

## Chapter 2

# The Theory of Green Development

Making Green Development a Choice.<sup>1</sup>

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.<sup>2</sup>

Hu Angang (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.<sup>3</sup> Although industrial civilization has achieved great things with "more massive and more colossal productive forces than ... all preceding generations,"<sup>4</sup> 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 21st century? We face unprecedented and

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<sup>1</sup>UNDP: China Human Development Report 2002: Making Green Development a Choice, UNDP, 2002.

<sup>2</sup>Research Center for Contemporary China of Tsinghua University, Hu An-gang and Wang Yahua: National conditions and development, page 187, Beijing, Tsinghua University Press, 2005.

<sup>3</sup>The Research Group of Chinese Sustainable Development for Forestry Strategy in 2002 stated that the 21st 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 21st 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: Introduction of strategic studies on the sustainable development of forestry, page 127–128, Beijing, China Forestry Publishing House, 2002.

<sup>4</sup>The Communist Manifesto.

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.

As Engels said, “Major historical disasters are always mitigated by tremendous historical progress.”<sup>5</sup> 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.

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<sup>5</sup>Marx and Engels Collected Works, volume 39, page 149.

## 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 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)<sup>6</sup>; 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.<sup>7</sup>

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”<sup>8</sup>; Xunzi (ca. 312–230 BC) had similar views, “as the grass and trees are

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<sup>6</sup>Zhuangzi, Qiwu Theory: “Nature and earth coexist with me and everything on earth is harmonious with me.”

<sup>7</sup>Ren Jixu: Chinese philosophy history of development, page 583, People’s Publishing House, 1985.

<sup>8</sup>Mencius, King Hui of Liang 1.

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.”<sup>9</sup>

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 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.<sup>10</sup>

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 (1917–), 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.<sup>11</sup> 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 21st century.<sup>12</sup> 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 21st century and beyond.

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<sup>9</sup>Xunzi, Li Theory.

<sup>10</sup>Qian Mu: Chinese culture's contribution to future humanity, Xinya Monthly Journal, 1990 (12).

<sup>11</sup>Unity of humanity and nature, and their mutual benefit, Nanfang Daily, November 18, 2009.

<sup>12</sup>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.” Qian Mu: Chinese culture's contribution to future humanity, Xinya Monthly Journal, 1990 (12).

### 2.1.2 *Dialectics of Nature in Marxist Philosophy*

The dialectics of nature in Marxist philosophy was first put forward by Engels,<sup>13</sup> and it developed into the Marxist view of nature and natural science. The dialectics 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.”<sup>14</sup> 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.”<sup>15</sup>

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.<sup>16</sup>

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.”<sup>17</sup>

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

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<sup>13</sup>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-19th 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 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.

<sup>14</sup>Collected Works of Marx and Engels, volume 42, page 128, Beijing, People's Publishing House, 1972.

<sup>15</sup>Marx: 1844—Philosophical Manuscripts.

<sup>16</sup>Collected Works of Marx and Engels, volume 20, page 519, Beijing: People's Publishing House, 1972.

<sup>17</sup>Engels: *Dialectics of Nature*, Selected Works of Marx and Engels, volume 4, page 383–384, Beijing, People's Publishing House, 1995.

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.”<sup>18</sup> 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 21st century.

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,<sup>19</sup> 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.”<sup>20</sup> 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

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<sup>18</sup>Engels: *Dialectics of Nature*, Selected Works of Marx and Engels, volume 4, page 383–384, Beijing, People’s Publishing House, 1995.

<sup>19</sup>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.

<sup>20</sup>Marx: *Economic and Philosophical Manuscripts of 1844*, page 77, Beijing, People’s Publishing House, 1985.

construction and social undertakings and achieve coordinated development of economic construction and the ecological environment.”<sup>21</sup>

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.<sup>22</sup> 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), 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 20th 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?”<sup>23</sup> 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

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<sup>21</sup>Jiang Zemin: Speech at the National Flood Rescue Summary and Awards Ceremony (December 28, 1988), Selected Works of Jiang Zemin, volume 2, page 232–233, Beijing, People’s Publishing House, 2006.

<sup>22</sup>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 An-gang et al.: China’s natural disasters and economic development, Wuhan: Hubei Science and Technology Press, 1997.

<sup>23</sup>Rachel Carson: *Silent Spring*, page 11, Shanghai, Shanghai Translation Publishing House, 2007.

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 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 21st 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.<sup>24</sup>

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<sup>24</sup>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



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.’”<sup>25</sup> 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 passive sustainable development concept has lagged behind the needs of human development; in the 21st 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 21st Century, is an overall strategy and policy measure that proposes promotion of mutually coordinated and sustainable development of the economy, society, resources, the environment,

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(Footnote 24 continued)

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.” Jiang Zemin: Properly handle major relationships in the socialist modernization drive (September 28, 1995), Works of Jiang Zemin, volume I, page 463, Beijing, People’s Publishing House, 2006.

<sup>25</sup>Jiang Zemin: Properly handle major relationships in the socialist modernization drive (September 28, 1995), Works of Jiang Zemin, volume I, page 464, Beijing, People’s Publishing House, 2006.

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."<sup>26</sup>

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."<sup>27</sup> Figuratively speaking, sustainable development means not "killing the goose that lays the golden egg,"<sup>28</sup> 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 21st century is to promote social transformation and human development, 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.<sup>29</sup>

**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

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<sup>26</sup>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).

<sup>27</sup>World Environment and Development Committee: *Our Common Future*, 1987.

<sup>28</sup>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." Jiang Zemin: *Unswervingly Implement the Basic National Policy of Family Planning* (March 10, 1996), *Selected Works of Jiang Zemin*, volume 1, page 518, Beijing, People's Publishing House, 2006.

<sup>29</sup>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.

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.<sup>30</sup>

**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.<sup>31</sup> 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 Seventeenth 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.”<sup>32</sup> 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.

### **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

<sup>30</sup>United Nations Development Programme: Human Development Report of China in 2002: Green Development To Be an Option, UNDP, 2002.

<sup>31</sup>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).

<sup>32</sup>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).

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.”<sup>33</sup> 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 every step, it would overextend not only national resources but also global resources; even several Earths would not be able to meet the huge demand.

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<sup>33</sup>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).

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-18th 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”<sup>34</sup> 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 (see footnote 34). 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

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<sup>34</sup>Zhang Peigang: *Agriculture and Industrialization: Exploration of the Industrialization Issues of an Agricultural Country* (1949), Wuhan, Central China Institute of Technology Press, 1984.



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

Period	First	Second	Third	Fourth
	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

(continued)

**Table 2.1** (continued)

Period	First	Second	Third	Fourth
	1750–1850	1850–1950	1950–2000	2000–2050
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

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.gdc.net/maddison/Maddison.htm>

revolution as follows: a series of strategic production functions<sup>35</sup> 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

<sup>35</sup>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), page 70–71, Wuhan, Central China Institute of Technology Press, 1984.

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.

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.

### ***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 U.S. 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),<sup>36</sup> 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 tons/year (carbon equivalent) by 2020 and drop to 24–26 billion tons/year (carbon equivalent) by 2030 and to 10 billion tons/year (carbon equivalent) by 2050, equal to half the amount in 1990 (20.9 billion tons/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.<sup>37</sup>

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<sup>36</sup>IEA: World Energy Outlook 2009, Paris, IEA.

<sup>37</sup>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-21st 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 %.

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.<sup>38</sup> 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 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

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<sup>38</sup>IEA: World Energy Outlook 2009, Paris, IEA.



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.<sup>39</sup>

A green civilization is the correct route for human development in the 21st 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” 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.

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<sup>39</sup>Arnold Toynbee: Humanity and mother earth, the Chinese version, Shanghai, Shanghai People’s Publishing House, 2001.

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

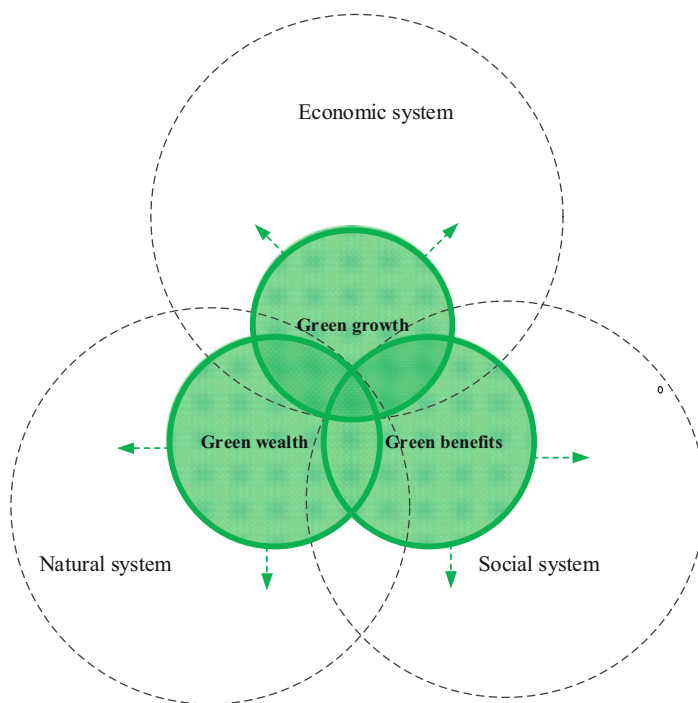
Green development is a complex system. Ma Shijun and Wang Rusong pointed out in 1984 that the social, economic, and natural systems have different characteristics, but the survival and development of each system are subject to the other systems' constraints of structure and function; thus, they are considered 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.<sup>40</sup> This is a holistic system theory proposed by Chinese scholars. Since the beginning of the 21st 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 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.

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<sup>40</sup>Ma Shijun, Wang Rusong: Social–economic–natural complex ecosystem. *Ecology*, 1984, Volume.



**Fig. 2.1** Three circles model of green development

### **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.<sup>41</sup> 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.

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

<sup>41</sup>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.

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 be indicated by a human development index (HDI) that is adjusted for unfairness,<sup>42</sup> 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 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.

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<sup>42</sup>The United Nations Development Programme: Human Development Report 2010.

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.”<sup>43</sup> 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 U.S. Commerce Department and created the GNP indicator and its accounting system. The United Nations’ *System of 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 20th century to measure economic wealth, but it has great defects and its use is questionable. In the 1990s, the United Nations Development

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<sup>43</sup>David W. Pearce: *Dictionary of Modern Economics*, 1981, Macmillan, revised in 1983.

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.<sup>44</sup> 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.<sup>45</sup> 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:

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

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 maximize development gains, but also to minimize development

<sup>44</sup>Hu An-gang: *China's Rise to Power*, page 41, Beijing, Peking University Press, 2007.

<sup>45</sup>UNDP: *Human Development Report 2010*, UNDP.

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.<sup>46</sup> 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:

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

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<sup>47</sup>; 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.<sup>48</sup> The measurement of green GDP adds four key indicators:

<sup>46</sup>World Bank: Expanding the Measure of Wealth: Indicators of Environmentally Sustainable Development, the Environment Department, the World Bank, 1997.

<sup>47</sup>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.

<sup>48</sup>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 Angang, Wang Yahua: National Conditions and Development, Tsinghua University Publishing House, 2005.



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

Specifically, the formula can be expressed as:

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

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)*.<sup>49</sup> 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,<sup>50</sup> 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,<sup>51</sup>

<sup>49</sup>The author directly participated in the design of plan objectives and indicators.

<sup>50</sup>National Long-term Talent Development Plan (2010–2020) (June 6, 2010).

<sup>51</sup>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.

which means less discharge of pollutants; and (3) investment in energy saving,<sup>52</sup> 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,

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<sup>52</sup>According to data provided by the Zero2IPO Research Center, Chinese investment in clean energy grew 30 % to USD 51.1 billion in 2010, the largest amount invested in global clean energy by any country.

[http://www.chinabidding.com.cn/zbw/zxzx/zxzx\\_show.jsp?record\\_id=7057118](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.

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 “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

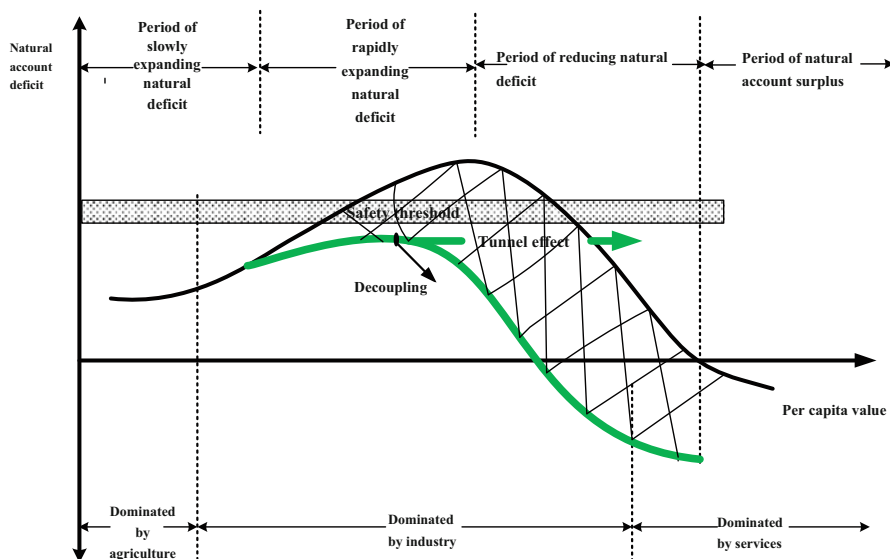


Fig. 2.2 From natural deficit to surplus

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 it 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.<sup>53</sup> 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.

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<sup>53</sup>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.

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 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.<sup>54</sup> 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,<sup>55</sup> 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-,

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<sup>54</sup>National Situation Research Group, Chinese Academy of Sciences, Hu Angang, Wang Yi: *Survival and Development*, Beijing, Science Publishing House, 1989.

<sup>55</sup>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.



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 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).<sup>56</sup> 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,

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<sup>56</sup>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).

energy- and land-conserving housing, and green buildings.<sup>57</sup> 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 implementation of the “equator principles,”<sup>58</sup> 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 5 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

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<sup>57</sup>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.

<sup>58</sup>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.

marketization. Further reforms include improving the policy, evaluation, legal, and compensation systems conducive 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.

**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]<sup>59</sup>; 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

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<sup>59</sup>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 tons 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.

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, 6, and 7.

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