices, the annual average growth in the GDP rate is 6.0%. In 1978, the total economic output was 4.71 times higher than it was in 1952, which amounts to a quadrupling in the total economic output over a period of 26 years.

During this period, China adopted the strategy of placing the priority on the development of heavy industry, though it did so by setting an artificially low cost of such development. It achieved this by depressing the price of capital, foreign exchange, energy, raw materials, agricultural products, and labor, and it reduced the threshold of establishing heavy industry capital. **China's industrialization has basically followed the mode of priority development of heavy industry that was utilized by the Soviet Union**. From 1952 to 1978, China's total industrial output value showed a 16-fold increase with an average annual growth rate of 11.3%; this includes a 28-fold increase in heavy industry capital heavy at an average annual growth rate of 13.7%. The proportion of industrial output value in national income rose from 19.5% in 1952 to 46.8% in 1978.[5]

The period of the First Five-Year Plan was an important one for China's resource and energy development. With the help of the Soviet Union, China undertook 156 major projects, in which the energy industry, vital to re-industrialization efforts, was given the highest priority (33.3%); as the source of raw materials, the metallurgical industry was given the fourth-highest priority (12.8%). These major projects were also major consumers of China's energy, resources, and raw materials, and the growth rate in energy consumption during this period was much higher than the economic growth rate: the energy consumption per unit of GDP from 1953 to 1957 showed an increase of 32.4% (Fig. 4.1).

The rapid growth that occurred during the time of the Great Leap Forward was related to the development of black industry throughout China. This development took place in villages, where it was almost at the level of cottage industry, as well as in towns and cities.[6] However, such a small-scale trend was contrary to the overall world development trends, and it came at a huge cost in human resources as well as to the environment. The small blast furnaces, coke ovens, and coal mines

[5] State Statistical Bureau (1981).

[6] In the Great Leap Forward in 1958, China built over 0.6 million primitive iron-smelting and steel-making furnaces, more than 59,000 of small furnaces, over 4,000 of small power plants, over 9,000 of small cement plants, over 80,000 farm tools built factories. Industrial enterprises soared from 170,000 in 1957 to over 0.6 million in 1959. *China's environmental protection administration in two decades*, China Environmental Science Press, 1994, p. 4.

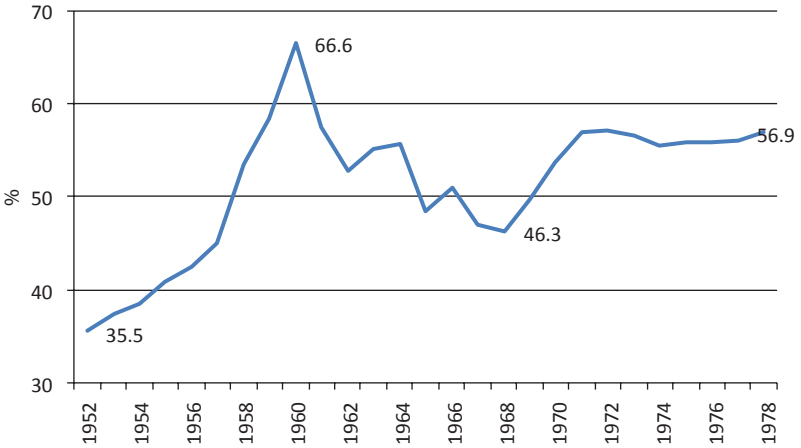

Fig. 4.1 Chinese heavy industry as a proportion of total industrial output value (1952–1978). (Sources: China Industrial Economic Statistics Yearbook (2007); the data for 1953–1956 and 1958–1962 derive from China Financial Statistics (1952–1996)

everywhere around the country represented an excessively expensive mode of economic development: compared with 1957 levels, the cost of energy per unit of GDP showed an increase of 138% by 1960, which is the highest figure in the country's history.

Subsequently, China's efforts to remedy the industrial chaos caused by the Great Leap Forward lasted until 1967. This resulted in a great reduction in the level of construction: the average annual investment in this sector from 1961 to 1967 was US$ 13.5 billion, which was about one-third the level of 1959 and 1960. After the Great Leap Forward, China also placed renewed emphasis on central planning control over investment in power, production, and material deployment, and this helped curb energy waste.

During this period, the Chinese economy grew at a great pace, and it was characterized by the high consumption of resources as well as high levels of pollution and emissions. China's energy industry developed rapidly as the country underwent the change from an impoverished, self-sufficient nation of small resources to a country that was a major producer of resources. At the same time, China's industrial products rose substantially in quality and as a proportion of the total world output. The development of China's resources industry was an important foundation upon which an independent and relatively complete industrial system was built. But as well, it also signifies a historical starting point for China's transformation into a world industrial superpower. During this period, China followed a resource-intensive, energy-intensive path of industrialization that achieved outstanding performance:

Table 4.2 Ranking and proportion of China's major resource-based industrial output in the world (1949–1980). Unit:%. (Source: data for 1950–1998 from the Japanese Situation Foundation: 100 Years of Japan, the Foundation, compiled by Yano Tsuneta Kinenkai)

Year	Iron ore	Crude oil	Generating capacity	Coal	Crude steel
1949/1950		0.04 (27)	0.48 (25)	3(9)	0.36 (26)
1957		(23)	(13)	(5)	(9)
1960	11.8	0.17	2.6	21.3	3.17
1970	5.7	0.47	2.33	16.8	2.97
1980	10.1	3.54 (8)	3.64 (6)	21.8 (3)	5.18 (5)

the resource-based industrial output share of GDP rose[7] from 24.6% in 1952 to 31.5% in 1957, 37.5% in 1960, and 39.2% in 1980 (Table 4.2).[8]

With the growing use of energy and resources, the energy consumption per unit of GDP increased from 6.89 t in 1953 to 18.27 t in 1977, with an increase of 165%. Over the same period, there was an annual average growth rate in energy intensity of 4.1%, which reflects the rise in energy-intensive processes in the initial stage of industrialization and is typical of an extensive growth mode of energy.

Based on 1952 prices, the energy consumption per unit of GDP in 1953 was only 6.89 t of standard coal per RMB 10,000. That increased during the period of the First Five-Year Plan and jumped during the Great Leap Forward to a peak of 21.73 t of standard coal per RMB 10,000; thereafter, it declined for the first time. Compared with the peak in 1960, energy consumption per unit of GDP showed a fall in 1967 of 55.6%. Foreign leap forward in 1977 resulted in relatively low energy, resource, and production efficiency; compared with 1967 levels, energy consumption per unit of GDP again showed an increase—of 57.3%.

In the 1970s, there was a growing awareness worldwide of environmental issues. In 1972 in Stockholm, the United Nations held its first conference on the human environment. Environmental issues also caught the attention of Chinese leaders: in December 1970, Zhou Enlai said to the person in charge: "We do not aim to become a superpower. For the sake of future generations, we are not desperate to achieve this. Industrial problems are new problems for us, and industrialization inevitably causes such problems."[9] In August 1973, China held its first conference on environmental protection as part of establishing an environmental protection policy: it discussed, overall planning, rational distribution, comprehensive utilization of resources, converting harms to benefits, relying on people, group cooperation, protecting the environment, and how this would benefit the people. After the meeting, China set up a central environmental protection agency with regional branches to oversee management of the environment.

[7] The industrial resources output value included in the statistics refers to the sum of the metallurgical industry, power industry, coal and coking industry, petroleum industry, chemical industry, building materials industry, and forest industry.

[8] This is the author's calculation using data come from the Industrial and Transportation Statistics Division of the National Bureau of Statistics, *Compilation for 50 Years of Industrial and Transportation Energy Statistics 1949–1999*, pp. 56–57, Beijing, China Statistics Press, 2000.

[9] Qi (1998).

Over this period, the population of China doubled, with the total population increasing from 540 million in 1949 to 1.01 billion in 1980. This had an enormous impact on the ecological environment and caused considerable damage. The period witnessed a greater and far quicker destruction of forest resources than that experienced at any time in the country's history: forest reserves fell from 9.028 billion m^3 in early 1949 to 8.66 billion m^3. In addition, there has been large-scale degradation of grasslands and other land resources together with huge ecological deficits and serious threats to biological diversity.

At the same time, artificial forest construction has made progress. The first generation of central collective leadership under Mao Zedong attached great importance to forestry. In 1955, Mao Zedong indicated to the nation that people should make efforts to promote the greening of their country and initiate afforestation schemes. The Chinese government at this time also identified the principle of universal forest protection with the focus on afforestation so as to provide a strong impetus for the development of forest resources. Because of China's large-scale afforestation activities over the past 30 years, the country's forest area has expanded: according to the first national forest inventory, over the period from 1973 to 1976, the forest area increased from 83 to 122 million ha, with the forest coverage rate showing an increase from 8.6 to 12.7%.

4.4 Reform and Opening-up—The Natural Deficit Dramatically Increased, then Slowly Shrank

Since China's reform and opening-up, along with the greatest industrialization and urbanization in history, rapid economic growth has produced considerable consumption of energy and resources, high emissions of industrial pollution, and exacerbated damage to the environment. Thus, China has taken a detour and implemented successful and cheap early reform. However, these economic policies have ignored the country's ecology, which should be at the center of such reform, ignored governance, and given importance to short term profits, without thinking long-term. The policies have placed great importance on the subjective, ignoring the objective, meaning that the ecological environment in China will face cumulative and serious consequences in the long-term, in the same way that major mistakes of the 1950s and 1960s concerning population policy, later caused irreparable catastrophic consequences to the entire nationality.[10]

In this period, economic growth has been made at the price of a huge depletion of natural capital: that loss as a proportion of GDP is as high as 10–20%. The biggest cause of this loss is the high proportion of energy depletion. Though the efficiency of energy use has increased, the overall depletion of natural capital began to decline

[10] Hu An-gang, Wang Yi, Niu Wenyuan: *Ecological Deficit, the Biggest Crisis of the Chinese Nationality to Survive in the 21st Century*, August 1989, Technology Review, Phase II and Phase III in 1990.

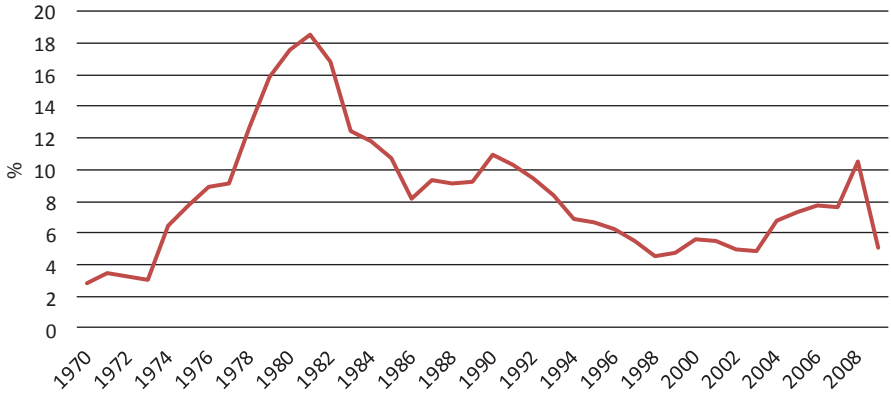

Fig. 4.2 Proportion of natural capital depletion in GNI (1970–2009). (Description: natural losses including loss of carbon dioxide emissions, particulate matter, net deforestation, energy depletion, mineral depletion. Data are from the World Bank, WDI (2010))

after a peak in the 1980s. Natural disasters resulted in a GDP economic loss of about 4%. Human capital maintained a high investment rate of 7–8%. Green investment dropped significantly, from 2.3% at the beginning of reform and opening-up to about 1% in the early 1990s. The trade in primary products was in a deficit, and long-term natural capital was exported to foreign countries.

China experienced the largest, most widespread, and severe ecological destruction and environmental pollution during this period, which led to the largest environmental crisis in its history. As the author pointed out in the *Survival and Development* national report (1989), the economic development in the early stages of reform was based on natural resources and an ecological environment "overdraft"; however, the costs of this have been much higher than were originally estimated (Fig. 4.2).

Since the mid-1990s China has for the first time followed a clear, sustainable development strategy[11] so as to respond actively to eco-environmental challenges. Sustainable development is a development mode that can meet the needs of people in the contemporary world and does not impair the ability of future generations to meet their own needs. Jiang Zemin has reflected on China's ecological damage and pointed out that if the country does not focus on environmental protection as part of its development, governance and recovery following ecological destruction would come at a heavy price and might even cause irreparable damage. To this end, Jiang

[11] On July 4, 1994, the State Council approved *The White Paper on Chinese Population, Environment and Development in the twenty-first Century*; on September 28, 1995 the 14th Fifth Plenary Session of the CPC proposed *The Suggestion on Formulation of the Ninth Five-Year Plan and 2010 Vision Goal*, which formally put forward the strategy of sustainable development and clearly stated that by the end of the twenty-first century, it would strive to control environmental pollution and ecological environment destruction trends as well as improving the environmental quality in some cities and regions; in 2010, it would fundamentally change the deterioration of the ecological environment and make obvious improvements in urban and rural areas.

Zemin put forward a strategy by which sustainable development could be implemented: "Do not follow the path of first wasting resources and causing pollution only to try and fix the problem later. Do not eat the ancestral rice and destroy the nation's future."[12]

Subsequently, China entered a period of shrinking natural deficit as improvements were made in energy-utilization efficiency, pollution control, and ecological environmental protection. Accordingly, the proportion of loss of natural assets as part of GDP showed a significant decrease of about 5 %. With increased capacity for the prevention and mitigation of disasters, the proportion of natural disasters resulting in a direct loss to GDP decreased significantly. Human capital maintained a high rate of investment. Green investment showed a significant increase from about 1 % in the early 1990s to about 2 %. With the foreign input of natural capital, the trade in primary products moved from a deficit to a surplus, and by 1995 China's green GDP was higher than its nominal GDP. Since, however, the World Bank does not include the loss of natural resources, such as water pollution, emissions of sulfur dioxide and other harmful substances, and ecological damage loss, the natural loss is underestimated. This does not mean, therefore, that China entered a period of natural surplus, but it certainly signifies a shrinking natural deficit (Table 4.3).

4.4.1 From Massive Energy Consumption to Integration of Energy Consumption

Since the reform and opening-up and the rapid growth of energy consumption, China has become a "superpower" of energy consumption and a super-buyer of global energy. The consumption of all kinds of energy in the world is on the rise. From the proportion of China's main indicators, it is the world's largest steel and coal consumer and energy producer, the world's second-largest economy, and the second-largest consumer of energy and power generation. China is the world's largest producer and consumer of raw coal, and in 2009 Chinese coal accounted for 45.6 and 46.9 %, respectively, of the world's production and consumption. This has led to problems with regard to energy consumption and excessive growth of resource consumption. In turn, this has produced panic in global markets and has provided a new basis for a "China-threat theory." (Table 4.4)

At the same time, after the reform and opening-up in 1978, China has made the change from an increase to a decrease in energy intensiveness. The Sixth Five-Year Plan proposed that industrial energy consumption be reduced: it required that the per-unit consumption of industrial output be decreased by 12.3–16.3 %; in fact, the energy consumption per unit of GDP fell by 23.5 %. The Seventh Five-Year Plan proposed "an increased production capacity based on efficiency", which required that energy consumption per unit of GDP be decreased by 11.6 %; the actual decrease was 11.9 %. The Eighth Five-Year plan placed the focus on both development

[12] Zemin (2006).

Table 4.3 China's green GDP accounting (1978–2009). Unit: %. (Sources: (1) from the National Statistics Bureau (2011) *China Statistical Yearbook 2010,* Beijing: Chinese Statistics Yearbook; (2) from the National Disaster Reduction Committee, 2010; (3) from the World Bank, WDI; (4) from the National Bureau of Statistics, R&D investment in 1978–1990 is the proportion of innovation funds and science and technology in GDP; (5) from the *China Water Yearbook 2010*, State Forestry Administration, 2010; (6) from the National Bureau of Statistics)

	Nominal GDP (1)	Loss of natural assets (2)	Losses through natural disasters (3)	Investment in human capital (4)	Green investment (5)	Balance of domestic natural account (5+4−3−2)	External natural capital input (6)	Real GDP (World Bank calculation) (1−2+investment in education)	Green GDP (author's calculation) (1+5+4−2−3+6)
1978	100	13.5	4.0	7.3	2.3	−7.9	−1.0	89.1	91.1
1979	100	17.3	4.0	7.7	2.3	−11.3	−1.0	85.5	87.7
1980	100	19.3	4.0	8.1	1.9	−13.3	−1.1	83.9	85.6
1981	100	20.5	4.0	8.1	1.6	−14.8	−1.1	83.0	84.0
1982	100	19.3	4.0	8.3	1.6	−13.3	−1.2	84.5	85.5
1983	100	14.8	4.0	8.5	1.5	−8.8	−1.7	88.9	89.6
1984	100	13.7	4.0	8.5	1.3	−7.8	−2.6	90.0	89.6
1985	100	11.9	4.0	7.6	1.1	−7.1	−2.8	91.5	90.1
1986	100	8.9	4.0	7.9	1.2	−3.9	−1.9	94.6	94.2
1987	100	10.0	4.0	7.4	1.2	−5.4	−2.3	93.2	92.2
1988	100	9.5	4.0	7.2	1.0	−5.2	−1.4	93.5	93.4
1989	100	9.7	4.0	8.0	1.0	−4.8	−1.0	93.8	94.2
1990	100	10.8	4.0	8.4	1.0	−5.5	−1.7	92.7	92.8
1991	100	9.6	5.6	8.2	1.2	−5.9	−1.4	93.7	92.7
1992	100	8.5	3.2	8.1	1.3	−2.3	−0.9	94.7	96.8
1993	100	7.5	2.8	7.6	1.3	−1.4	−0.6	95.5	98.0
1994	100	5.9	3.9	7.4	1.1	−1.3	−0.6	97.2	98.1
1995	100	5.4	3.1	7.2	1.1	−0.2	0.4	97.7	100.2
1996	100	5.1	4.1	7.6	1.1	−0.6	0.4	98.0	99.8
1997	100	4.5	2.5	7.9	1.2	2.0	0.5	98.7	102.5
1998	100	3.2	3.6	8.5	1.6	3.3	0.2	100.3	103.5
1999	100	3.2	2.2	9.0	1.6	5.2	0.6	100.5	105.9

Table 4.3 (continued)

	Nominal GDP (1)	Loss of natural assets (2)	Losses through natural disasters (3)	Investment in human capital (4)	Green investment (5)	Balance of domestic natural account (5+4−3−2)	External natural capital input (6)	Real GDP (World Bank calculation) (1−2+investment in education)	Green GDP (author's calculation) (1+5+4−2−3+6)
2000	100	4.0	2.1	9.4	1.9	5.3	1.8	99.9	107.0
2001	100	3.9	1.8	9.8	1.8	5.9	1.5	100.3	107.3
2002	100	3.4	1.4	10.4	2.1	7.7	1.4	101.1	109.1
2003	100	3.7	1.4	10.6	2.1	7.6	2.3	100.9	109.9
2004	100	5.5	1.0	10.5	2.0	6.0	4.0	99.0	109.9
2005	100	5.8	1.1	10.7	2.0	5.8	4.4	98.8	110.2
2006	100	5.8	1.2	10.7	1.9	5.6	4.9	98.8	110.5
2007	100	5.7	0.9	10.7	2.0	6.0	5.2	99.0	111.2
2008	100	7.6	3.9	11.2	2.2	1.9	6.3	97.2	108.1
2009	100	4.3	0.8	11.7	2.3	9.0	4.5	100.5	113.5

The data in this table were calculated by the author; the methods used to calculate real GDP and green GDP appear in Sect. 2.5 of Chap. 2

Table 4.4. China's proportion of the world's energy production and consumption (1980–2009). Unit: %. (Source: IEA, 2007, World Energy Outlook 2007; 2009 data: of BP Statistical Review of World Energy, June 2010)

	1980	2000	2005	2009
Crude oil consumption	2.93	6.10	8.38	10.4
Crude oil production	3.22	4.17	4.37	4.9
Natural gas consumption	0.92	1.10	1.79	3.0
Natural gas production	0.92	1.10	1.79	2.8
Coal consumption	17.4	28.3	37.6	46.9
Coal production	17.3	29.2	39.4	45.6

and conservation, and it required prominent savings; over the course of the plan, it required that reductions in energy use should be the equivalent of 100 million t of standard coal and that the energy consumption per unit of GDP be reduced by 8.6%; the actual decline was 25.5%. In the 1990s, the country's leaders recognized that China as a nation with a large population and relative shortage of resources should implement "simultaneous exploitation and conservation of resources, with the priority being given to conservation, so as to improve the efficiency of using resources."[13]

During the period of the Ninth Five-Year Plan, China undertook large-scale industrial restructuring. The growth pattern thus began to shift from one of high capital investment and growth to a relative decline in capital investment and high growth. The country also made the change from high energy consumption, high pollution emissions, and high growth to low energy consumption, less pollution, and high growth. China was able to achieve an 8.63% economic growth rate though an energy-consumption growth rate of only 1.10%, an elasticity coefficient of energy consumption growth of 0.127, and a decline in energy intensity of 26.7%. Following a significant reduction in coal consumption, carbon dioxide emissions also fell: they peaked in 1996, after which there was a 17.1% decline that meant the level of emissions in 2000 was equivalent to that in 1993.

Based on purchasing power parity, China's energy efficiency has continued to improve, and it has been much faster than the international level over the same period. In 1978, Chinese energy consumption per unit of GDP was 1.4 times that of the United States, and the gap between it and the United States has been narrowing since 2000. However, it took China only 50 years to complete the transition from extensive use of energy to intensive use, compared to the United States, which took 100 years to do so.

[13] Jiang Zemin: Hold High the Great Banner of Deng Xiaoping Theory for an All-round Advancement of the Cause of Building Socialism with Chinese Characteristics (September 12, 1997), the Chinese Communist Party Literature Research Center: Selected Important Documents Since the 15th National Congress of the CPC, volume 1, p. 28, Beijing, People's Publishing House, 2001.

4.4.2 *From a Large Greenhouse Gas-emitting to a Low-carbon Nation*

Since the 1990s, China has been a major producer of greenhouse gas emissions, and its proportion of the world's carbon dioxide emissions has rapidly increased: 8.08% in 1980, 11.3% in 1990, and 19.16% in 2005; at 24.2% in 2009, China's was close to the figure for the United States. China's proportion of the world's carbon dioxide emissions now exceeds that of the United States and is the highest in the world (19.3%). In fact, China has brought the world the largest negative externality in terms of greenhouse gas emission. **Only by transforming its economic course and following a path of green development will China be able to reduce the low efficiency of its energy consumption and make its due contribution to mitigating global climate change**.

In terms of carbon dioxide emissions per unit of GDP, China has gone through a period of increase (1949–1976), reached a peak (1977), and gone into a period of decline (from 1978). This is consistent with its energy consumption per unit of GDP. In the future, China's energy consumption and carbon dioxide emissions per unit of GDP will decrease.

As a latecomer to industrialization, China has followed both a similar and different trajectory with regard to carbon emissions and industrialization as such pioneers as the United States. First, China and the United States went through a rise in such emissions followed by a decline. Second, China's carbon emissions intensity peak is much lower than that of the United States (Fig. 4.3). This means that China's per capita GDP entered the intensity period of carbon emissions at a lower level. The industrialization of the United States is a highly carbon-intensive process, and carbon dioxide emissions per unit of GDP peaked at 30.65 t per US$ 10,000 (purchasing power parity in 1990 international dollars) in 1917. Per capita GDP reached US$ 5,248, and carbon dioxide emissions per unit of GDP slowly declined to 5.69 t per US$ 10,000 in 2009. It is estimated that this will decline to 2.5 t per US$ 10,000 by 2030; this means that over a period of about 100 years, the United States will have gone from having a highly carbon-intensive pattern of growth to attaining a pre-industrial level, achieving decoupling of carbon emissions. Compared with the United States, China reached its peak of carbon dioxide emissions per unit of GDP of 15.84 t per US$ 10,000 in 1977 with a per capita GDP of only US$ 894, which is far below the peak figure for the United States. China quickly achieved convergence with the United States at 7.01 t per US$ 10,000 in 2009. It is estimated that China's carbon dioxide emissions per unit of GDP will be 2.06 t per US$ 10,000 by 2030. This will be far lower than the United States level at that time; and it will have taken China less than 60 years to achieve the transformation from high-carbon growth mode to decoupling carbon emissions from that growth.

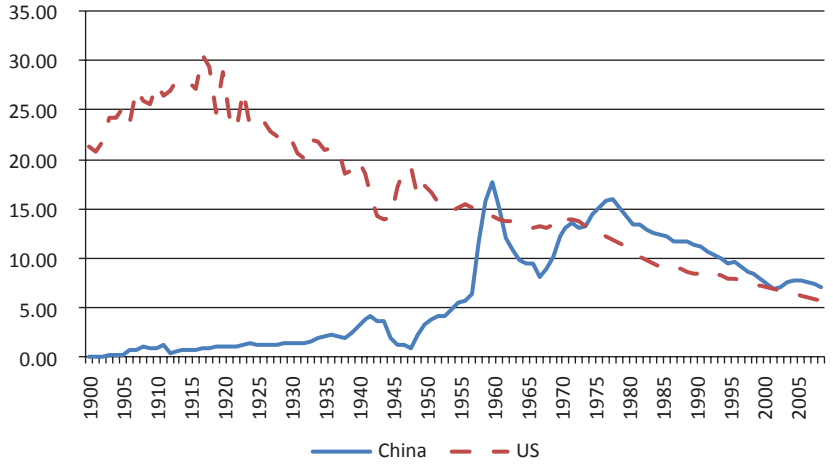

Fig. 4.3 Carbon dioxide emissions per unit of GDP in China and the United States (1900–2009). (Note: These calculations are by the author, and GDP refers to PPP with constant prices (1990 International Geary-Khamis, dollars); data are from Angus, Maddison, *Historical Statistics of the World Economy*: 1-2008 the AD; carbon dioxide emissions data from CDIAC (the Carbon Dioxide Information Analysis Center),18-Jan-2011; 2010–2030 data are the author's estimates)

4.4.3 From Pollution Emissions to Emission Reductions

Since the reform and opening-up, pollution in China has undergone a process of pollution followed by measures to clean up the problem. From 1985 to 2006, industrial COD discharge grew at an annual negative rate of 1.39 % with an elasticity coefficient of −0.14; industrial sulfur dioxide emissions grew at a rate of 2.52 % with an elasticity coefficient of 0.26. Organic water emissions and sulfur dioxide per unit of GDP were much higher than the world average during this period. At the beginning of the reform and opening-up, rapid economic growth also produced severe environmental pollution. This reached a peak in the period of the Eighth Five-Year Plan. In the course of the Ninth Five-Year Plan, the Chinese government started to reinforce pollution controls and environmental protection, and it began to transform the mode of economic growth so as to achieve the green development mode of high growth and low emissions. The result was a decrease of 8.3, 14.8, and 35.5 %, in industrial wastewater chemical oxygen demand, sulfur dioxide, and smoke emissions, respectively. The Tenth Five-Year Plan was influenced by rapid economic growth driven by new rounds of high investment and growth of the heavy chemical industry; as a result, China's economic growth pattern reversed into a pattern of high growth and high pollution. With the Eleventh Five-Year Plan, the comprehensive utilization of industrial solid waste increased from the 2005 rate of 55.8 to 68.4 % by 2010. In addition, the emissions of major pollutants were significantly reduced: sulfur dioxide emissions declined by 12.5 %, and chemical oxygen demand emissions declined by 14.3 %, which were positively in excess of the planning objectives.

Table 4.5 Major industrial pollutant emissions and the elasticity coefficient (1985–2010). (Source: [a]China Statistical Abstract (2008); [b]China Statistical Yearbook (calendar year))

Time	GDP growth rate[a] (%)	Growth rate of industrial chemical oxygen demand emissions (%)[b]	Growth rate of industrial sulfur dioxide emissions (%)[b]	Elasticity coefficient of industrial chemical oxygen demand emissions	Elasticity coefficient of industrial sulfur dioxide emissions
Seventh Five-Year Plan	7.9	−0.53	2.44	−0.07	0.31
Eighth Five-Year Plan	12.3	1.65	4.81	0.13	0.39
Ninth Five-Year Plan	8.6	−1.71	−3.14	−0.20	−0.37
Tenth Five-Year Plan	9.6	−4.68	6.11	−0.49	0.64
Eleventh Five-Year Plan	11.2	−1.66	−2.60	−0.15	−0.24

China's decoupling of major pollutant emissions from economic growth has gone through a recurring process. In the period of the Ninth Five-Year Plan, the discharge of major pollutants was decoupled from economic growth for the first time; this resulted in rapid economic growth, and the emission of major pollutants decreased. In the period of the Eleventh Five-Year Plan, however, some pollutants did not fall but actually rose; although, pollutant emissions continued to be decoupled from economic growth. With the Twelfth Five-Year Plan, it is proposed that emission reduction requirements be increased for all types of major pollutants. With this, China will achieve full decoupling of economic growth from emissions of major pollutants (Table 4.5).

4.4.4 From Ecological Destruction to Construction

Since the founding of the new China, forestry development has not followed an even course. Mistakes have been made through ignorance as to the value of forest resources, when forests have been regarded as an obstacle to agricultural development. Forest resources have been exploited with a view to obtaining economic maximization of timber production. Later, it came to be recognized that comprehensive ecological, economic, and social development of forests amounts to sustainable development. Overall, the development of China's forest resources has followed a pattern of initial decrease followed by increase. After the 1980s, the trend of widespread forest deficit was curbed. In the 1990s, three indicators were used to assess the state of forests: forest cover, area, and stock volume grow. These were employed to recognize that the long-term forest deficit had

become a surplus. The Seventh National Forest Resources Inventory[14] showed that the 20.36% forest coverage represented an increase of 7.38% over the figure for the third inventory: 195 million ha of forest area had increased to 700 million ha, and the forest stock volume amounted to 13.721 billion m^3, having increased by 4.58 billion m^3 (Table 4.6).

Global forest coverage now amounts to about 31%, and China is 0.66 of the world average. The global forested area is 4 billion ha, which is equivalent to 0.6 ha per capita. The forest area in China accounts for about 1/20 of the world's; this ranks the country fifth in terms of area, though on a per capita basis its forest area is 0.26 of the world average. China's forested area as a proportion of the global total has shown a "U"-type trend: from 1990 to 2010, the world's forested area grew at −3.25%, though China's grew at 31.64%. Excluding China, the world's forest growth rate will decline at −4.61%. Thus, China's contribution to the growth rate of the world's forests is 1.36%. The world's forest stock volume is 527 billion m^3, which amounts to about 131m^3 per ha; China has approximately 2.6% of the world's forest stock volume, and the volume per hectare is about 53% of the world average. From 1990 to 2010, the world's average annual area of forest reduction was 8.3 million ha, which amounts to an average annual growth rate of −0.2%. China's forest area, however, continues to increase: it showed an annual growth rate of 1.2% in 1990–2000 (this compares with −0.3% among the world's low- and middle-income countries and 0.1% among the world's high-income countries over the same period), and 2.2% in 2005–2010 (this compares with −0.3% among the world's low- and middle-income countries and 0.1% among the world's high-income countries over the same period)[15]. Countries with the fastest forest growth showed an annual growth rate of 1.39% in 2000–2005 (compared with the world's figure of −0.14% over the same period)[16]. In terms of forest area and stock volume, China showed the world's greatest growth over the period of 1990–2000 and 2000–2010 among the world's major nine countries.[17]

4.5 Twenty-first century: Toward a Natural Surplus

As China entered the new century, its leaders proposed the notion of science-based development, an inseparable and integral part of which is the concept of green development. In a speech at a national meeting about earthquake relief on October

[14] The Information Office of the State Council held the conference of China's forest resources and other aspects on November 17, 2009.

[15] The data are from *2009 World Development Indicators* of the World Bank.

[16] The world's forest resource assessment data show that China's annual rate of change in forest area was 1.87% in 2000–2005 and 1.39% in 2005–2010, which ranked its growth rate 10th in the world; it ranked seventh among the fewer than 30 developing countries that had a positive growth rate.

[17] The world's major nine countries are the five permanent members of the United Nations plus Japan and other the three BRIC nations.

Table 4.6 China's forest resources and carbon sequestration capacity changes (1950–2010). (Source: Development Plan and Assets Management Agency, Center for Economic Development Research of the State Forestry Administration: *Digital Interpretation of Forestry Development in the Tenth Five-Year Plan*; data from the Seventh National Forest Resources Inventory; the Fourth National Forest data were calculated by the author; the method of calculating the total cumulative absorption of carbon dioxide by the forest is the forest stock volume × 1.83 t per m^3 (IPCC Special Report in 2000: trees with per growth cubic meters can absorb 1.83 t of carbon dioxide))

Year	Forest coverage rate (%)	China's forest area (0.1 billion ha)	Forest stock volume (0.1 billion m^3)	Total stumpage volume (0.1 billion m^3)	Accumulation of total absorption of carbon dioxide (0.1 billion t)
1949	8.6	0.83	90.28		165.21
First National Forest Resources Inventory (1973–1976)	12.7	1.22	86.6		158.48
Second National Forest Resources Inventory (1977–1981)	12	1.15	90.3		165.25
Third National Forest Resources Inventory (1984–1988)	12.98	1.25	91.41	105.72	167.28
Fourth National Forest Resources Inventory (1989–1993)	13.92	1.33	106.7	119.5	195.26
Fifth National Forest Resources Inventory (1994–1999)	16.55	1.59	112.7	124.9	206.24
Sixth National Forest Resources Inventory (1999–2003)	18.21	1.75	124.56	136.18	227.94
Seventh National Forest Resources Inventory (2004–2009)	20.36	1.95	137.21	149.13	251.09

The forest area in the Sixth National Forest Resources Inventory includes new shrubs based on special national provisions during the course of the inventory

8, 2008, General Secretary Hu Jintao further clarified the profound relationship that exists between humanity and nature: "Human efforts to understand the laws of nature is a never-ending process. Natural phenomena have to be grasped by means of continuous development of science and technology. As long as we unswervingly follow the road of scientific development and explore and understand the laws of nature, adhere to the laws of nature, and increase our ability to promote harmony between humanity and nature, we will continue to make discoveries, inventions, creations, and advance. In this way, we will make humans better adapt to nature, and this will bring benefits to humanity."[18]

In this new century, China possesses an ecological surplus. There has been a significant drop in loss in GDP through natural disasters; there has been a substantial increase in investment in human capital as well as a substantial increase in green investment. China's green GDP now stands at about 10% higher than its nominal GDP.

In the period of the Eleventh Five-Year Plan, China began to shift toward green development, and it showed a preliminary ecological surplus of its main resources. In this period, its environmental indicators were better than those in the period of the Tenth Five-Year Plan. The trend toward a reduction in arable land was effectively curbed, and water consumption per unit of industrial added value continued to decline. There was evidence of the effectiveness of environmental protection benefits, with initial improvements in the quality of atmospheric environment and water quality. In 2005–2010, the proportion of state-controlled sections of seven major river systems that were higher than Class III increased from 41 to 59.6%. Over the same period, the proportion of Chinese cities that had air-quality standards above Class II increased from 59.3 to 82.7%. Efforts made toward ecological and environmental protection proceeded smoothly, and deterioration in the ecological environment has been initially contained. Conservation areas were effectively protected, and forest coverage increased to 20.36%. Ecological degradation has gradually been brought under control and restored. The natural wetland protection rate of 45% in 2005 has increased to 49.6%. There has been a decrease in the area of soil erosion and the area of grassland subject to degradation, desertification, and salinization (Table 4.7).

The Twelfth Five-Year Plan proposed a green development strategy and was the first Five-Year Plan to tackle green development.[19] This indicates that China will make the transfer from a local to a comprehensive ecological surplus, and it will fundamentally reverse the long-term trend toward ecological deterioration. China will lead the world's green development.

With respect to the green economy, China has two advantages. First, as a latecomer, China has spent less in developing a green economy, and it can take advantage of the leapfrog effect to accelerate such development. Second, in the promotion of green economic development, there may be inadequate investments through

[18] General Secretary Hu Jintao's speech at national meeting about earthquake relief on October 8, 2008.

[19] Refer to Chap. 5 of this book.

Table 4.7 Changes in major eco-environmental indicators in China (2005–2015). (Source: National Bureau of Statistics: *China Statistical Abstract 2010*; State Department of Environmental Protection: *State of the Environment Bulletin in 2005*, June 5, 2006, Ministry of Environmental Protection website in 2011. The indicator for 2015 is derived from the Twelfth Five-Year Plan of the People's Republic of China national economic and social development)

Indicators	2005	2010	2015	Actual change in 2005–2010	Change in 2010–2015
				(%)	(%)
Water consumption per unit of industrial added value				43.5	−10
Coefficient of efficient utilization of agricultural irrigation water	0.45	0.50	0.53	0.05	6
Total irrigation water (0.1 billion m^3)	3,580	3,655		2.1	
Amount of cultivated land (0.1 billion ha)	1.2208	1.212	1.201	−0.7	−1
Forest coverage (%)	18.21	20.36	21.66	2.15	6.4
Sulfur dioxide emissions (10,000 t)	2,549	2,267	2,083	12.45	−8
COD emissions (10,000 t)	1,414	1,237	1,138	14.29	−8
Industrial solid waste treatment rate (%)	56.1	68.4	72	12.3	5.3
Urban sewage treatment rate (%)	52	73	85	21	16.4
Urban life garbage treatment rate (%)	51.7	69	80	17.3	15.9
Proportion of state-controlled sections of seven major river systems better than Class III (%)	41	59.6		18.6	
Proportion of cities with air-quality standards above Class II (%)	59.3	82.7	80	23.4	
Natural wetland protection rate (%)	45	49.6		4.6	
Soil erosion area (10,000 km^2)	356	356.92		0	

market forces alone. As a consequence, it may be necessary for China's government agencies to lend direction by generating appropriate policies and supplying suitable incentives as well as operating in a regulatory capacity with respect to development. China will promote industrial agglomeration, enhance international competitiveness, and accelerate the development of seven strategic emerging industries. Those industries will constitute the four pillar industries of the national economy—energy saving and environmental protection, new generation IT, biological science, and high-end equipment manufacturing—in addition to three leading industries—new energy, materials, and energy vehicles. As a proportion of GDP, those industries will increase from about 4% in 2010 to about 8% in 2015, with a further increase to approximately 15% in 2020. Adopting these strategic emerging industries as its core, China will make efforts to shape its industrial structure in line with the needs of sustainable economic development such that it is able to implement a knowledge-intensive, resource-intensive, and eco-friendly system.

China will lead the world's green energy efforts. China will optimize energy structures in three ways. First, it will increase the proportion of non-fossil energy

sources—especially, solar, wind, and other renewable forms—within the framework of total energy consumption. Second, within the consumption of fossil fuels, it will reduce the proportion of coal. Third, by means of technical transformation, it will use coal in a much cleaner fashion. According to the Twelfth Five-Year Plan, the proportion of non-fossil energy within total energy consumption will amount to 11.2% by 2015. And in accordance with the objectives proposed by the State Council at the end of 2009, the renewable energy proportion will attain 15% by 2020. We estimate that China will exceed that goal, with the proportion of non-fossil energy amounting to 12% by 2015, 19% by 2020, and 26% by 2030[20]; these proportions are greater than those estimated for the United States and the EU and signify that China will become the nation with the highest proportion of green energy[21].

China will be come the world leader in developing a low-carbon economy. According to *World Energy Outlook 2010*, which was published at the end of 2010 by the IEA, it is predicted that the average annual growth of natural gas demand will reach 1.4% over the period of 2008–2035. With 6%, China will have the fastest growth and will account for 23% of the total growth in global demand over this period. The IEA report even stated that China might play the role of leader in ushering in a golden age of gas for the world.

China's huge domestic market and investment demand will stimulate the rapid development of low-carbon technologies[22]. China has become a forerunner in windpower and photovoltaic production as well as being a major equipment supplier. Compared with regions that have enormous potential for the large-scale development of solar power, such as the Middle East and North Africa, China has many advantages with respect to market size, technological level, and political stability. According to the IEA's predictions, China will account for 19, 26, 29, and 21%, respectively, of the world's proportion of low-carbon, new-technology applications in the fields of solar energy, wind energy, nuclear energy, and hybrid cars.

China will engineer the world's largest ecological construction efforts. China will become the world's fastest growing country in terms of forestry resources, and it will rapidly narrow the existing gap with other large-forest countries. China will become the nation with the largest artificial forest carbon storage and the largest artificial forest carbon sinks. By means of the national ecological safety barrier system, China will dramatically increase its water-conservation efforts. This will combat desertification as well as promoting sand fixation, soil and water conservation,

[20] This estimate is relatively conservative; the Chinese Academy of Sciences predicts that China non-fossil energy ratio will attain 20% in 2020 and 34% in 2030. See the Chinese Academy of Sciences: *Technological Revolution and Chinese Modernization*, p. 46, Science Press, 2009.

[21] Countries around the world have formulated development plans and objectives for clean energy (non-fossil energy) by 2020. Among these, Germany sets the highest targets for increasing its clean energy proportion in the entire energy at 30% by 2020; this is followed by those of the EU as a whole and the United States, which both set targets of 20%. However, in practice, those targets may be very difficult to achieve.

[22] Low-carbon technology refers to a reduction or elimination of carbon dioxide emissions based on clean and efficient use of energy and resources, including new energy, energy-saving and reduction, and carbon-capture and sequestration technologies.

maintenance of biological diversity, protection of natural resources, and other functions in key national ecological areas.[23] China will present an attractive scenario of an intensive and efficient production space, a comfortable and livable living space, an ecological space, green mountains and clean water, and a coordinated population, economy, resources, and environment.

China will build a nation with blue skies, clean water, and green mountains. As China continues to promote an environment-friendly society, environmental quality will steadily show improvement. First, the level of pollution emissions will be gradually reduced to below the environmental self-purification capacity. Second, the ecological environment will be significantly improved to achieve cleaner skies, cleaner water, and green mountains. China will build an ecological society. It will create a social form that will achieve harmony between humanity and nature. China will coordinate the production and consumption between human activities and natural ecosystems, and it will establish patterns for saving resources and healthy, civilized consumption. China will establish patterns for industrial structure, growth modes, and energy consumption. It will find ways to save resources and protect the environment and achieve environmental protection that is coordinated to economic development. China will minimize the environmental costs of economic and social development by decoupling economic growth from the consumption of main resources and pollutant emissions. It will manage ways of living and production so as to find the best ecological, social, and economic balance while achieving sustainable development.

Based on the results of the past three decades of reform and opening-up, China has a dream: "one world, one dream, the same action," which is an extension of the slogan used for the Beijing Olympic Games in 2008. This slogan shall become the goal for the future, a goal that reflects global cooperation and a joint coping with the problems of world environmental change.

The green dream means that the world should become the green home of humans. Clearly, this world dream is also that of China, and China's dream is at one with the world's. China and the rest of the world should work on the path toward green development. Green development will be not only the path of China's development but also that of the whole world. With a country of over 1 billion people, China should have the courage to bear the responsibility as the world leader. In 1956, Mao Zedong said, "China shall make a greater contribution to the world." Over 50 years have passed since then. We believe that this responsibility lies in the area of green participation, in which China should become a leader and innovator. China should create the initiative in making a positive, responsible response to the challenges of the global ecological environment and, in so doing, make its greatest contribution to the future world.

[23] The national key ecological function areas include 25 regions, such as the Da and Xiao Xing'anling forest ecological function areas, with a total area of about 3.86 million km^2; these account for 40.2 % of the national land area; at the end of 2008, total population the in these areas was about 1.1 million, which accounted for 8.5 % of total national population.

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Chapter 5
Green Development Plan

> Just as humans have evolved over hundreds of thousands of years, China has undergone its own economic and cultural development as a result of the planning that has been implemented in the past. China's economic outlook will change from year to year; a greater change will take place every five years and an even greater change over the space of several five-year periods.[1] (Mao 1955)

> The future of humanity depends on the choices that people make in the present. Humans will either blindly shape a disastrous future or consciously build toward a better one.[2] (Hu et al. 1990)

The five-year plan is an important expression of the planning decisions made by the Chinese government, and it is a principal element within the Chinese version of the socialist market economy. As Deng Xiaoping once said, "The five-year plan and market developments are both economic processes."[3] National development planning aims to provide knowledge for the whole of society, and it regulates the functions of government in economic, physical, social, and other fields. The five-year plan leads and guides China's development, and these plans play an important role in promoting China's transformation toward a green society.

China has developed its five-year plans since 1953, the plans initially having been modeled on those of the Soviet Union. China has developed and completed 11 five-year plans since that time, and formulated and implemented the Twelfth Five-Year Plan in 2011. Following China's reform and opening-up, its five-year plans have gradually transformed into strategic plans. Compared with those preceding reform and opening, subsequent plans have undergone a fundamental change in that instead of being characterized by introduction, imitation, and correction, they

[1] Mao Zedong: comment on "The Long-Range Plan of the *Red Star* Collective Farm"; see Mao Zedong's *Presentation Since the Founding of New China*, fifth volume, Beijing, Central Literature Publishing House, 1998:503.

[2] On behalf of the early warning group of the Ecological Environment Research Center of the Chinese Academy of Science, the author, Wang Yi and Niu Wenyuan jointly wrote "The Ecological Deficit: the Biggest Survival Crisis for China in the Future—Analysis of Ecological and Environmental Conditions" in August 1989, and it was published in the Chinese science publication *National Conditions and Decision-Making*, page 190, Beijing, Beijing Press, 1990.

[3] Deng (1993).

A. Hu, *China: Innovative Green Development,* DOI 10.1007/978-3-642-54962-5_5,

now emphasize innovation. The purpose of the five-year plan is "to clarify national strategic intent and government priorities as well as to guide the behavior of market players. It is a grand blueprint for China's economic and social development over the next five years. It represents an action program for all nationalities, and it is the key basis for the government to execute economic regulation, market supervision, and social management as well as perform public services."[4] The five-year plan has gradually made the transformation from an economic command to a strategic development plan, from an economic plan to a comprehensive development plan, from micro-level development to macro-level control, and from concentrating on economic indicators to dealing with public service indicators.[5]

With these changes in the character of the five-year plan, the plans themselves have increasingly taken on aspects of green planning. There has been a gradual increase in the emphasis on green development as well as a growing proportion of green development indicators. The proportion of resources devoted to green development and the focus on environmental indicators has increased since the Sixth Five-Year Plan; the fastest growth in this area was observed during the periods of the Tenth, Eleventh, and Twelfth Five-Year Plans. The Twelfth Five-Year Plan, in particular, became the first green development plan in China and in the world as a whole. The manner in which the five-year plans have developed reflects the expansion of the green economy within the whole economic system, and it is expected that future five-year plans will mark an additional shift in the green direction.

How have China's five-year plans undergone the change from black to green plans? How have the plans transformed their emphasis from quantitative change to qualitative change (Eleventh Five-Year Plan) and become green plans that aim to achieve both quantitative and qualitative change (Twelfth Five-Year Plan)? How do the main areas of functional planning and other special types of planning embody the idea of green development? How can China's planning serve to guide green development? What is China's planning experience in green development?

This chapter aims to address the above questions. It also discusses issues that have arisen in the history of planning; it makes an assessment and evaluation of the Eleventh and Twelfth Five-Year Plans, and it outlines the main functional areas of planning. Our research shows that the following factors are important in successful **green planning success. (1) The planning process is flexible and resilient. Full use is made of visible strategies, which complement rather than replace invisible strategies; overall knowledge is promoted, which complements rather than displaces dispersed knowledge; and public incentives supplement rather than replace private incentives. (2) The planning is achieved through intelligent decision-making, which involves brainstorming ideas. Constant efforts are made such that this process is scientific and democratic. (3) The planning undergoes continuous adjustment, and it involves the transformation of black planning to green planning. (4) The planning is an authoritative process; to be effective, it**

[4] Eleventh Five-Year Plan for National Economic and Social Development of PRC (2006–2010) (March 2006).

[5] Hu et al. (2010).

has to include an implementation system. (5) The various components within the planning process work together, and different visible components complement each other rather than work against each other. Five-year plans are a particularly Chinese innovation.

5.1 National Plan to Promote Green Development

The path to green development as marked out by successive five-year plans has been long and tortuous. In 1953, China, influenced by what it had learnt from the planned economy of the Soviet Union, began developing its first five-year plan, and generally continued to follow the Soviet approach with its five-year plans over a considerable period. The main objectives of the early five-year plans were the promotion of China's economic development and social progress; however, they differed in their approach as well as in their priorities and specific targets. China's five-year plans have undergone a transformation from economic plans to strategic plans and finally to comprehensive development plans; in the process, they have developed from a promotion of the black economy to that of the green economy. In the following analysis, the development of these five-year plans will be divided into three stages in terms of resources, the environment, and development:

5.1.1 Period of Black Development—First to Fifth Five-Year Plans

During this period, China formulated five five-year plans, with their main tasks being the development of industry and agriculture as well as the promotion of industrialization. The aim was to achieve an independent and relatively comprehensive industrial and economic system by the end of the fifth five-year plan. The early five-year plans were thus characterized by their emphasis on heavy industry: the First Five-Year Plan established heavy industry as a priority; the Second Five-Year Plan placed its focus on the development of the steel industry; the Third and Fourth Five-Year Plans underlined the importance of heavy industry as the basis for military preparedness; the Fifth Five-Year Plan aimed to promote a significant advance in the industrial sector, and this set China on the road of black industrialization, characterized by high input, consumption, and emissions. There are certain drawbacks with the planned economy approach since it results in significant wastage of energy and resources, and outstanding performance is achieved at the cost of rising energy consumption and carbon emissions per unit of GDP. The early five-year plans therefore not only resulted in a planned economy with inefficient use of resources, but they also amounted to a plan for black industrialization and development.

5.1.2 Initial Transition—Sixth to Eighth Five-Year Plans

With the transformation of China's economic system since the reform and opening-up, the five-year plans have also undergone considerable modification: they have gradually changed from mandatory to guiding plans, from solely economic plans to economic and social development plans. In addition, the five-year plans have progressively abandoned the path of the black economy, having undergone their preliminary transformation over course of the sixth to eighth five-year plans. The Sixth Five-Year Plan states, "This is a new type of five-year plan that adopts novel ways of socialist modernization."[6] Unlike the old approach, which took economic construction as its central element, the Sixth Five-Year Plan aimed to improve the national economy through healthy and steady development. It aimed to achieve this by implementing adjustments, reforms, rectifications, and improvements, and it required a "total social product and national income growth rate based on improving economic efficiency." "The Seventh Five-Year Plan proposed to undertake "internally expanded reproduction." The Eighth Five-Year Plan placed an emphasis on development and conservation; particular prominence was given to conservation. At the same time, the Eighth Five-Year Plan emphasized energy use as one of its main objectives, and it proposed relevant quantitative indicators to assess this (see Table 5.1).

5.1.3 Further Transition—Ninth to Tenth Five-Year Plans

The Ninth Five-Year Plan introduced two changes: "the economic system will change from a traditional planned economy to a socialist market economy"; and "the economic growth mode will change from extensive to intensive." This indicates that China had begun to enter the transition from a period of black development to one of green development. In the Ninth Five-Year Plan, the proportion of green development indicators increased to 11.8%. This played a large role in promoting an initial change in the economic development mode during this period; energy consumption per unit of GDP dropped significantly, and emissions of major pollutants began to decline. However, GDP showed an annual average growth rate of 8.6% during this period, which was therefore a rare time of economic growth coupled with coordinated development of resources and the environment.

The Tenth Five-Year Plan signaled greater progress toward green development, with green development indicators showing an additional increase to 16.7%; with this plan, environmental protection and ecological indicators became the main

[6] Premier Zhao Ziyang described the main points of the Sixth Five-Year Plan at the fifth session of the National People's Congress. He stressed that "under the premise of improving economic efficiency, one of our important principles is to maintain industry and agriculture at an appropriate development pace." (Zhao Ziyang, report on the Sixth Five-Year Plan, the Office of NPC financial and Economic Committee, Development and Planning Agency of the National Development and Reform Commission, 2008:376)

Table 5.1 Proportion of different types of green development indicators in the Sixth to Twelfth Five-Year Plans

		Sixth Five-Year Plan	Seventh Five-Year Plan	Eighth Five-Year Plan	Ninth Five-Year Plan	Tenth Five-Year Plan	Eleventh Five-Year Plan	Twelfth Five-Year Plan
Indicators of intensive use of resources		1	1	2	2	3	5	5
Environmental protection indicators	Caliber a	0	0	0	0	3	2	4
	Caliber b	0	0	0	0	3	1	1
Ecological construction indicators	Caliber a	0	0	0	0	2	1	2
	Caliber b	0	0	0	0	2	1	1
Indicators of response to climate change		0	0	0	0	0	0	1
Total number of green development indicators	Caliber a	1	1	2	2	8	8	12
	Caliber b	1	1	2	2	8	7	8
Proportion of green development indicators (unit: %)	Caliber a	3	3.6	7.7	11.8	16.7	29.6	42.9
	Caliber b	3	3.6	7.7	11.8	16.7	26.9	33.3

Caliber a refers to the actual number of indicators and Caliber b to the combined number of key indicators. In the Eleventh Five-Year Plan, there were two environment indicators and one combined indicator of pollutant emissions made up of two separate indicators. In the Twelfth Five-Year Plan, there were four environmental indicators and one combined indicator of pollutant emissions, which consisted of four separate indicators; there were also two ecological indicators and one combined indicator of forest resources, which was made up of two indicators

indicators of a five-year plan for the first time. During the period of this plan, however, increased domestic consumption caused China's economic development to enter a new round of heavy industrialization. Thus, following the progress made with the Ninth Five-Year Plan, China's economic development mode reverted to one of high consumption, investment, and pollution. There were sharp increases in national energy consumption, and the average annual growth rate rose to 10.2% (it had been only about 1% during the period of the Ninth Five-Year plan, and it decreased from 1997 to 1998). In addition, there was further industrialization

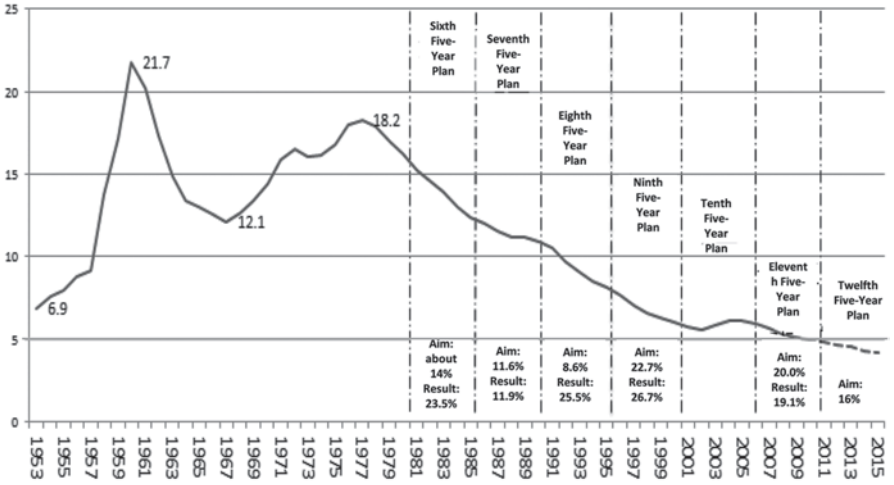

Fig. 5.1 Energy consumption per unit of GDP (1953–2010). (Source: National Economic Comprehensive Statistics Division of the National Bureau of Statistics, *New China Statistical Information Collection over 55 Years*, Beijing: China Statistics Press, 2005. National Bureau of Statistics, *China Statistical Yearbook of 2009*, electronic version, Beijing: China Statistics Press, 2009. Sixth Five-Year Plan for National Economic and Social Development of PRC (1982–1985); Seventh Five-Year Plan for National Economic and Social Development of PRC (1986–1990); Eighth Five-Year Plan for National Economic and Social Development of PRC (1991–1995); Ninth Five-Year Plan for National Economic and Social Development of PRC (1996–2000); Eleventh Five-Year Plan for National Economic and Social Development of PRC; Twelfth Five-Year Plan for National Economic and Social Development of PRC)

during the period of the Tenth Five-Year Plan, especially of heavy industry: the industrial added value as a percentage of GDP increased by 1.8 % (compared with a 1 % decrease during the period of the Ninth Five-Year Plan), while the proportion of tertiary industry rose by only 1 % (compared with a 6.1 % increase during the period of the Ninth Five-Year Plan). Furthermore, with the weakening regulatory functions of the Tenth Five-Year Plan, China was unable to cut emissions of major pollutants, and there were increases, rather than decreases, in chemical oxygen demand and sulfur dioxide emissions (Fig. 5.1).

5.1.4 Turn to Green Development—Eleventh to Twelfth Five-Year Plans

The Eleventh Five-Year Plan was the first plan to be drawn up under the guidance of scientific thinking with respect to development. As a result, 29.6 % of its indicators were related to green development, and particular prominence was given to energy conservation and environmental objectives. The Twelfth Five-Year Plan was the first plan with a central commitment to green development, as reflected in the fact

that such indicators rose to 44.9% (see Table 5.1). This is a clear indication of the growing green character of the five-year plan, with a view to making China a much greener country.

5.2 Eleventh Five-Year Plan—Turning to Green Development

The Eleventh Five-Year Plan (2006–2010) was the first plan to be drawn up after the central government proposed in 2003 that "scientific outlook on development" be incorporated into such plans. In this plan, the national development goals consisted of binding and expected indicators depending on areas of government responsibility and market mechanisms. With the Eleventh Five-Year Plan, the proportion of economic development indicators dropped to its lowest-ever level, while the proportion accounted for by energy saving, emissions reduction, and environmental protection rose to its highest level. There were 16 green development indicators: 12 direct and four indirect indicators of green development; 11 highest-priority indicators and five sub-priority indicators. This plan thus fully constitutes the change to green development.

Among 11 direct indicators of green development in the Eleventh Five-Year Plan, which aimed to promote the greening of China, the goals of nine indicators were achieved. These included achieving a forest coverage rate of 20.36%, a net increase of forest reserves of 1.123 billion m^3, and an average annual net increase of 225 million m^3; as a result, China leads the world in terms of its carbon sink capacity.[7] The amount of cultivated land was maintained at 120 million ha. The aim of reducing the industrial added value of water consumption by 30% was achieved 1 year ahead of schedule. The solid-waste comprehensive utilization rate was 65%, which exceeded the planned aim of 60%, and it was achieved ahead of schedule. The treatment rate of urban sewage increased from 48.4% in 2005 to 72.3% in 2009. Cumulative sulfur dioxide emissions were reduced by 14%, and chemical oxygen demand was reduced by 12%, which exceeded the planned objective of 10%. Energy consumption per unit of GDP fell by 19.1%, which was in line with the planned aim.

However, some green development indicators were not achieved: two sub-priority direct green development indicators failed to be realized, including the 200,000 km^2 target required by the plan, and the goal of zero growth of total irrigation water. In addition, the aims of optimizing the industrial structure and upgrading indirectly related to green development were not achieved. Added value of services amounted

[7] According to an evaluation by the Chinese Academy of Forestry, the total carbon stock of forest vegetation in China amounted to 7.811 billion t. Water conservation in forest ecosystems amounted to 494.766 billion m^3; this saved 7.035 billion t of soil and 364 million t of fertilizer; the annual absorption of air pollutants amounted to 0.32 million t, and there were 5.001 billion t of dust. Jia Zhibang, November 17, 2009.

to 43.0% of GDP in 2010, and the aim is to achieve a target of 43.5%. Employment in the service sector as a proportion of total employment rose to 34.8% in 2010; however, the target of 35.4% will not be achieved on schedule. The Service Trade Division of the Ministry of Commerce estimates that the total trade in services was US$ 364.5 billion in 2010, though this failed to achieve the aim of US$ 400 billion; the proportion of research and experimental development expenditures in GDP was 1.75% in 2010 (see Table 5.2), which failed to meet the target of 2%.

It should be noted that an important innovation of the Eleventh Five-Year Plan was that it defined government responsibility targets as binding. It also stipulated that the binding targets identified in the plan were legally effective and had to be included as part of the comprehensive evaluation and performance appraisal of various regions and departments in terms of economic and social development.[8] Six binding indicators related to green development were successfully achieved.[9] At the same time, compared with the Tenth Five-Year Plan, all the binding indicators showed significant improvement: the decrease in the area of arable land was faster; there were improved resources and energy efficiency; and there were reduced pollution emissions. This clearly shows that the introduction of binding indicators signaled a clear obligation on the part of the government to implement its goals and adjust its behavior. This therefore made a significant contribution to the transformation of the government, and it pushed the national economy and society onto the path toward green development.

In addition to clear green development indicators in the Eleventh Five-Year Plan, the state also established energy-saving targets, which have had an effect on the energy-saving behavior of local governments and enterprises. As a result, all local governments have introduced policies, measures, laws, and regulations to promote market development, and various kinds of enterprises have increased the intensity of their investments in energy saving. Led by local governments, contract energy management, the energy services market, and the renewable energy development market have been established to lower the barriers for small and medium-sized enterprises (SMEs) in financing energy-saving measures. At the end of the period of the Eleventh Five-Year Plan, Beijing, Hubei, Tianjin, and Chongqing in addition to other regions exceeded the target value of energy consumption per unit of

[8] See Chap. 48 of the Eleventh Five-Year (2006–2010) Plan for National Economic and Social Development of PRC by National People's Congress on March 4, 2006.

[9] Premier Wen Jiabao stated at the Eleventh Five-Year Plan for National Economic and Social Development (Draft) that "the outline puts forward the aims of decreasing energy consumption per unit of GDP by 20% and reducing the total discharge of major pollutants by 10%. This was proposed to address the acute problem of mounting pressure on resources and the environment, and it reflects the requirement of saving resources and achieving an environment-friendly society. It is also appropriate in terms of current and long-term interests by providing clear policy guidance. Although it is very difficult to achieve this goal, we have the confidence and determination to make it succeed." Wen Jiabao: "Report on the Work of the Government in 2006," which appeared in *Compilation of Important Documents for National Economic and Social Development of the Five-Year Plan since the Founding of New China* prepared by the office of NPC Financial and Economic Committee, Development and Planning Division of National Development and Reform Commission, page 18, Beijing, China's Democracy and Legal System Publishing House.

Table 5.2 Implementation of green development indicators related to the Eleventh Five-Year Plan (2006–2010). (Source: Urban employment figures derive from the Ministry of Human Resources and Social Security; transfer of the agricultural labor force derives from the Ministry of Agriculture; agricultural irrigation water effective utilization coefficient derives from the Development Research Center of the Ministry of Water Resources: *Water Development Report in 2010*; main pollutant emission-reduction data in 2009 derive from the Ministry of Environmental Protection: *Bulletin of National Environment in 2009* (June 5, 2010); energy consumption indicators in 2009 are from the National Bureau of Statistics, National Development and Reform Commission, and National Energy Administration: bulletin of GDP energy consumption and other indicators of provinces, autonomous regions, and municipalities in 2009 (July 15, 2010); other data derive from the China Statistical Abstract (2010))

Category	Indicator	Properties	Level	2005	2010	Planned value in 2010	Percentage complete (%)
Direct indicator	Energy consumption decrease per unit of GDP (%)	Binding	Priority		[19.1]	[About 20]	95.5
	Reduced water consumption per unit of industrial added value(%)	Binding	Priority			[30]	99.5
	Agricultural irrigation water efficient utilization coefficient	Expected	Priority	0.45	0.5	0.5	100
	Comprehensive utilization of industrial solid waste (%)	Expected	Priority	56.1	68.4	60	292.9
	Arable land (100 million ha)	Binding	Priority	1.2208	1.212	1.2	Good
	Sulfur dioxide emissions reduction (%)	Binding	Priority		−14	[10]	131
	Reduction in chemical oxygen demand emissions (%)	Binding	Priority		−12	[10]	100
	Forest coverage rate (%)	Binding	Priority	18.21	20.36	20	119.4
	Irrigation water (100 million m^3)[c]		Sub-priority	3,580	3,707	Zero growth	Not completed
	Added soil-erosion area (10,000 km^2)[c]		Sub-priority	2.65		20	34.7[d]
	Urban sewage treatment rate (%)[c]		Sub-priority	52[a]		≥70	104.2[c]
	Urban life garbage treatment rate (%)[c]		Sub-priority	51.7[a]	71.3	≥60	118.8
Indirect indicator	Proportion of value added in services (%)	Expected	Priority	40.5	43.0	43.5	83.3

Table 5.2 (continued)

Category	Indicator	Properties	Level	2005	2010	Planned value in 2010	Percentage complete (%)
	Proportion of service sector employment (%)	Expected	Priority	31.4	34.8	35.4	67.5
	Proportion of research and experimental development expenditure in GDP (%)	Expected	Priority	1.32	1.75	2.0	44.1
	Import and export volume of trade in services (US$ 100 million)[c]		Sub-priority	1,571	3,645[b]	40,000	91

[a] Topics of "The Two Meetings in China" (National People's Congress and the Chinese People's Political Consultative Conference) in 2009 from the government network, http://www.gov.cn/2009lh/content_1252680.htm

[b] Service Trade Division of the Ministry of Commerce estimated these data; see the ministry's Web site

[c] Indicates that the data were calculated from 2009 and that they were at the sub-priority level

[d] Indicates that the figure was calculated from 2008 data

GDP. Most of the other provinces and areas have likewise met their targets (see Table 5.3). This also points to the fact that under the guidance of the Eleventh Five-Year Plan, regions have been able to begin their efforts toward green development. Local governments in China have generally made important contributions in efforts leading to green development.

In addition, China made important progress in terms of its climate-change policy during the period of the Eleventh Five-Year Plan. According to observers both at home and overseas, China's great improvement in energy and environmental policies in the period of the Eleventh Five-Year Plan indicates the great potential and bright future for China in green and low-carbon industrial development. Sir Nicholas Stern, a former advisor to the British government on climate change, commented in 2010, "China has accounted for a large share in the existing low-carbon market and will make further growth" and "China will most likely play a leadership role in the low carbon revolution, and bring benefits to itself and the world."[10]

[10] Nicholas Stern made the comments on October 31, 2010 at the Summit of the Shanghai World Expo. http://www.zgjrw.com/News/2011322/home/833652896400.shtml.

Table 5.3 Completion of energy consumption per unit of GDP for different areas during the period of the Eleventh Five-Year Plan. (Source: The achievement of the provinces partially refers to the announcement of completion of energy-saving targets for each region in the Eleventh Five-Year plan by the National Development and Reform Commission and National Bureau of Statistics, and the completion of Xinjiang Uygur Autonomous Region partially refers to the comprehensive work program of energy saving in the Twelfth Five-Year Plan)

Classification	Region	Target value (% decrease)	Actual value (% decrease)	Actual value/target value
Regions exceeding the target	Beijing	20.00	26.59	1.33
	Hubei	20.00	21.67	1.08
	Tianjin	20.00	21.00	1.05
	Chongqing	20.00	20.95	1.05
	Heilongjiang	20.00	20.79	1.04
	Shanxi	22.00	22.66	1.03
	Inner Mongolia	22.00	22.62	1.03
	Fujian	16.00	16.45	1.03
	Guangdong	16.00	16.42	1.03
	Yunnan	17.00	17.41	1.02
Regions attaining the target	Jiangsu	20.00	20.45	1.02
	Hunan	20.00	20.43	1.02
	Anhui	20.00	20.36	1.02
	Sichuan	20.00	20.31	1.02
	Guangxi	15.00	15.22	1.01
	Gansu	20.00	20.26	1.01
	Shaanxi	20.00	20.25	1.01
	Hainan	12.00	12.14	1.01
	Henan	20.00	20.12	1.01
	Hebei	20.00	20.11	1.01
	Ningxia	20.00	20.09	1.00
	Shandong	22.00	22.09	1.00
	Guizhou	20.00	20.06	1.00
	Qinghai	17.00	17.04	1.00
	Jiangxi	20.00	20.04	1.00
	Jilin	22.00	22.04	1.00
	Liaoning	20.00	20.01	1.00
	Zhejiang	20.00	20.01	1.00
	Shanghai	20.00	20.00	1.00
	Tibet	12.00	12.00	1.00
Region not achieving the target	Xinjiang	20.00	8.91	0.45

5.3 Twelfth Five-Year Plan—Green Development as the Theme

As noted above, the Twelfth Five-Year Plan was China's first green development plan. It partially achieved qualitative change in switching from black development to green development; it set both quantitative and qualitative targets. The Twelfth

Five-Year Plan contained an increase in the number of indicators for climate change, and the proportion of green development indicators rose to 43 %, with those relating to the economy, nature, and society fully reflecting the course toward green development. This plan clearly proposed "to establish a resource-saving, environment-friendly society and to improve the level of ecological civilization" as one of its focuses of development. The plan also aimed to significantly reduce the levels of energy consumption and carbon dioxide emissions as binding indicators. In addition, the plan targeted reasonably controlled total energy consumption, improvements in energy efficiency, adjustments in the structure of energy consumption, and increases in forest cover and carbon sequestration capacity. One section of the Twelfth Five-Year Plan was dedicated to green development and the establishment of a resource-saving, environment-friendly society and setting green development as a principle of ecological construction. Therefore, as already noted, the Twelfth **Five-Year Plan became China's first green development plan. It was an action plan for China'sparticipation in the world's green revolution and was a historical starting point for the green modernization of China in the twenty-firstcentury.**

First, the proportion of green development indicators increased significantly in the Twelfth Five-Year Plan. For priority indicators, the resources and environment indicators rose from seven indicators with a proportion of 25.9% in the Eleventh Five-Year Plan period to nine indicators with a proportion of 32.1% of 28 key indicators in the Twelfth Five-Year period: among the actual indicators, there were 12 green development indicators, which accounted for 42.9% of the total. In addition, there were four educational science and technology indicators and one improving service proportion indicator, which indirectly promoted green development; there were 17 direct and indirect indicators of green development (see Table 5.4). These accounted for 60.7% of key indicators, which underlines the greater importance placed on resource and environment indicators in the Twelfth than in the Eleventh Five-Year Plan.

Second, the Twelfth Five-Year Plan emphasizes comprehensive, fair, and harmonious sustainable development of the economic system, natural systems, and the social system by means of green growth through the promotion of green benefits and wealth. The Twelfth Five-Year Plan is a green plan, as is fully reflected in the way it aims to achieve dynamic growth though green development, wealth, and welfare; this is best expressed in the indicators of the plan (see Table 5.4). With respect to three green indicators, the proportion of green wealth and benefits is higher than that of green growth, which signifies a transfer from green growth to green wealth and welfare. Specifically, indicators of green growth include added value of the service sector and decreased energy consumption per unit of GDP; indicators of green welfare include average life expectancy, increase in the number of new urban jobs, affordable housing construction, disposable income of urban residents, and per capita net income of rural residents; indicators of green wealth include area of arable land, forest growth, and pollution emissions. In each chapter of the published plan, an outline addresses aspects of the green development policy[11]: promoting green building and construction; expanding the financial

[11] Ping (April 2011).

Table 5.4 Key indicators of green development in the Twelfth Five-Year Plan. (Source: Twelfth Five-Year Plan for National Economic and Social Development of PRC (March 2011))

Category	Indicator		Properties	Importance	2010	Planned value in 2015	Average annual growth
Green growth	Proportion of added value of services sector (%)		Expected	Priority	43	47	[4]
	Energy consumption decrease per unit of GDP (%)		Binding	Priority			[16]
	Total sulfur dioxide emissions decrease per unit of GDP		Binding	Priority			[17]
	Proportion of research and experimental development expenditure of GDP (%)		Expected	Priority	1.75	2.2	[0.45]
	Invention patents per 10,000 people (units)		Expected	Priority	1.7	3.3	[1.6]
Green wealth	Arable land (100 million ha)		Binding	Priority	18.18	18.18	[0]
	Water consumption decrease per unit of industrial added value		Binding	Priority			[30]
	Utilization efficient coefficient of agricultural irrigation water		Expected	Priority	0.5	0.53	[0.03]
	Forest growing stock (100 million m^3)		Binding	Priority	137	143	[6]
	Forest coverage rate (%)		Binding	Priority	20.36	21.66	[1.3]
	Main pollution emission reduction (%)	Chemical oxygen demand	Binding	Priority			[8]
		Sulfur dioxide		Priority			[8]
		Ammonia		Priority			[10]
		Hydroxide		Priority			[10]
	Resource output rate increase		Sub-priority			[15]	
	Ratio of air quality in cities above the prefectural level achieving at least level-2 standard			Sub-priority			[80%]
	Efficient water-saving irrigation area (10,000 mu)			Sub-priority			[5,000]
	Land for construction decrease per unit of GDP (%)			Sub-priority			[30]
	Number of green energy counties			Sub-priority		200	
	Improved grassland (100 million mu)			Sub-priority		[3]	
	Area of artificial grass (100 million mu)			Sub-priority		[1.5]	

Table 5.4 (continued)

Category	Indicator	Properties	Importance	2010	Planned value in 2015	Average annual growth
Green welfare	Average life expectancy	Expected	Priority	73.5	44.5	[1]
	Maternal mortality rate (per 100,000)		Sub-priority	30.0	22	
	Increase in number of new urban jobs (10,000)	Expected	Priority			[4,500]
	Urban affordable housing construction (10,000 units)	Binding	Priority			[3,600]
	Rural residents' per capita net income growth (%)	Expected	Sub-priority			[7]
	Infant mortality rate (per thousand)		Sub-priority			[12]
	New rural population with safe drinking water (100 million)		Sub-priority	[1.7]	[3]	
	Renovating dilapidated houses of poor rural households (10,000 households)		Sub-priority		[800]	
	National affordable housing coverage area (%)		Sub-priority		Around 20	

Urban employment (10,000). Items in *square brackets* represent a five-year cumulative number

services sector and developing the green economy; developing green mining and establishing green and low-carbon development concepts; developing a green lifestyle as well as implementing government green procurement and other supporting policies and measures. This approach fully reflects the fact that the change from black to green development is a comprehensive transformation of the economic, natural, and social system.

Third, the Twelfth Five-Year Plan clarifies incentive and restraint mechanisms of green development. This marked the first time for a five-year plan to adopt the aims of "perfecting price reform for natural resources and enhancing environmental protection" as its fundamental direction.[12] It also required greater stringency over assessing energy-saving targets, proper control of total energy consumption, and the implementation of green development throughout all aspects of economic activity. The plan aimed to stimulate the transformation of business enterprises along the path of green development and encourage such enterprises to become major players in the area of green development. It endeavored to do so by improving the price formation mechanism of resource products, promoting environmental reform, and establishing trading mechanism resources and environment property rights along with various other policies and measures. The aim of the plan was to promote green planning and green development at the national level and ultimately to advance the green transformation of the market.

[12] Ping (April 2011).

Fourth, the Twelfth Five-Year Plan was the first such plan to clearly propose a positive response to global climate change. The plan plainly declares that it will undertake "an active response to global climate change" in Chapter One[13] of Section. By 2015, the plan intends to carry out its response to climate change in terms of indicators such as reducing carbon dioxide emissions per unit of GDP, as well as quantitative indicators of a reduction in the proportional increase in non-fossil energy consumption compared with emissions. As well, forest coverage, forest growing stock and new forest areas will be increased to enhance carbon sequestration. The plan emphasizes control of greenhouse gas emissions and an enhanced adaptation to the problems of climate change from a Chinese perspective. Among the countries of the world, China needs to stand at the forefront in terms of emissions reduction, and it needs to make green contributions to humanity so as to achieve the aim of "One World, One Dream, and One Action."[14] China's basic stance in breaking the current impasse with respect to global climate change involves the establishment of a Chinese-led framework as part of the mechanism of global governance.

5.4 Main Functional Area Planning—Remaking the Economic Geography of a Green China

China's vast land territory and offshore areas form the basis for the sustainable development of the nation. China has established spatial long-term plans for strategy implementation in the main functional areas to work towards better homes, a more developed economy, greater coordination among its regions, richer residents, a more harmonious society, and a cleaner environment for future generations[15].

The strategy of establishing main functional areas according to different resource carrying capacity, existing development strength, and development potential of China's various regions is an attempt to coordinate population distribution, economic layout, land utilization, and urbanization pattern. This is done with a view to determining the main features of the country's different regions. Consequently, better definition of development direction, improved development policy, control of development intensity, and a specific development order can be achieved so as to

[13] The Eleventh Five-Year Plan states in the last chapter of Section 6 that it will promote rational use of marine and climate resources.

[14] "One World" refers to China as a part of the world and the fact that the world needs China as never before. "One Dream" refers to China's world dream of actively responding to global climate change and stabilizing the global climate so that average global temperature will not rise above 2 °C compared with levels in the pre-industrial period. "One Action" refers to achieving common emissions reduction along with the rest of the world, taking the lead in emissions reduction, and undertaking measurable, reportable, and verifiable actions in a spirit of information transparency so that the world at large can properly understand the stringent emission reduction actions made by China.

[15] National Main Functional Area Plan, December 21, 2010.

create a national spatial development pattern characterized by a harmonious population and stable economy, resources, and environment.[16]

The Eleventh Five-Year Plan for National Economic and Social Development of PRC was the first such plan to propose planning of China's main functional areas.[17] In October 2007, the report to the 17th National Congress of the Communist Party of China made the following statement: in the next 5 years, "we will reinforce our efforts in land planning, improve our regional policy, and adjust our economic layout according to the requirements for establishing the main functional areas," and "the basic layout of the main functional areas will be achieved by 2020." These main functional areas were envisaged as becoming the basis for China's major regional development strategy over the first 50 years of the twenty-first century. We regard to this development as a Chinese innovation: the world's most populous and third-largest country and the country with the most complex ecological environment has introduced a plan and action program for the scientific development of its national land area. China has modified its regional policy to meet local conditions and classified management to promote common care of the home planet for human survival and to make a significant green contribution for human development.

The Twelfth Five-Year Plan divides China's main functional areas into four categories: optimized, key, restricted, and prohibited-development areas.[18] The first two types relate to urban agglomeration and encompass the main functions of supporting economic growth and providing financial products; the second two items relate to rural areas that possess outstanding ecological importance, and the major object here is to afford ecological security and promote ecological products. The main purpose behind the above division of the main functional areas is to facilitate the coordination between urban and rural areas such that both people and nature benefit in each area[19].

A core concept with these main functional areas is to break away from a local GDP-driven development model and abandon the development principles and models that focus only on material goods rather than on people. The object is to achieve a coordinated population, economy, resources, and environment,[20] and thus

[16] Ping (April 2011, p. 514).

[17] Chapter 20 of the Outline made the following statement: "According to resource and environment carrying capacity, existing development density, and development potential, coordination efforts will take into consideration China's future population distribution, economic layout, land use, and urbanization patterns and divide the land space into four types, such as optimized, key, restricted, and prohibited-development areas".

[18] National Main Functional Area Plan, December 21, 2010.

[19] Chen Deming, deputy director of the National Development and Reform Commission, pointed out at a meeting in Huizhou in May 2007 that promotion of the formation of main functional areas was "to implement a scientific outlook on development, coordinate urban and rural development, regional development and harmonious development of human and nature, and it is related to the overall situation of China's economic and social development and long-term development of the Chinese nation." See Chen Deming: "Comprehensively Implement Scientific Outlook of Development, and Push Forward National Main Functional Areas Plan Work", *China Economic Herald*, June 30, 2007.

[20] Ma Kai: "Implementation of the Strategy of Main Functional Areas and Scientific Development of Our Homeland", September 1, 2011.

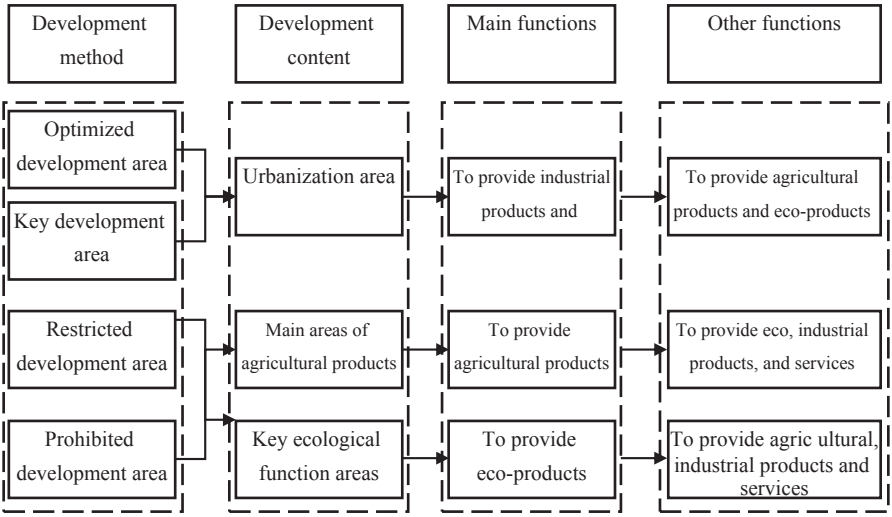

Fig. 5.2 Classifications and functions of the main functional areas. (Source: State Council, *National Main Function Area Plan*, December 21, 2010)

we proposed the notions of **policy-making based on local conditions and the development, assessment and use of classifications**. Taking into account the various characteristics of different regions and land spaces, the objects behind the main functional areas are the following: providing different products; urbanized areas are developed as optimized, key areas to provide industrial products and services, namely GDP products; for major crop areas, industrial and commercial land use should be restricted, and these areas should be allowed to play their main role of producing agricultural products, or mixed products; and, finally, for key ecological function areas industrial and commercial land use should be restricted or prohibited in order for these areas to be able to provide ecological or green products.

Thus, GDP products are categorized as three types—GDP, mixed, and green products. Moreover, the GDP itself is in effect green, both in terms of overall development and the provision of green products; the GDP is also green in terms of performance, and the provision of green products amounts to a great achievement. According to the different main functional areas, different development goals, evaluation mechanisms, and supporting policies are proposed (Fig. 5.2).

The use of restricted- and prohibited-development areas reflects the green thinking behind the main functional area plan by providing ecological products. Such products are consistent with the notions of green demand,[21] green development,[22]

[21] Human needs include the demand for agricultural, industrial, and service products as well as for fresh air, clean water, a good climate, and other ecological products. See *National Main Functional Areas Plan*, December 21, 2010.

[22] Protection and expansion of nature's ability to provide ecological products also adds to the value-creation process, and protection of ecological environment and provision of ecological products are part of development. See *National Main Functional Areas Plan*, December 21, 2010.

and green products.[23] In addition, a major goal with the restricted- and prohibited-development areas is to limit or prohibit inappropriate development activities while offering protection to ecological barriers and the ecological network, all which is in keeping with the grand strategy of long-term survival and development in China. Restricted-development areas include many of the important ecological barriers in China, such as the sand-protecting zone in the north of the country, the northeast forest zone, the Qinghai-Tibet Plateau, junction regions of the three gradient terrains of China (known locally as the "three ladder junction" area), and hilly and mountainous zones in south China. Prohibited-development areas constitute a decentralized network of ecological barriers, including national nature reserves, world cultural and natural heritage sites, key national scenic spots, national forest parks, and national geological parks, and they account for 11.5 % of the total land area of China. Prohibited-development areas aim to provide protection and prohibit interference with and destruction of the ecological environment through economic and social activities; the aim is also to offer protection to the natural and cultural heritage. The main national functional areas involve establishing an ecological security strategy of "two screens and three belts," which is in keeping with the notion of green development. The plan states that the ecological security strategy outlined above will be developed over the next two decades. To establish a framework for ecological safety, industrial and commercial land use should be tightly restricted or prohibited in many key ecological function areas, including: boundaries between agricultural and pastoral areas; transition regions among the three gradient terrains of China; the Three-North Protection Forest System; the northeast forest, southern hilly and mountainous zones; the Tibetan and Loess plateaus; the Sichuan-Yunnan ecological protection areas; and major rivers.[24] Over the next two decades, the ecosystem will become more stable. By 2020, the layout of the main functional areas will have basically taken shape.[25] By 2030, the national ecological safety barrier system will have been principally established, and China will be characterized by an intensive, highly efficient production space, a comfortable living space, an ecological space with clean mountains and water, and demographic and economic resources coordinated with the environment (see Figs. 5.3 and 5.4).

[23] Overall, China has a rapidly increasing ability to provide industrial products but a weakening ability to provide ecological products; with the improvement in living standards, the demand for ecological products will continue to rise. Therefore, we must consider ecological products as an important part of development, and regard enhancement of ecological production capacity as an important task in national spatial development. See *National Main Functional Areas Plan*, December 21, 2010.

[24] National prohibited-development areas refer to the natural concentrated region of natural ecosystem and rare and endangered wildlife species, natural heritage sites and cultural sites of special value; in these areas, industrialization and urbanization are prohibited, and instead the emphasis is on key ecological functions as part of national spatial development. As defined by laws, regulations, and other provisions, there are 1,443 prohibited-development areas, with a total area of approximately 1.2 million km^2, which amounts to 12.5 % of China's land area. In the future, newly established national nature reserves, world cultural and natural heritage sites, national scenic spots, national forest parks, and national geological parks will automatically join the list of national prohibited-development areas. *Main Functional Area Plan*(December 21, 2010).

[25] *Main Functional Area Plan*, December 21, 2010.

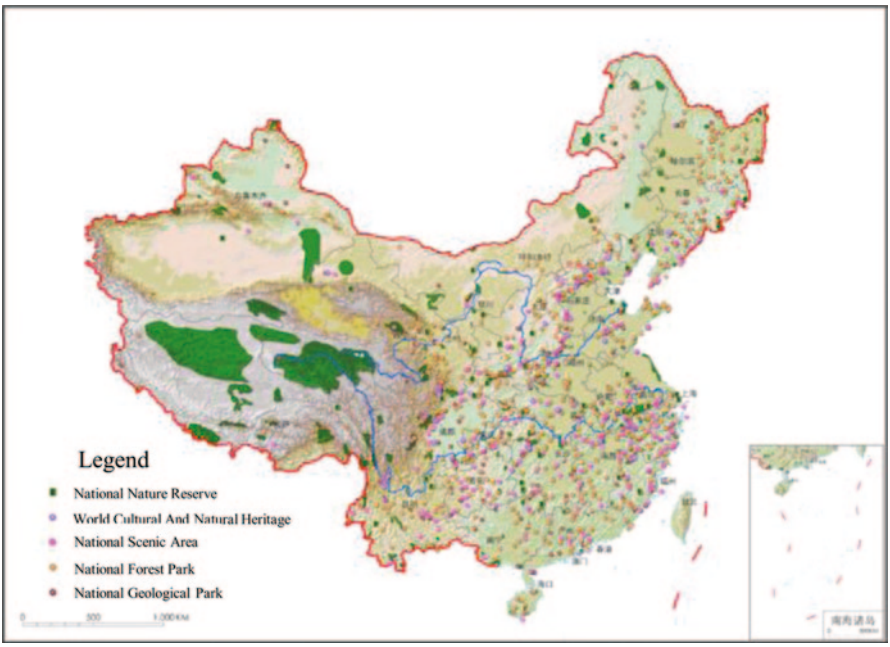

Fig. 5.3 National key ecological function areas. (Source: *Main Functional Area Plan*, December 21, 2010)

5.5 China's Green Development Planning Road

The five-year plan has become an element of green development planning, and it has played an important role in putting China on the road to green development. Efforts will be made to adhere to the plan and introduce further improvements in its design such that China will be able to achieve its green goals. China's experience with five-year plans includes the following six points.

First, the full application of visible planning strategies has to supplement rather than replace invisible market strategies. As Premier Wen Jiabao has stated, "The invisible hand of the market and the visible hand of government and social supervision should both act, and act vigorously. Only in this way can resources be distributed according to market rules and distributed in a reasonable, coordinated, fair and sustainable manner."[26] The aim with five-year plans is to achieve overall knowledge not dispersed knowledge. A five-year plan amounts to the consensus of 1.3 billion people, and it is the result of the combined effect of economic, political and social factors. Because China's five-year plans are no longer based on heterogeneous information related to reform efforts, the plans have undergone the gradual change from economic plans to strategic plans. The plans now emphasize strategy

[26] Wen Jiabao: "See China in the light of her development"—Speech at Cambridge University, February 2, 2009. *http://www.fmprc.gov.cn/eng/wjdt/zyjh/t536420.htm*.

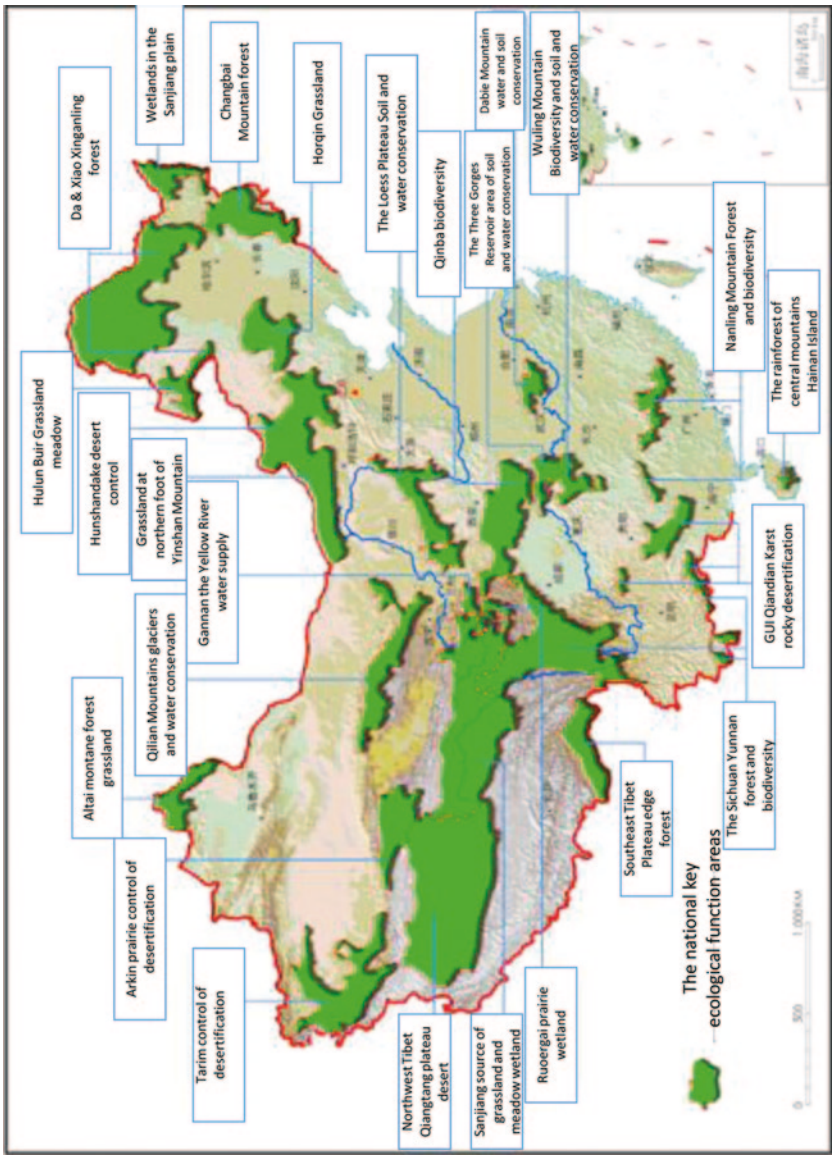

Fig. 5.4 National prohibited-development areas (Source: *Main Functional Area Plan*, December 21, 2010)

at the macro-level, and the plans recognize their objectives in terms of macroscopic variables of economic and social development. Thus, their development largely depends on overall information, rather than on the decentralized information relating to the inputs and outputs of various enterprises, and the plans combine scientific forecasting with planning intent. Market forces and planning efforts have therefore their own relative strengths; they are not in conflict but can work in a complementary relationship. When the emphasis in the five-year plans was on personal acquisition and scattered knowledge through micro-economic activities, marketization, and trade liberalization, there was a minimization of interventions and maximization of economic development vitality. In terms of overall knowledge and public goods, the aim of the five-year plan is not to weaken but to strengthen interventions. By contrast, normal development plans aim to be market-friendly and sustain market-supplement policies, but they fail to provide overall knowledge and public goods; in conjunction with market forces such plans may maximize net social welfare. Therefore, it should be our aim to increase our efforts in strategic planning.

Second, there has to be continuity and adaptation of the five-year plan. There is a long-standing incongruity between human development aims and nature; however, specific aspects of this conflict change with time. The historical development of China's five-year plans points to the importance of achieving long-term stability and continuity of policy. China is one of the few countries in the world that is able to pursue a particular line of development in terms of its own optimal strategy, and it is able to follow long-term national development goals. In this way, it has successfully avoided strategies and policies that result in discontinuity or even complete failure as a result of political or institutional turmoil.

The system of green development indicators that began with the Twelfth Five-Year Plan is the outcome of the process of learning and development initiated by the Eleventh Five-Year Plan. Most direct indicators of green development were successfully achieved during the period of the Eleventh Five-Year Plan. Policy objectives were likewise attained in the course of that plan, and this basic process continued into the period of the Twelfth Five-Year Plan. So as to achieve reduction targets in national emissions by 2020, the Twelfth Five-Year Plan also advanced a number of new indicators, which reflects a process of effective policy learning.

Third, the five-year plan reflects both horizontal and vertical development with respect to national strategy. The methodology involved in this procedure is one of the most important developments and successful experiences over the past few decades in China, and it also embodies the only way for China to achieve green development. This methodology is based upon China's socialist modernization construction: every five years, there is a new five-year plan. In this manner, China advances to a new level, and the ongoing efforts made in the course of successive five-year plans allow China to achieve significant changes. According to specific national conditions and long-term strategies, China has to develop appropriate development goals every five years, and it thus moves forward a step. And by such step-by-step medium-term objectives through the efforts made in the course of three five-year plans, China will by 2020 ultimately achieve its green development strategy. Thus, it will realize the perfect combination of five-year plan policy methodology and green development strategy.

Fourth, there is a planning mode that utilizes collective wisdom. The Chinese central government is able to develop its plans essentially according to the principles of democratic centralism, which amounts to a process that involves both democracy and centralization. From the perspective of those who participate in the planning process, it is characterized by participation and consensus. After the outline has been developed, this is then subjected to discussion and modification. This essentially involves a process of brainstorming, which demands contributions from all participants, who examine different aspects of the matters at hand by means of particular procedures and institutional arrangements. In this way, it is possible to achieve constant optimization in the decision-making process with respect to the policy text. Effective decision-making is able to proceed along the following lines: the premise faced by decision-makers includes inadequate information; the participants also possess diverse interests; and there is a limit to the prudence that can be exercised in the decision-making process. However, through brainstorming, it is possible to collate diverse kinds of information and overcome the information asymmetry to achieve political consensus and surmount the one-sidedness and subjectivity that is part of individual decision-making. With democratic decision-making, the rationale behind an effective decision-making mode is that brainstorming is fully democratic, and it is an effective means of achieving decision-making consensus without falling into the trap of policy deadlock. In the case of China, as noted above, this is a process of democracy and centralization.

Fifth, powerful planning is congruent with effective planning and an effective implementation system. Former British Prime Minister Tony Blair has spoken highly of China's national planning: "China's target is very challenging, and not easy to be completed, but China is a 'trusted' country, once it sets a goal, it will keep its promise until the completion of the goal. But in our political culture (the political culture of the West), it's just largely desire to determine a goal."[27] The strategic plan for 2020 put forward by the EU includes some worthy goals, such as the reduction of greenhouse gas emissions, increasing the proportion of renewable energy, improving energy efficiency, and developing an action plan to build a "Europe with more efficient resources."[28] However, the EU plan lacks institutional guarantee, and it cannot overcome national constraints and provide incentives. Thus, it will be difficult for this plan to be fulfilled.

China has formed a series of institutional arrangements to complete the objectives of the Eleventh Five-Year Plan. The government will implement a system of accountability for achieving energy-efficiency goals. There will be clarity at all levels with respect to the government's goals on energy-saving, and it will identify the local leaders who will be responsible in this area. The government will improve energy statistics and bolster the monitoring system in this regard, and there will be links to the government performance appraisal of energy-efficiency goals. In

[27] China promotes low carbon growth "from the bottom up," Voice of America, 2010, March 29, 2011, Beijing.

[28] http://wenku.baidu.com/view/8907e04ce518964bcf847ce2.html.

contract energy management, the government will set up ESCO financing as a secure platform to ease the financing problems of SMEs. The government will establish a renewable-energy system. It will promulgate the Renewable Energy Law. To improve government intervention and guidance functions, it will set forth a series of renewable energy systems, including those related to problem target systems, compulsory online registration systems, electricity price classification systems, cost-sharing systems, and special funds systems. Reinforcing the five-year plan's system of monitoring and evaluation is an important institutional arrangement to secure implementation of the plan, and mid-term evaluation is part of the implementation of the plan. Mid-term evaluation of the five-year plan will allow adjustments to be made to the plan in a timely fashion so as to secure the completion of its goals.

Sixth, in the planning process, different visible strategies complement each other rather than being at odds with each other. China has formed a grading and classification plan system to guide green development. The five-year plan guides economic and social development along the road to green development. Green development plans regarding land space include the following: the national main functional areas plan; the national ecological function area plan; and the regional ecological functional area plan. Special national green plans include the Twelfth Five-Year Plan on renewable-energy development, national environmental protection, national water resources development, and national disaster prevention and mitigation. Local green plans include provincial, municipal, and county-level green development plans. Therefore, China's green plan system operates from different aspects and at different levels. However, all these agents complement each other as part of a concerted effort to promote China's accelerated shift to green development.

As we proceed in the twenty-first century, China has entered a period of strategic opportunities, but, more importantly, it has entered a green era. The Eleventh Five-Year Plan was the first green plan, and it set China's development on the track to green development. The Twelfth Five-Year Plan amounts to a comprehensive green plan, and China will basically continue along this road to green development. The Thirteenth Five-Year Plan will be entirely green, and it will signal China's development as a fully integrated green economy.

China's road to green development has combined strategy innovation with concept innovation and innovation in development practices as part of an innovative green development plan. The ongoing greening of the five-year plans has lent strong impetus to the overall greening of China. Therefore, the five-year plan represents a dominant advantage for China[29] since it is able to depict a grand blueprint for short-term development as well as embodying an action program to achieve development goals.[30]

[29] Wen Kai, director of Asia-Pacific Agency of World Bank Group Multilateral Investment Guarantee Agency (MIGA) said that the "China model" has four system advantages, and the important one is the government's willingness and ability to plan an intervention in economic affairs. See Chinese Edition of the *Wall Street Journal*. http://cn.wsj.com/gb/20111206/KAI074656.asp?source=channel.

[30] The famous economist and Nobel Prize winner Joseph Stiglitz said: "What we measure determines the direction we develop." See the book Stiglitz (January 2011).

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Chapter 6
Local Green Practice

> Where do correct ideas come from? Do they drop from the skies? No. Are they innate in the mind? No. They come from social practice and from it alone.[1] (Mao 1963)
> True knowledge comes from practice. The policy comes from the population. And innovation comes from the local region.[2] (Hu 2010)

True Knowledge Comes from Practice This refers to the notion that knowledge and theory derive from practice and in turn they are put back into practice. As Mao Zedong stated, "Knowledge begins with practice. Theoretical knowledge is acquired through practice, and it must then be put back into practice. The active function of knowledge manifests itself not only in the active leap from perceptual to rational knowledge, but—and this is more important—it must manifest itself in the leap from rational knowledge to revolutionary practice."[3] Mao Zedong also said, "Generally speaking, those that succeed are correct and those that fail are incorrect."[4] Practice is a criterion not only for testing truth but also for fallacy.

Innovation Comes from the Local Region This refers to innovative invention deriving from a local region and innovative practice being returned to the local region. This is the methodology of China's reform and innovation as advocated by Deng Xiaoping. Anhui, Sichuan, and other provinces implemented a bold reform of their agricultural household contract responsibility system in 1978, which led to intense controversy. However, this local innovation was supported by Deng Xiaoping, who advocated and actively encouraged local innovation to solve agricultural issues by means of new concepts and ideas. [5] In the process, this forged the unique, innovative methodology of China.

The above two views constitute China's green innovation methodology The internal logic between them is as follows: social practice determines social theory; social theory guides social practice; both practice and theory are constantly

[1] Mao 1999.

[2] Hu 2010.

[3] Mao 1937.

[4] Mao 1963.

[5] Wang 1998.

A. Hu, *China: Innovative Green Development,* DOI 10.1007/978-3-642-54962-5_6,

innovative—otherwise practice would not make progress and theory would not develop. It is important to regard both social practice and theory innovation as risk activities because they are not automatically successful, and in many cases they fail. However, after many failures, new discoveries and successes always appear. In this process, innovation is the most meaningful and valuable practical and theoretical result. The end of each round of practice and theoretical innovation also marks the beginning of a new round of practice and theoretical innovation.

In the face of green development, local governments need to know how to address the various issues involved. How should local governments best achieve green transformation? Mao Zedong once said that without investigation, no one has the right to speak. Investigation might be likened to a pregnant woman, though resolving the issue of the investigation in effect amounts to an uncertain delivery date. Tackling the investigation is akin to solving a problem. Getting a proper grasp of China's innovative efforts requires a great deal of investigation; it involves visiting different parts of China, reading Chinese, and writing about the country. Different regions face different green development challenges, and therefore they require different kinds of green innovation. To study innovative practices in green development and survey local green innovation, I selected Beijing, Chongqing, and the Source of the Three Rivers (the Yangtze, Yellow River, and Lancang River) in Qinghai. In this way, I aimed to examine local transitions toward green mechanisms, investigate innovative efforts as part of local green transformation, and thus obtain an understanding of the progress made along the road to green development in China.

6.1 Green Beijing—Building a World-Class Green Modernized Capital[6]

> We can expect that by 2020 the real "Green Beijing" will be displayed before the world. We hope that Beijing will complete its green modernization as a mega-city in China and thereby provide valuable experience for China's green modernization.[7] (Research notes of the author in 2009)

In 2008, the Olympic Games were held in Beijing[8] under the slogans of "the People's Olympics," "the Hi-tech Olympics," and "the Green Olympics." And after the

[6] This section is based on several research reports about Beijing written by the author, Hu An-gang, and Xiong Yizhi: "How To Achieve 'Two Leadings' for Beijing in China" (March 25, 2007); *National Conditions Report, 2007* (14); Hu An-gang: "Innovative Green Beijing Practice, First Achieve Green Modernization" (November 17, 2009), *National Conditions Report, 2009* (33)2009.

[7] "Innovative Green Beijing Practice, First Achieve Green Modernization" (November 17, 2009), *National Conditions Report*, Issue 33, 2009.

[8] The Beijing Olympic Games are "truly exceptional Games," said International Olympic Committee (IOC) President Jacques Rogge at the Games' closing ceremony staged in the National Stadium in north Beijing on Sunday night.

Olympics, Beijing's basic concept of urban development has continued as "Humanistic Beijing," "Hi-tech Beijing," and "Green Beijing"[9]. This is in line with efforts to convert the Beijing of the twentieth century into a modern green world metropolis to serve as a demonstration of China's significance.

The status of Beijing and its strategic objectives reflect its move toward a new stage of green development. They also point to the city as being a place of innovative practice and scientific outlook as well as a forward-looking model of creative development. It can be said that Beijing leads China in terms of green transformation innovation, and among the country's large and medium-sized cities, it is the one that best demonstrates green modernization and development.

Beijing is one of the world's few super-large cities, and thus the significance of Beijing's green modernization has tremendous significance. In domestic terms, Beijing's economic and population growth take the lead in decoupling carbon emissions. In reducing carbon emissions, Beijing stands as a model for urban development patterns for all of China. From an international perspective, Beijing's rapid growth into both a world-class mega-city and a green city means that it can act as a model for mega-cities all around the world. Beijing has successfully held what some regard as the best-ever Olympic Games and Paralympic Games, and Beijing also showcased the best urban infrastructure, which helped substantially increase its international image.[10]

Compared with large cities in developed countries that have completed their modernization, Beijing is still undergoing the process, and so it has obvious latecomer advantages and unique advantages in talent agglomeration. Beijing is able to stand as both a representative of China's green urbanization and as the outstanding example of green modernization. Of course, Beijing is still obliged to take the initiative and learn from the innovative experiences of other cities in China as well as from major cities around the world to achieve green modernization that is appropriate for its own situation in terms of centralized, integrated, and indigenous innovation.

For Beijing, the road to green modernization is not a smooth one, but one that presents various challenges. First, Beijing is a city with a great shortage of water resources. According to the results of the sixth census, the population in Beijing was 19.61 million. However, Beijing's per capita water resources declined from just under 300 m^3 many years ago to about 100 m^3 in recent years. This is significantly below the internationally recognized per capita level of 1,000 m^3. Beijing is thus one of the big cities in China that suffer from the greatest shortages of water.

At the same time, the air quality of Beijing also faces severe challenges. The number of vehicles in Beijing has grown rapidly in recent years: the number exceeded 2, 3, and 4 million in August 2003, May 2007, and December 2009, respectively. By the end of 2010, the number stood at almost 5 million. Thus, vehicle exhaust

[9] Liu Qi: "Build Humanistic Beijing, Hi-tech Beijing and Green Beijing," *Qiushi*, December 1, 2008.

[10] IOC President Jacques Rogge thought that the Beijing Olympic Games were "truly exceptional Games." International Paralympic Committee President Philip Craven believed that the Beijing Paralympic Games were "the greatest Paralympic Games."

emissions have become an important cause of the decline in air quality, as evident in the frequent smog. As a result of dry lakes, degraded pasture land, and dust sources in Inner Mongolia, Ningxia, and other such areas, cold and warm air currents in winter and spring bring large amounts of dust, and this exacerbates the poor air quality.

So how should Beijing build its road to green development? How should the green modernization of Beijing be achieved? How can Beijing become a world-class green city? How should Beijing turn green?

6.1.1 Green Beijing Road Map

At the beginning of this new century, Beijing held the Olympics, which were characterized as the Green Olympics and provided further impetus for the development of a green Beijing. Beijing has developed a green industrial system: the proportion of the service industry amounted to 75% in 2010; renewable-energy use accounted for 2.5% of total energy consumption; the proportion of coal was 34%; and energy consumption per unit of GDP in 2008 showed a 50% decrease from the level in 2000.

Beijing has a green consumption system in place. Its green consumption and living is evidenced by the fact that energy-efficient buildings account for 51.9% of existing civil constructions. Its green transportation is reflected in the fact that the proportion of public transportation in central urban areas amounts to 36.8%. Its green life is seen in the fact that the garbage-recycling rate stands at 35% and the recycled-water utilization rate is 57%.

Beijing already possesses a green ecological environment. As emissions of major pollutants in Beijing have continued to decline, by 2010 the proportion of days throughout the year with air quality of level 2 and above in Beijing amounted to 78.4%. The forest green rate stands at 53.0%, and the per capita green area at 15 m^2. According to the *Annual Report of 2011 China Green Development Index—Province Comparisons*,[11] the green development index of Beijing was the highest in China (Table 6.1).[12]

In the future, Beijing will become even greener. Combined with the Green Beijing Action Plan (2010–2012), we have designed a two-step strategy for constructing a Green Beijing.

[11] Research based on scientific outlook on development and economic sustainable development, Beijing Normal University: *2011 China Green Development Index—Province Comparisons*, Beijing: Beijing Normal University Publishing Group, Beijing Normal University Publishing House, October 2011.

[12] Based on the green development index system of the report, in 55 basic indicators among three categories—green degree of economic growth, resources and environment carrying capacity, and government policy support (weighted respectively 30, 45, and 25%)—Beijing ranked in no.1, 12, and 1 in the three indicators, and it ultimately came top with a total score of 0.7917, followed by Qinghai, Zhejiang, Shanghai, and Hainan.

Table 6.1 Green Beijing construction index system. (Source: Electronic version of Beijing Statistical Yearbook in 2001; Twelfth Five-Year Plan for "National Economic and Social Development of Beijing")

Indicator name		Unit	2000	2008	2010	2012	2020	Indicator properties
Green production indicator	Sales revenue of new energy and energy-saving environmental protection industry	RMB 100 million		958		1,450	3,000	Guiding
	Proportion of renewable energy use in total energy consumption	%		2.5		5	9	Guiding
	Proportion of coal in total energy consumption	%		34		25	13	Binding
	Energy consumption per unit of GDP	Ton of SCE/ RMB 10,000	1.31	0.66	0.49	Implementation according to national requirements		Binding
	Water consumption per unit of GDP	Cubic meters/ RMB 10,000		36.62		32	25	Binding
	Carbon dioxide emissions per unit of GDP	Tons/RMB 10,000		–		Implementation according to national requirements	Ranking top in China	Binding
Green consumption indicator	Level 2 and above energy-efficiency products market share	%		30		60	80	Guiding
	Proportion of energy-efficient buildings in existing civil buildings	%		51.82		56	65	Binding
	Proportion of public transportation in central city	%		36.8	40	42	55	Guiding
	Household waste-recycling rate	%	–	35		40	65	Binding
	Of which: waste classification standard rate	%	–	–		50	60	Binding
	Reclaimed water utilization	%	–	57		70	85	Binding

Table 6.1 (continued)

Indicator name		Unit	2000	2008	2010	2012	2020	Indicator properties
Ecology environment indicators	Proportion of days of level 2 and above air quality among total days	%	48.4	74.9	78.4	Basically meets national standard	Ranking top in China	Binding
	COD emissions decline rate	%	5.3 (2001)	4.92	7.1	Implementation according to national requirements		Binding
	SO_2 emissions decline rate	%	10.3 (2001)	18.76	3.4	Implementation according to national requirements		Binding
	Tree greening ratio	%	42.0	52.1	53.0	54	60	Binding
	Public green area per capita	Square meters	9.66	13.6	15	15.5	20	Binding

The first step is to complete a green modern world city by 2020 With transformation and upgrading of the economic development mode, and comprehensive promotion of green consumption patterns and lifestyles, a livable ecological environment will basically take shape. Beijing will be constructed as a green modern world city with clean production, friendly consumption, an attractive environment, and efficient use of resources.

The second step is to create a green modern world city by 2030 Beijing will become the world's knowledge and technological innovation base. It will also be a base for high-quality education and cultural innovation. Beijing will be an international tourist city and using only high-quality, clean energy it will achieve a constant decrease in sulfur dioxide and carbon dioxide emissions. With further expansion of the proportion of green space, Beijing will become the city with the largest green space in the world.

6.1.2 How Should Beijing Become Green?

How should Beijing become green? How should the greening of Beijing develop in the future? The greening of Beijing amounts to the coordination of three systems of green development—natural, economic, and social systems—and it will result not only in the accumulation of green wealth in the natural system (ecological surplus), but also help develop the green economy by providing wide and equitable social benefits (green welfare). The greening of Beijing will be an all-encompassing process that will involve the establishment of a **green development system made up of green production, green living,and a green eco-system**.

The green production system will include the factors outlined below.

Ongoing Greening of Beijing's Industries At the beginning of reform and opening-up, Beijing was a city that was dominated by heavy industry. In 1979, Beijing accounted for 63.7% of China's heavy industry output; the second-highest area was Liaoning.[13] In the process of reform and opening-up, it was recognized by the central government that Beijing was not suitable for development as a heavy industrial city and that Beijing should become an economic center.[14] Thus, starting in the mid-1990s and over little more than a decade, Beijing made the change from being a city dominated by industry to a modern services-oriented city. Beijing's service industry accounted for only 38.84% of the GDP in 1990; in 1995, it exceeded half of the GDP for the first time, having risen to 52.29%; in 2010, it rose further to 75.1%. Over the same period, the proportion of employment by the services sector exceeded that of the secondary industry: it stood at 43.6% in 1992 and then rose to 54.0% in 2000 and 74.4% in 2010. In terms of these two sets of figures related to

[13] China Land and Resources Website: Beijing City Positioning and Development Goals. http://www.clr.cn/front/read/read.asp?ID=36570.

[14] In 1983, the central government approved the Beijing Urban Construction Main Plan.

the service industry, Beijing's was clearly the most developed in China, far exceeding Tianjin and Shanghai, which came in second and third place, respectively.[15] Beijing is thus China's largest modern-service-sector city, and it has followed a modern industrial service-oriented development pattern.

Ongoing Greening of Beijing's Production Beijing's energy consumption per unit of GDP showed a cumulative decline of 62.6% over the period of 2000 to 2010,[16] with its average annual rate standing at 9.06%; over the same period, the added value of the service sector and the proportion of its people employed in that sector accumulatively increased by about 10%, with the average annual increase amounting to almost 1%. Beijing has the lowest energy consumption per unit of GDP in all of China, with the figure for Shanghai being 22.3% higher and that for Tianjin 41.9% higher.[17] Water-conservation efforts in Beijing have also achieved remarkable results: water consumption per RMB10,000 of GDP dropped from 49.5 m^3 in 2005 to 29.4 m^3 in 2010. This was a 40% decline, and in terms of water-use efficiency Beijing leads China. Water use has been decoupled from economic growth, with total volume of water used having been reduced from 3.89 billion m^3 in 2001 to 3.52 billion m^3 in 2010. The effectiveness of the adjustments to the energy structure have been remarkable: compared with 2005 figures, the proportional consumption of natural gas, electricity, and other high-quality energy sources increased to 70% in 2010, while the proportion of coal consumption fell by 11%.

Beijing's industry will continue to be green and have high added value. The city will develop green industries, whereby it will decouple carbon emissions from growth in industrial output: carbon emissions will be considerably smaller than industrial growth. "Green industry" signifies a high-tech, high value-added industry that is also characterized by low energy consumption, emissions, and pollution. Beijing will achieve green energy, optimize its energy-production structure, and increase the proportion of clean, renewable energy. The city will achieve the transition from black to green energy, and this will represent a new growth point in its green industry. Beijing will create perfect green production systems as it becomes the center of China's largest green industry with a low-carbon industrial base (Table 6.2).

Green living systems will include the factors outlined below.

Promoting Green Lifestyles and Consumption Patterns In 2010, reclaimed-water reuse in Beijing amounted to 680 million m^3, which was a 1.6-fold increase over the figure of 260 million m^3 in 2005. The 2010 figure was in excess of the surface-water supply, and reused water is thus a very important source for the city. With enhanced environmental awareness as a starting point and using a cultivated green business environment as a basis, Beijing will play an exemplary role in terms of green government. Beijing will fully mobilize various social forces to vigorously

[15] In 1994, Beijing tertiary industry accounted for 46.99% of GDP, higher than 39.56% in Shanghai, with a difference of 7.43%; in 2010, Beijing tertiary industry accounted for 75.11% of GDP, higher than 57.28% in Shanghai, with a difference of almost 20%.

[16] Electronic version of Beijing Statistical Yearbook 2011.

[17] Electronic version of Beijing Statistical Yearbook 2011.

Table 6.2 Service-sector proportion and energy consumption per unit of GDP for Beijing (1978–2010). (Source: Beijing Statistical Bureau: Beijing Statistical Yearbook (calendar year), Beijing, National Statistics Publishing House; National Bureau of Statistics: China Statistical Abstract (2011), Beijing, National Statistics Publishing House, 2011; Comprehensive Statistics for National Economic of National Bureau of Statistics: New China Statistical Information Collection for Six Decades, Beijing, China Statistics Publishing House, 2010)

Year	Service-sector proportion of total employed population (%)	Value-added services section within GDP (%)	Industrial added value within GDP (%)	Energy consumption per RMB10,000 of GDP (ton of SCE)	Coal proportion in energy consumption (%)
1978	31.6	23.7	64.5		
1980	32.8	26.8	62.5	13.71	
1985	36.3	33.3	50.8	8.60	
1990	40.6	38.8	43.8	5.41	63.60
1995	48.7	52.3	35.0	2.34	54.64
2000	54.6	64.8	26.7	1.31	46.86
2005	66.6	69.1	24.8	0.80	
2008	72.5	73.2	21.0	0.66[b]	34
2010		75.0	19.6	0.61[b]	29.3[a]

[a] Data derived from Beijing Municipal Development and Reform Commission: Beijing Energy Development Report (2011)

[b] Data calculated from GDP prices in 2005

promote green products and services. The city will monitor product launches, market liquidity, and consumer behavior, and it will strive to support a green lifestyle and consumption patterns by creating an advanced culture-driven green consumer system.

Beijing's Green Traffic as China's Cleanest Transport Hub and Network The period of the Eleventh Five-Year Plan saw a 33 % increase in passenger transport in Beijing. During this period, the proportion of public transport increased to 40.1 %, and public transport provided full coverage of urban and rural areas.[18] Beijing will make efforts to further develop public transport facilities, encourage more residents to use public transport, and further improve the public transport system proportion. It will support these moves in such ways as introducing on-street parking fees and collecting night-time roadside parking fees. The fourth stage of the implementation of the national vehicle emission standards[19] removed all old buses, private cars, taxis, postal vehicles, sanitation vehicles, and trucks from the streets. There was also increased construction of Beijing's rail transport, notably its inter-city express railway, during the period of the Eleventh Five-Year Plan.

The green eco-system, the third set of factors, will include the following.

[18] The data in this paragraph derive from the Major Infrastructure Development Plan during the Twelfth Five-Year Plan.

[19] Beijing took the lead in implementing national vehicle IV emission standards and national vehicle fuel IV standards.

Pollution Control for Cleaner Air and Water During the period of the Eleventh Five-Year Plan, Beijing continued to reinforce air pollution control, and so the city's air quality showed significant improvement. The proportion of days when the urban air quality rose to level 2 and over was 78%, which represents a 14% increase over the figure for 2005. During the eleventh "Five-year Plan" Beijing will further enhance its capabilities in domestic waste management. In 2010, 17,000 t of urban domestic wastes were treated daily, with a decontamination rate of 96.7%; meanwhile, the sewage treatment rate reached 95% in central areas and 90% in newly established communities.

Increasing Ecological Construction for a Greener Beijing The urban green space of Beijing expanded during the seven years of preparation for the Olympic Games; by 2010, its urban forest coverage had increased to 53%.[20] Beijing has also established various levels of urban forest, and the city now possesses riparian forest parks, country parks in green isolated areas, and an open city leisure park. These effectively form three major ecological barriers.

At the same time, Beijing will actively participate in the construction of the Beijing-Tianjin ecosystem, to which it will attach great importance since this will allow further optimization of the ecological environment. This construction will involve the establishment of ecological barriers, water conservation, "home garden", and production bases for air purification and green agriculture. By carrying out high-standard ecological constructions in Beijing-Tianjin-Hebei region, we can reasonably expect more achievements in desertification control, water conservation, air/water purification, regional afforestation, and agricultural product safety. In this way, it will establish a new model for national ecological construction.

As well as having undergone a fundamental change in its development model, green Beijing also represents a major level of innovation in practical scientific development. The development goal of the city is ambitious and its development is a long-term task. We believe that when the per capita GDP exceeds USD 10,000, Beijing will enter a new historical development stage, which will be that of accelerated green modernization. This stage will have as its core accelerated green industrialization, urbanization, information, infrastructure modernization, and internationalization. This demands the creation of an innovative green development model despite the huge challenge presented by global climate change. **Beijing's population growth and economic growth need to be decoupled from its carbon emissions. The city, one of the largest cities in the world, must first decelerate and then reduce its carbon emissions so that it can develop a green economy**

[20] In the 7 years of preparation for the Olympic Games, the urban green space in Beijing increased by over 10,000 ha, and this achieved the target of creating visible green parks every 500 m. The greening rate for main roads and rivers reached 100% and landscape levels were increased substantially for more than 500 roads. The green area per capita amounted to 48 m^2, and the public green space per capita was 12.6 square meters. In the suburbs, the area of total new afforestation increased by 154,100 ha. The Beijing-Tianjin Sandstorm Source Control Project achieved an afforestation area of 255,200 ha, with 22 million trees having been planted on a voluntary basis over the seven-year period, which is equivalent to creating 15 new Summer Palaces.

and in doing so it will use green energy, bring about innovative green technologies, and promote green and healthy lifestyles and consumption patterns. It is to be expected that by 2020, the real green Beijing will come into being for all the world to see, and it is hoped that Beijing can take the lead in achieving the position of a mega-city that is characterized by green modernization. In this way, Beijing will offer valuable experience for China's green modernization efforts.

6.2 Reforested Chongqing—Rising Green Star in the West[21]

> The case of Chongqing provides a methodological example of the implementation of a practical scientific outlook in development. As such, it fully reflects these points: true knowledge comes from practice; policy comes from population; innovation comes from local areas.[22] (Research notes made by the author in 2010)

Chongqing is located in western China, and it is the central region of the Three Gorges Reservoir area in the upper reaches of the Yangtze River. Chongqing has a total area of 82,400 km^2, and it is composed of 19 districts and 19 counties, with a total population of 31.98 million. In 2010, its GDP amounted to RMB780 billion; its GDP growth rate ranked second in China, and its per capita GDP reached a new level of USD 4,000.

With 3,000 years of history, Chongqing has been integral to the development of the nation; particularly, it has many historical sites dating to the War of Resistance against Japan (also known as, the second Sino-Japanese war) and the War for Liberation (1945–1949). As the only municipality in central western China, Chongqing was set up by the State Council as a national urban and rural comprehensive reform pilot area. It was one of eight such central cities established in this way. Chongqing is also the economic center and transport hub of western China in the upper reaches of the Yangtze River. Since mountainous areas account for more than two-thirds of Chongqing's land area, the regional ecology is very fragile, especially as a result of the Three Gorges Reservoir. As one of eight key provinces and cities in areas of rocky desertification, 37 districts and counties of Chongqing are characterized by a karst landscape, and these account for 39.7% of its area. Chongqing is also one of China's four major geological disaster areas, and it is a key area of soil erosion.

With the city's rapid economic development, Chongqing also faces a great many problems, such as how to deal with environmental issues, how to make constant improvements to residential life quality, and how to thoroughly upgrade its quality

[21] This section is based on several research reports about Chongqing, including: Hu An-gang: "Green Development Practices—Take 'Forest Chongqing' as an Example," National Conditions Report, issue 28, 2009. Hu An-gang: "True Knowledge Comes from the Practice and Innovation from Local Areas," National Conditions Report, issue 22, 2010.

[22] Hu An-gang: "True Knowledge Comes from the Practice and Innovation from Local Areas," National Conditions Report, Issue 22, 2010.

as a big city. Chongqing also needs to allow its residents in mountain areas to be able to thrive in a scientifically viable and sustainable manner. Chongqing has to maximize its forest efficiency, open channels that permit the prosperity of rural residents, maintain the ecological safety of the Three Gorges Reservoir Area, restore the ecological environment in the upper reaches of the Yangtze River, and also ensure the long-term safety of the Yangtze River. All of the above are major strategic issues for Chongqing.

The reforestation of Chongqing shows the practice of a scientific approach to development. It reflects that significant innovation in ecological construction, especially in forestry construction, can provide convenience, benefits, and prosperity to local residents as well as enhancing the local image and enriching local conditions. The effective, high-quality program engineered by Chongqing in accordance with domestic and international circumstances as well as its own historical background is consistent with what might be termed a challenge-response mode. Further, it may offer lessons in ecological performance for future leaders as well providing ecological capital for future residents by making a contribution to China's ecosystem services. These achievements are greater and more significant than Chongqing's contribution to growth in GDP (it accounted for 1.98% of the national GDP in 2010). However, with its **innovative green transformation, Chongqing has established itself as a leader in the area of green modernization of central and western regions, especially with respect to forestry development.**

6.2.1 History of Chongqing—U-Shaped Curve

Historically, the change in the ecological capital of Chongqing has followed a typical U-shaped curve. In this way, it is also a microcosm of China's changes in ecological capital. Historically, Chongqing has been extremely rich in forest resources, and it had an ecological surplus. With natural population growth and immigration into Chongqing in the modern era, trees have been felled, and Chongqing experienced a significant drop in its forest coverage rate; thereafter, it began suffering from a serious forest deficit.

According to data provided by the Chongqing Municipal Forestry Bureau, in the early years of the Ming Dynasty during Emperor Hongwu's reign (about 1368–1370), there were 15 km^2 of forest in Chongqing, which amounted to a cover rate of over 80%. In 1929, the 18 km^2 of urban forest had dropped to a cover rate of about 60%. During the extensive melting down of iron and steel products during the Great Leap Forward, all of Chongqing's forests were cut down, which resulted in a forest coverage rate of almost zero in 1960. This is an extremely serious and rare form of damage. After that time, reforestation efforts were made; however, by 1980, within Chongqing's jurisdiction area of 23,113.95 km^2, the forest coverage rate still amounted only to 8%. It rose to 20% in 1997 and 33% in 2007, and it is expected to reach 45% in 2017. In this sense, reforestation in Chongqing is an effort to re-create the green character of the place as it formerly was, marked by an abundance of trees in a natural green setting.

6.2.2 Chongqing Today—Leader in Forestry Construction

According to data from the Chongqing Forestry Bureau, since the goal of making Chongqing a reforested city was established in 2008, it has undergone 16.888 million mu (1 mu = 666 m^2) of afforestation, which amounts to 77.2 % of the targeted 22 million mu. The target figure includes 10.819 million mu of afforestation and 6.069 million mu of inefficient forest transformation. All this amounted to an accumulated investment of RMB40.28 billion and involved the planting of 1.55 billion trees. This project transformed Chongqing into the city with the greatest number of planted trees and the most abundant number of tree species in China. In 2011, Chongqing was the only provincial city to be awarded the Eco-Cities China City Award, it won the right to declare itself as China's first "forest city." The Beibei District of Chongqing City has been named as the only "National Demonstration Zone of Standardized Forest City". By October 2011, Chongqing had met all of the 38-item requirements for a "standardized forest city", among which the forest coverage rate, green areas, and park green area per capita dramatically exceeded the standards. **Under the theme of "Forest city, mountain city, happiness Chongqing," the Chongqing municipal government has promoted the following six forest construction projects.**

Urban Forest Projects Having placed the emphasis on scale enhancement and inaugurating high-quality projects, Chongqing has completed the initial stage of urban forest projects in its river and mountainous areas. This has involved the planting of large areas of trees, setting up extensive parks, building expansive squares, and constructing large barriers. The 521,000-mu forest barrier that surrounds Chongqing provides this city, which stands among four mountains, with an ecological barrier. Forests also surround the districts and counties of the entire urban area, and the 316 urban roads and the area's key transport nodes are part of the complete green upgrading process.

Rural Forest Projects Chongqing has been able to achieve ecological development by greening barren hills and establishing green bases. In its various-sectors, it has been able to enrich both forest development and the lives of its residents through reforestation of barren mountains, diversification of industrial structure, optimization of tourism design, and reaching economies of scale for its forest undergrowth. Through the combination of artificial reforestation and aerial seeding, Chongqing has achieved over 2.5 million mu of reforested mountains, with the focus being on overall reforestation of the barren mountains within sight of expressways and reforestation of barren mountains where forest rights have been implemented. In addition, Chongqing has established different types of forestry industry over an area of 13.39 million mu. It has extended its industrial chain by introducing various enterprises for processing timber products. In this regard, each county has basically taken the initiative with forest planting for industrial raw materials, fast-growth forest planting, and planting for local specialty products. In 2011, the forestry output value in Chongqing exceeded RMB30 billion, and the income per capita of rural residents rose to over RMB600.

Expressway Greening Projects Expanding forest areas and improving the forest grade has largely focused on the forest areas close to roadways. Over the past three years, Chongqing has implemented expressway greening along 20,000 km of roads. This has involved 2,000 km of expressway greening along the second ring road and its eight radiations, 9,500 km of greening along national and provincial roads, and the establishment of a complete landscape forest on either side of the expressways that connect Chongqing with surrounding cities. With such moves, Chongqing has been able to create a new image for itself, and this amounts to a new environment for investment as well as making the place a more comfortable one in which to live, providing employment opportunities, and helping to create an attractive tourist destination.

River Forest Projects The focus with these projects is on bolstering the green network by conserving water resources so as to ensure the vitality of the regional watershed. Over the course of three years, Chongqing has made a considerable effort to clean the Wujiang River, the Jialing River, and other rivers in its various counties in addition to key water-resource areas. Six model green areas occupying an area of 10,000 mu have been set up in Yubei, including those on the Wentang and Yulin rivers. At an investment of over RMB100 million, the Boyang River park has been completed in Wuxi County. Orchards of citrus fruits covering an area of over 0.1 million mu have been established in the Changshou Lake area along with a 5,000-mu lakeshore forest garden. The cleaner rivers of this area have brought ecological benefits, such as making them attractive to water birds, for example, the Chinese merganser—an endangered species of duck.

Forest Projects on Either Side of the Yangtze River These projects have demanded the mobilization of social forces to bring about rapid improvement in the area of forest construction. In 2010, Chongqing initiated the **Green Yangtze-Chongqing Action Program** to build 23 project areas using social forestry donations. In 2011, Chongqing invested RMB620 million to restore 0.31 million mu of farmland on a gradient of over 25 to forest. In 17 districts and counties in the Three Gorges Reservoir Area, Chongqing also reforested the zone from 175 m above the river to the top of the ridge above the reservoir. Since 2008 Chongqing has invested a total of RMB3.88 billion to plant 1.7 million mu of forest to help control sediment levels in the Yangtze River in the Chongqing area.

Nursery Projects These projects involve efforts to establish a local seedling industry and thereafter to achieve economies of scale. Over the past three years, Chongqing has carved a position for itself as a kind of "seedling warehouse" for western China. Chongqing has set up over 400,000 mu of seed-growing facilities, 100,000 mu of new integrated facilities; these include 32 1,000-mu nursery facilities, and five nursery facilities of over 5,000 mu. According to statistics provided by the Chongqing Forestry Bureau, as of October 2011 there were 1.6 billion nursery seedlings; the output value of the seedlings amounted to RMB11.68 billion, which was a 14.6-fold increase compared with the 2007 figure. This is very much in keeping with the efforts to establish a reforested Chongqing, and it also represents a new growth of local prosperity.

Table 6.3 Development goals of reforestation in Chongqing (1996–2017). (Source: Chongqing Forestry Bureau)

	1996	2008	2012	2017
Forest coverage rate (%)	21	34	38	45
Green coverage rate (%)	18	34.5	35	38
Green land rate (%)			32	36
Output value of forestry (RMB0.1 billion)	13	174	250	500
Forestry income per capita	20	336	500	>1,000
Living wood growing stock (0.1 billion m^3)	0.78	1.3	1.46	1.72
Carbon sequestration (10,000 t of carbon equivalent)	1,419	2,298	2,568	3,041
Oxygen release (10,000 t)	1,030	1,668	1,863	2,206

6.2.3 Future of Chongqing—A Model of Ecological Civilization

In July 2008, the third plenary meeting of the third Chongqing Municipal Commission formally proposed the implementation of the forested Chongqing project. This large-scale reforestation is regarded as an important measure toward improving the ecological environment of the city and the upper reaches of the Yangtze River as well as adding to the city's urban character.

Chongqing proposed in 2008 that it would invest RMB50 billion in establishing this forested Chongqing over a 10-year period (2008–2017). Based on its natural mountainous and humid conditions, Chongqing put forward the idea of creating this reforested character, which has as its targets improving the ecological environment and developing the living environment. The specific goals of this project include the greening of barren mountains, changing poor mountainsides into areas of rich resources, and transforming the character of the place from a "stove" (consumer of oxygen) to a producer of oxygen.[23] As a result, it is regarded as a major development strategy.

To achieve its various development goals, Chongqing has prepared an overall plan with respect to its reforestation projects, and this is underpinned by the two major themes of "Creating a forest city" and "Enriching the Bayu rural area." In addition, specific goals, such as the greening of 600 km along either side of the Yangtze River over a period of 10 years, are part of the scientific and operational design toward achieving the strategic vision of a reforested Chongqing. The plan is divided into two phases (see Table 6.3).

By 2017, Chongqing will have achieved its reforestation goal. By then, the forest coverage rate will have shown an 11% increase over 2008, and there will have been a 4% increase in the total green space area. This demonstrates that the expansion of the green space will play an important role in maintaining an ecological safety

[23] Historically, Chongqing, one of three "stoves" of the Yangzi River, has up to 49 days of extreme climate with over 40 °C.

Table 6.4 Key ecological indicators for Chongqing (1997–2017). (Source: Chongqing Forestry Bureau)

Item	1997	2007	2017
Forest coverage rate	20%	33%	45%
Soil erosion modulus	4,261 t/km/year	3,641.95 t/km/year	2,660 t/km/year
Soil erosion area	52,130.27 km^2	40,000 km^2	23,550.5 km^2
Influx of sediment load into the Three Gorges Reservoir area	500 million t	210 million t	110 million t

barrier along the upper reaches of the Yangtze River. The live wood volume will amount to 172 million m^3 in 2017, which signifies an increase of 32% over the 2008 level; with this, Chongqing will have entered a stage of accelerated forest surplus. At the same time, a corresponding increase in the carbon sequestration capacity and oxygen release will represent a significant response to global climate change. By 2017, the per capita income of farmers will have shown a three-fold increase over that for 2008, which of course will amount to a substantial rise in local prosperity.

Meanwhile, the reforestation project in Chongqing is also an important element in building a strategy for national ecological security. At both the national and local level, ecological capital is a scarce commodity; ecological products are the ones suffering from the greatest deficiency; and ecological services are the most critical kind of services. With the Three Gorges Reservoir at its center, Chongqing is an important ecological barrier for the Yangtze River basin. It is also a strategic area for national water resources, and it occupies a very important ecological niche. Geographically, 75% of Chongqing's area consists of hills and mountains, though the figure for Pingba County in Chongqing is only 7%. Chongqing has a year-round warm and humid climate, and it offers good natural conditions for forestry development. However, if forests are cleared, the result is soil erosion, which leads to ecological disaster. According to statistics for 1997, the soil erosion modulus was as high as 4,261 t/km/year, and the area of soil erosion in Chongqing was 52,130.27 km^2; this caused 500 million t of sediment to be deposited into the Three Gorges Reservoir. Expansion of the forest area helps reduce the area of soil erosion and thus the amount of sediment into the reservoir; for example, the amount of sediment fell to 210 million t in 2007, and it will drop to 110 million t in 2017 (Table 6.4).

Located in Chongqing, the remarkable Three Gorges Reservoir attained a water area of 1,084 km^2 following the completion of its 175-m impoundment. The reservoir has a capacity of 39.3 billion m^3, which makes it one of the world's largest reservoirs—equivalent to 80% of the annual flows of the Yellow River. With an average annual runoff of 450 billion m^3, the reservoir accounts for 46.9% of the total water resources of the Yangtze River. The Three Gorges Reservoir Area is a strategic reserve base for national freshwater resources, and it is integrally related to the sustainable development of the entire Yangtze River basin as well as the ecological security of the whole country. The Yangtze River basin is known as the "lungs" of China, and this underlines the importance of reforestation efforts in Chongqing: the natural resources of this area represent not only a regional public good, but also a national public good since they function to protect the national ecological safety barrier.

Furthermore, complete establishment of the reforestation of Chongqing remains a long-term task. Even by 2017, Chongqing's forest coverage rate will still amount to only less than 60% of what it was in 1929. Thus, reforestation efforts will have to continue at least until 2050. However, the work carried out so far has laid a good foundation for the implementation of this scientifically based, tenable green development idea.

6.3 Ecological Qinghai—Providing China with its Largest Public Goods[24]

> Protecting the Source of the Three Rivers is not only a national public good, but also a global public good; it is not only a national ecological treasure, but also a common ecological wealth for humanity.[25] (Research notes made by the author (2009)

As a less developed province in western China, Qinghai has the following basic characteristics: large grassland area, little livestock;[26] large resource reserves, small resource production;[27] very fragile ecology, and the most prominent ecological role in China; the coexistence of modern and traditional factors; the coexistence of development and underdevelopment; the coexistence of rich and poor people; the coexistence of a highly intelligent and an illiterate population; the coexistence of densely and sparsely populated areas; the coexistence of economically strong and weak areas. There are thus unique internal disparities within this region. Qinghai is, however, experiencing an unprecedented economic and social transformation. There has been an increase in modernizing factors, development phenomena,

[24] The section is based on a research report for Qinghai Province by the author. Hu An-gang: "The Province Situation and Development—Take Qinghai as an Example," National Situation Report, issue 8, 2008; Hu An-gang: "Measurement for Four Categories of Poverty: Take Qinghai Poverty Reduction as an Example (1978–2007)", National Situation Report, issue 18, 2009; Hu An-gang: "Recommendations on the Establishment of a National Ecological Security Fund—Take the Source of the Qinghai Three Rivers as an Example," National Situation Report, issue 19, 2009; Center for China Situation Studies: "Provincial Multi-Dimensional Poverty Reduction Experience: Take Qinghai as an Example," National Situation Report, issue 19, 2009.

[25] Hu An-gang: "Recommendations on the Establishment of a National Ecological Security Fund: Take Qinghai Source of the Three Rivers as an Example, 19 of 2009.

[26] In Qinghai, grassland areas amounted to 40.38 million ha in 2004, accounting for 10.10% of the total for China. Except for the higher proportion of lamb products, the other livestock production account for a relatively small proportion. In 2006, milk production in Qinghai accounted for 0.81% of that for China, while mutton production accounted for 2.04%, beef for 1.03% (see National Bureau of Statistics, China Statistical Abstract 2007, p. 139, 2007). This reflects the very low livestock production grassland area per unit, and this is still at the stage of a traditional livestock industry.

[27] Qinghai is the only province with large resource reserves but a low resource product yield. In 2006, in Qinghai, the output of raw coal accounted for 0.26% of that for China as a whole, crude oil production accounted for 1.21% and electricity generation accounting for 0.98% (see National Bureau of Statistics, China Statistical Abstract 2007, p. 144, 2007). Only the output of individual resource-based products accounted for a higher proportion.

personal affluence, and an intelligent population; there has been a decline in traditional factors, underdevelopment, poverty and illiteracy.

As noted above, the natural ecological environment of Qinghai is very fragile. Qinghai consists of arid and semi-arid regions. Drought exists in most areas, and Qinghai's annual precipitation is about 300–400 mm, though it is only 17 mm in some areas. The lack of precipitation is responsible for the extremely low forest coverage rate. Thus, even though the area of grassland is extensive, biological growth and productivity of the land are extremely poor; vegetation is poor and easily subject to damage. Unlike many other arid and semi-arid areas in the world and in other parts of China, Qinghai is located on a plateau, having an average elevation of 3,000 m: 72.0% of its area is above 3,000 m in altitude and is characterized by extreme hypoxia, with the oxygen content of the air being only 60–70% that of sea level. The region is cold, with an annual average temperature of −5–8 °C. Mountainous and hilly topography covers 69.9% of Qinghai's area, which is significantly higher than the national average of 40.6% and is also higher than the average level in terms of areas with ethnic minorities. At only 1.12%, the proportion of arable land is very low, being equivalent to just one-tenth the national average.

Because of its basic situation, Qinghai faces basic contradictions with respect to its development: it needs to develop its economy and reduce poverty, but it also has to implement environmental protection and instigate ecological construction. This is the problem facing Qinghai, although it is also a problem for China as a whole and indeed the world. The solution for Qinghai is to set a new course that will establish it as an ecological province.

The ecological security strategy is one of China's core national strategies. And **ecological safety** has to be implemented to the **same degree in Qinghai as elsewhere,especially since it is the 'Source of the Three Rivers'**. Over 30 years ago, China's reform and opening-up had just begun, and then economic development was of overriding importance. Now, in the twentieth **century, scientific and green development have taken over as being of paramount importance.** The long-term development of Qinghai will have to deal with two core issues—poverty reduction and ecological protection—especially conserving the ecology of the Source of the Three Rivers.

6.3.1 From Industrial to Ecological Province

Since the second half of the 1990s Qinghai has ushered in a new round of rapid economic growth, mainly in industry, especially heavy industry. In these efforts, it relied predominantly on capital-driven high growth. From 1995 to 2005, Qinghai showed growth in the GDP of 10.47% and a capital growth rate of 15%, and it was one of the provinces that contributed most to the national economic growth of 57.19% over this period.

Qinghai has vigorously developed its secondary industry. It has cultivated a number of quality industries, and it has inaugurated a number of major industrial projects, such as the joint operation of electricity and aluminum. The proportion of

the secondary industry exceeded 50% in 2006 and 55.0% in 2008. Qinghai also relies on its substantial resources. It has increased investment in competitive industries and rapidly developed resource-dominated heavy industry; the heavy industry proportion of the total industrial output amounted to 93.8% in 2008, which signified an increase of 27.9% compared with the figure for 1978.[28]

Qinghai has a high rate of investment and is characterized by capital-driven economic growth. In 2003, the fixed capital formation rate rose to 74.7% in Qinghai, which was much higher than the national average of 42.8%. The province has focused on a long-term strategy of capital-intensive industries with high capital flows. Such flows are much higher than the national average levels and also higher than many of China's western provinces and autonomous regions.

The industrial strategy of Qinghai has been one of promoting rapid economic development, and this has resulted in enormous pressure on resources and the environment in Qinghai. This has been especially evident in many regions that are unsuitable for agricultural and industrial development, including tertiary industry. There have thus been large restrictions on economic development in Qinghai, and this point has to be taken into consideration with Qinghai's fragile natural environment.

Qinghai occupies a unique eco-strategic position. The source of the Yangtze, Yellow and Lancang rivers is located on the Qinghai-Tibet Plateau in Southern Qinghai. The area gathers 90% of the total water volume of the Yellow River, 25% of the total water volume of the Yangtze, and 10% of the total water volume of the Lancang River, and it is known as the "Water Tower of China." This characteristic has important implications for the ecological environment of the Qinghai-Tibet Plateau and the entire watershed of the Three Rivers.

The population, GDP, and fiscal revenue in Qinghai are rather small for China,[29] though Qinghai does present unique features and offers certain advantages. It is Qinghai's unique advantages for China's eco-development strategy that greatly raise its importance. Thus, Qinghai's role as an ecological barrier and provider of ecological services has brought it increasing prominence, not only in China, but also further afield as a result of world climate change. **By 2020, since the total GDP of China will be 42 times greater than it was in 1978, there will be no shortage in terms of the country's GDP; however, there will be a serious deficiency in ecological products, services,and assets. It is clear that Qinghai has the potential to make a great eco-contribution to China in addition to providing significant ecological protection and functioning as an ecological barrier.**

One aim of scientific development is to promote China's transition from black to green development, which will ensure the long-term survival and development of the nation. For Qinghai's future development strategy, it appears to me that new ideas toward establishing an ecological province that will benefit future generations need to be advanced based upon scientific assessment. Before China's central government addresses the question of Qinghai's future, Qinghai should itself take

[28] Qinghai Bureau of Statistics, Hou Bibo: "Continue to Adjust and Optimize the Economic Structure in Qinghai," Qinghai Statistical Information Network.

[29] Qinghai GDP is proportionally about 0.3% of that of all China.

the initiative in putting forward the innovative concept of establishing itself as an ecological province. From the national perspective, although Qinghai covers a large land area, it does not always occupy a clear position in terms of national strategy; in fact, Qinghai is a particularly important region in China not because of its economy or taxation but because of its ecology.

In a meeting in East Asia, Premier Wen specifically mentioned protecting the Source of the Three Rivers region; this shows that the central leadership is aware of ecological products that have global ecological significance and is not simply concerned about the national ecological public good. **The future generations that will benefit from the creation of an ecological province are not just those of Qinghai and China, but those of the entire world.**

I have full confidence in the "Green Qinghai, green plateau, and green environment" scheme proposed by the Qinghai provincial government.[30] In this regard, I would make further recommendations: the formulation of green development goals; implementation of a green reform strategy; application of green production technology; active development of green energy; efforts to create green jobs; development of green cities; establishment of a green industrial system. Qinghai should promote strategic thinking that goes beyond the creation of an ecological province and green development such that it becomes in effect a national development strategy. This would thus become a win-win situation for both China and Qinghai: it would use national power for the further development of Qinghai and provide Qinghai with the power to better serve the nation.

6.3.2 Elimination of Ecological Poverty as the Highest Priority

As noted above, the natural ecological environment of Qinghai is very fragile, poor, and characterized by arid and semi-arid plateau conditions. Qinghai is affected by several types of natural disasters. These disasters are frequent, severe, and they result in large-scale eco poverty.[31] Thus, poverty in Qinghai is actually an ecological problem, and the poor are also the eco-poor.

All of the poverty-stricken populations in Qinghai (about 1.335 million in 2004; according Qinghai Provincial Poverty Alleviation Office) live in ecologically harsh areas. Of even greater concern is the fact that with ecological degradation and further deterioration of the natural environment, about 200,000 of these impoverished people will be forced to live under severe ecological conditions. This number represents about 5% of the total rural population and 15% of the province's poor people. For these people, poverty may be alleviated by ecological immigration. For others, efforts should be made to avoid the risk of ecological poverty; therefore,

[30] Qiang Wei: "Ecological Province to Benefit Children and Grandchildren," *Qinghai Daily*.

[31] Ecological poverty is the poverty of the living environment. According to definition, deterioration in the ecological environment brings about a reduction in its capacity to meet the basic needs for survival and reproduction of the people living in a region. Or owing to deterioration natural conditions or natural disasters, people's basic living and production conditions are reduced; these factors include poverty of the climate and of resources.

Table 6.5 Types and characteristics of ecological poverty in Qinghai. (Source: Qinghai Province mid-term evaluation report on implementation of China rural poverty alleviation and development program, pp. 12–19)

Ecological poverty type	Region	Area (10,000 km^2)	Population (10,000)	Poor population (10,000)	Natural disasters	Characteristics of ecological poverty
Alpine pastoral poverty	6 states, 22 counties, and 155 townships in Golok, Yushu, Hainan, Huangnan, Haibei, Haixi State	39.97	84.55	31.26	Drought, degradation of over 80% of grassland, degradation of alpine meadows, meadow desertification	"Being thirsty although one is at the water source", decreased grass resources
Poverty in arid mountainous areas	13 counties: Huzhu, Hualong, Yuedu, Minhe, Ping'an, Xunhua, Huangzhong, Huangyuan, Datong, Guide, Jianzha, Tongren, and Menyuan	2.84	287.50	95.51	Drought incidence of 65%	No land or less land
Desertification poverty	Qaidam Basin and Gonghe Basin	12.23	40.25	6.73	Desertification	Villagers retreat as sand advances

eco-friendly production methods should be implemented and moderate ecological ccompensation should be made.

Owing to the particular natural conditions and ecological environment that exist in Qinghai, there are special types of ecological poverty, such as alpine pastoral poverty, arid mountainous poverty, and desertification poverty (see Table 6.5). With the alpine pastoral type, a growing number of ecological refugees are seen every year, mainly through unchanged degradation trends in the overall ecological environment, shrinking lakes, falling water tables, and degradation of wetlands. On one hand, the reduced surface runoff causes water crises and results in the Qinghai water paradox: "being thirsty although one is at a water source"; on the other hand, the reduced grazing resources result in the increased number of ecological refugees. A typical example is Maduo County, which is the source of the Yellow River. It was formerly known as the "county of thousands of lakes," though now it is a poverty-stricken area and suffers from extreme water shortages. Eco-poverty arise through the arid mountain climate, in which the percentage of area that experienced drought

Table 6.6 Ecological poverty in Qinghai (2000–2020). (Source: Ministry of Health: China Health Statistics in 1998, 1999; Qinghai Provincial Poverty Alleviation Office: Qinghai Province Mid-Term Evaluation Report on Implementation of China Rural Poverty Alleviation and Development Program, 2004)

	2000	2007	2015	2020
Ecological poverty population (10,000)[a]	41.0	20.0	7.0	0.0
Ecological poverty population proportion(%)	12.2	6.1	2.0	0.0
Population not covered by safe drinking water (10,000)	169.8	80.3	0.0	0.0
Non-coverage rate of safe drinking water(%)	50.4	26.1	0.0	0.0

[a] These data derive from estimates in accordance with the mid-term evaluation report mentioned above

each year reached 65% (severe: 20%; moderate: 45%). Poverty in the desertification area is evident in the increasingly smaller habitable area: in the Gonghe basin, the land desertification area of 1.267 million ha accounts for 91.3% of the total basin area. This can be aptly described by the saying "villagers retreat as the sand advances".

The eco-poor population has received increased attention because of the problem of ecological migration. According to data for 2000–2007, severe ecological poverty in Qinghai has clearly shown a downward trend—410,000 people in 2000 to about 200,000 in 2007, which amounts to a reduction in ecological poverty of almost half. The harsh natural conditions that exist in the midwestern part of Qinghai led to a concern about difficulties in alleviating poverty as early as the time of the "87" anti-poverty program in 1994–2000. However, relief efforts only addressed food and clothing; they did not improve the ecological environment and survival of the impoverished population.

The proportion of safe drinking water in rural areas of Qinghai Province has gradually increased: the non-coverage rate was reduced to 26.1%. In 2007, the national rural cumulative water changes brought benefits to about 900 million people, which accounted for 92.8%[32] of the total rural population; thus, only 7.2% of China's rural population was unable to receive safe drinking water. In Qinghai Province, 0.8 million people are still affected by problems with drinking water, and the non-coverage rate of safe drinking water is higher than the national average by nearly 20%.

After Qinghai's proposed ecological and ecological poverty-reduction strategies are implemented, unsafe drinking water will basically be eradicated by 2015. Qinghai will essentially eliminate its ecologically poor population by 2020, and the ending of ecological poverty will also represent its biggest development achievement (Table 6.6).

[32] China Development Research Foundation: Building and Development of a Social Welfare System Shared by the People, Beijing, China Development Publishing House, 2009, p. 82.

6.3.3 *Protecting the Source of the Three Rivers—Providing Large Public Products*

Qinghai's ecological policy signifies that the province will achieve a strategic transformation from providing GDP products to providing ecological products. In this way, it will contribute to China's ecological security and even to that of humankind as a whole. Of the public goods of Qinghai, protecting the Source of the Three Rivers will represent its greatest contribution to China.

From the perspective of public economics, it is necessary to analyze more closely the reasons for protecting the Source of the Three Rivers region. This area represents not only a national public good, but also a global public good; it is not just a national ecological treasure, but a common ecological treasure for all humanity.

From 2004 to 2009, the net area increase in the Source of the Three Rivers region was 245 km^2, while the area of desert ecosystems showed a net decrease of 95.63 km^2. Over the same period, vegetation coverage as part of grassland desertification prevention and control areas increased by 23.2%; vegetation coverage in the "Blackland Area" after treatment increased to 80%, and grassland vegetation coverage as part of the process of restoring grassland from pasture reached up to 90%. Exit water from the region increased from 41.2 billion m^3 in 2006 to 77.63 billion m^3 in 2010 with an average annual increase of 9.1075 billion m^3. From 2004 to 2009, the Yangtze annually supplied 16.89 billion m^3 of water downstream: this marked an increase of 4.46 billion m^3 over the 12.43 billion m^3 in 1975–2004. Thus, Qinghai's new policy has had a remarkable effect on water resources. The land cover conversion indicators of the Source of the Three Rivers Nature Reserve showed a significant increase. In this regard, the net primary productivity of grassland areas displayed a large increase, with an increase in the water area and a halt to the declining trend of forest cover. In some regions, there was also an increase in the area of wetlands, lowered grassland degradation, and reduction in the area of desertification.

In the "Main Functional Area Plan—Building Efficient, Coordinated and Sustainable National Spatial Development Pattern" promulgated by the State Council on December 21, 2010, the Source of the Three Rivers region in Qinghai was officially declared a "prairie meadow and wetland ecological function zone." I believe that the functional position in this plan for the Source of the Three Rivers region is scientific, accurate, and timely. At the same time, the region's efforts in protecting its ecological environment and construction also need to be scientific, effective, and sustained. Thus, it is necessary to go beyond the long-term mechanism of the green Source of the Three Rivers and view the broader picture of Qinghai's green transformation.

To fundamentally curb the declining trend in the ecological functions of the Source of the Three Rivers and explore the establishment of institutional mechanisms conducive to ecological construction and environmental protection, Qinghai has made the following proposal. **By 2015, the Source of the Three Rivers region will be made into a national major ecological safety barrier and experimental ecological protection zone. In this way, it will offer experience and act as a model for**

other regions in China and Qinghai in establishing mechanisms for ecological compensation. In the Source of the Three Rivers region, the governed grassland degradation area will amount to 150 million mu; the grassland vegetation coverage will increase by 5% and the forest coverage rate by 5.58%. By 2020, the new governed grassland degradation area will be 001 million mu; grassland vegetation coverage will be more than 5% higher than in 2015, and the forest coverage rate will be 6.1%. The ecosystem will thus enter a virtuous circle. The income of urban and rural residents will approach or attain the average provincial level, and the capability of basic public services will be close to or attain the national average. As a result, there will be full realization of the goal of building a moderately prosperous society.

After having gone from an ecological capital accumulation deficit to a surplus, the Source of the Three Rivers will become a leader for restoration and conservation efforts in China's ecologically fragile areas. Furthermore, it will demonstrate protection and construction functions as an ecological region. Based on related theories in public economics and on specific national conditions in China—and also following maximization of incentives (such as establishing an ecological province) and minimization of treatment costs (in particular information costs)—I make the following recommendations: **a national ecological security fund should be established in conjunction with a list for central fiscal expenditure; it will be necessary to make long-term investments in major national ecological safety engineering.**

Figuratively speaking, this proposal aims to purchase "national ecological wealth" through public finance to safeguard national ecological security. It is thus akin to national defense spending in protecting national security. This proposal requires the following: the promulgation of a national ecological security strategy; the use of national public finance investment; an increase in national ecological assets; and an expansion of national eco-service functions. In terms of China's basic national conditions and core national interests, the greatest deficiency in national wealth is not financial income, which can increase rapidly with GDP growth, but the national ecological capital. This is in seriously short supply, and this growing loss can be financed at the national level. Chinese governments at all levels are in office for only five years, and following re-election, national and local officials are not in office for more than 10 years. Thus, it is necessary to set up institutional arrangements to protect and accumulate this area of low national wealth because this kind of factor does not appear in officials' performance figures during their terms of office. This is the main reason for making this innovative system proposal.

The national ecological security fund is not a financial income fund, but a public finance expenditure fund; it does not involve general transfer payment spending, but ecological capital investment spending; it does not provide a local public good, but a national public good; it does not achieve certain objectives relating to local ecological security, but it achieves public objectives relating to national and global ecological security. To establish an ecological output (magnitude quantity[33]

[33] This can be calculated using drinking water and hydroelectric power generation value as the basis.

or physical quantity) account, a national ecological security fund should buy ecological products or services in the Source of the Three Rivers and Qinghai Province; [34] national finances (including finances of the upstream and downstream regions) would then pay Qinghai for ecological services to allow that province to enrich people's lives and achieve its own development by means of those services.

6.4 Green Transformation in Local Areas

In the case of a green Beijing, a reforested Chongqing, and an ecological Qinghai, different types of regions have successfully achieved a green transformation. They show how China as a whole can follow the road to green transformation.

First, it is necessary to combine national strategy with local innovation National strategy addresses the problem of the "across the river" (see footnote 36) target of China's future development direction. Strategies that adopt a scientific outlook with respect to development are able to create the conditions and prerequisites for local green transformation and then achieve green transformation at a broader level.

China has a vast territory, a large population, and is distinguished by major regional differences. As a result, every region has to resolve for itself the methodological problems of implementation and adopting a scientific approach in developing—in the words of Mao Zedong—the bridges and boats to green transformation.[35] Local innovation has to be developed ahead of central innovation. Local innovation acts as a kind of fountainhead for national innovation, and central innovation acts as a conduit for national innovation. The central government has to respect, support, and encourage local innovative moves, allow local innovation to fail, and guide local innovation by correcting errors. However, innovators should not be punished because of failure; they should be motivated to develop new innovative efforts all over the country. Innovation should be undertaken in a competitive spirit that aims to encourage local "virtuous" innovation—whereby the innovation in one region has a positive spillover effect on other areas—rather than "vicious" innovation—whereby the innovation in one region exerts a negative spillover effect on other areas.

[34] Ecological products refer to natural elements to maintain ecological security, protect ecological adjustment function, and provide a good living environment, including clean air, clean water, a comfortable environment and pleasant climate. Eco-products, like agricultural, industrial, and service products, are all the necessary products for human survival and development. The main functions of ecological regions to provide ecological products are as follows: carbon dioxide, oxygen, water conservation, soil and water conservation, water purification, sand-fixing, climate regulation, clean air, noise reduction, adsorption and dust, protect biodiversity, and mitigating floods.

[35] Mao Zedong pointed out, "We must not only put forward the task, but solve it. Our mission is to cross the river, but we cannot cross the river without a bridge or boat; crossing the river is an empty act. If we do not solve the methodological issues, the task is useless." Mao Zedong: To Pay Attention to Work Methods in Caring for People (January 27, 1934), Selected Works, Vol. 1, p. 134.

Second, it is necessary to address the relationship between central public goods and local public goods Local ecological construction has a very strong positive effect in providing important ecological products for the country as a whole in the form of major rivers and basins. Therefore, it is necessary to continue increasing national investment and purchasing of ecological public goods using public finances. Based on national funding and local capabilities, such investment should encourage and provide ecological products, functions, and services for the whole country directed by financial support from the local area. The country is thus responsible for the overall plan; the provincial government is responsible for the particular duties; and the municipality and county act as the implementation body, while being monitored and evaluated by third-party observers. Ecologically fragile areas should be judged using ecosystem services assessment, which is a different performance-appraisal from that of GDP assessment.

Third, local GDP competition should be turned into a green contest In China, there should be fierce competition not only between the main market players, but there should also be local competition under the guidance of the central government; however, efforts should be made to fundamentally alter the current modes and indicators; ideally, these competitions should be carried out in a fair and reasonable manner, without violating regulations or causing bottlenecks. Although serving the main players in the market may ensure fair, open market competition, serving local residents may ensure fair, equitable, and open public services.

Since reform and opening-up, encouraging competition among local governments has been one of the advantages of the Chinese system, and it has assisted in the country's rapid economic development. At the same time, local competition in the spirit of accelerated development makes many local cadres take rather too ruthless an attitude in their pursuit of GDP since it promotes the strong impulse to invest in faster development.

It is necessary that the central government should take the step of reducing the emphasis on GDP assessment indicators. This would greatly liberate local cadres and give them proper guidance on not focusing excessively on the GDP, but on adopting a scientific view of development. This would help them assess the performance of green development, which will in turn promote local GDP competition to competition for public services, energy-saving competition, and green development competition. This will help various regions make the transition to green development and achieve success in some areas that will lead to transformation in others.

Fourth, local areas need to address the challenge of the ecological environment and be innovative in their efforts to resolve the crisis Local development needs to face a variety of challenges, and these should force local leaders to turn the ecological environment crisis into an opportunity for green development. For example, Beijing is facing crises relating to water shortages and air quality. It also faced pressure in hosting the Olympic Games as a world city. These crises presented tremendous pressures and challenges in the green transformation of Beijing. Beijing may resolve its various crises through the construction of a green Beijing and following the path toward green modernization.

Fifth, system plans continue to promote the key measures in green transformation The greening of Beijing was coordinated under the overall plan of "Three Beijing's" (green Beijing, humanistic Beijing, and high-tech Beijing), which also led to the formulation of its Green Action Plan. To achieve the development goals of a reforested Chongqing, the city prepared its Overall Plan for Forest Projects in Chongqing. To protect the Source of the Three Rivers, the State Council examined and approved the Ecological Protection and Overall Construction Plan in the Qinghai Three Rivers Nature Reserve.

System plans have been used to clarify green transformation goals, ways, and tasks at different stages. They have also been used to avoid self-inflicted setbacks, which are quite common in many Chinese cities. For example, many new mayors have political motivations for destroying trees left by their predecessors so that they can then manipulate statistics by planting more trees.

As Mao Zedong said, "Our large country is complex and has a large population. Thus, both central and local enthusiasms are much better than only one enthusiasm."[36] The national government advocates and plans green development, while it is up to local governments to put this into practice and provide innovative green development.

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