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Leading China's Sustainable Development by Meeting Global Challenges and Achieving Green Innovation

BAI Chunli
(the Chinese Academy of Sciences)

Dramatic changes have taken place in global environment and sustainable development patterns since 1992, when the United Nations Conference on Environment and Development convened in Rio de Janeiro, Brazil. The global landscape of the environment and development has been altered by an expanding world economy, the rise of China and other emerging economies, and a smoothly developing green economy. Since 1996, when sustainable development was made a national strategy in China, amazing achievements have been accomplished in such aspects as population control, energy efficiency, emissions reduction and ecological conservation.

In today's world, global political and economic patterns are subject to great changes and adjustments, with profound transformations in the economic growth mode, social governance structure and global security. Global sustainable development is threatened by the increasingly sharp contradiction between the huge demands of rapid socioeconomic development on the one hand and the limited carrying capacity of the Earth, scarcity of energy and resources, and ecological and environmental constraints on the other. This situation is aggravated by the interaction and overlap of many different problems. At the same time, China is facing multiple complicated and formidable challenges, with its growing dependency on imported resources and energy, and its economic growth mode that continues to feature high input, high consumption, high pollution, low output and low efficiency. Resource and environment problems are major constraints on achieving China's goal of becoming a *xiaokang* (moderate prosperity) society. These complex and severe problems, which challenge China's socioeconomic development and, in particular, its S&T advancement, should be dealt with by comprehensively employing natural sciences, social sciences, humanities and various technological means.

I. S&T Progress is the Eternal Driving Force and Source for Sustainable Development

S&T progress and knowledge advancement are an inexhaustible resource for humankind to deal with challenges and realize sustainable development. Modern history shows that S&T progress and innovation have always played a revolutionary role in advancing human progress. So far, human society has experienced five S&T revolutions. Every one of them, with major S&T innovations and breakthroughs, has greatly raised social productivity, reshaped people's thinking and changed their production modes and lifestyles, offering much greater scope for sustainable development and having profound impacts on human civilization.

During the first S&T revolution in the 16th and 17th centuries, scientists such as Nicolaus Copernicus, Galileo Galilei and Isaac Newton established the theoretical framework of modern science. During the second one,

in the mid-18th century, the industrial revolution marked by the steam engine opened a huge prospect for the development of productivity by removing the limitation of people's physical strength. The late 19th century witnessed the third such revolution, when electric motors and internal combustion engines greatly expanded the scope and effects of human activities, taking mankind into the era of electricity. The fourth S&T revolution, from the late 19th century to the mid-20th century, is represented by the theories of relativity and quantum physics. It triggered the advent of a series of technologies and industries such as atomic energy, information communication, aeronautics and astronautics, greatly expanding people's cognitive space. The fifth revolution, starting in the 1990s, has seen the rapid growth and development of information communication technology that has allowed the development of the Internet- and knowledge-based economy and accelerated overall economic transformation and upgrading, taking people into an "information society."

While countries like the United States, Germany, the United Kingdom and Japan grew into world powers by seizing the opportunities of these five revolutions, China lags behind, as it failed to catch the first four. Although China took advantage of the fifth revolution, which has led to its rapid socioeconomic development over the past 30 or so years, it has a long way to go to catch up with the world advanced level.

With the appearance of signs of revolutionary breakthroughs in some key S&T fields, it is expected that the sixth S&T revolution is imminent. Thanks to the information technology revolution, the new round of revolution will open new prospects in such fields as materials science, life sciences and their interdisciplinary areas, leading to a rapid intersection and integration between different disciplines and continuous mushrooming of emerging fields. In turn, this will bring about accelerated movement of global innovation resources, efficient matching of knowledge, technologies and talents, and faster, highly efficient technology transfer and transformation. Driven by both the green economy and innovation, a new round of S&T and industrial revolution is very likely to happen in the coming decades. Their breakthroughs and development directions will offer great opportunities and areas for sustainable development.

CAS scientists have played a key role in offering S&T expertise for desertification control in China. The pictures show the Tarim Desert Highway before and after the construction of green corridor shelterbelts.

II. Sustainable Development Raises New Topics for S&T Innovation

1. Green economy has become a new trend for global sustainable development.

Since the start of this century, to cope with a series of global problems such as climate change and the global financial crisis, promoting a transition to a green economy has become a worldwide trend. At both the global and regional levels, and in developed and developing nations, including emerging economies, people are making strategies, policies and action plans for green economic development, so as to speed up the tempo of a global green transition. While working hard to promote economic growth and employment, to protect the environment and safeguard social justice, people have endeavored to realize a sustainable future characterized by energy-saving and environment-


CAS gives importance to the development of technologies for ameliorating low-quality farmlands and building up the capacity for raising grain productivity. The pictures show a landscape of a strip of soda-salinized field before and after the application of amelioration techniques.

friendly production, low carbon emissions and social inclusiveness. At the same time, a new S&T and industrial revolution is blooming worldwide, showing that the world is entering an unprecedented innovation-intensive era.

Facing the spreading trend of the global financial crisis, in October 2008, the United Nations Development Program (UNDP) proposed the green economy initiative, calling for a "Global Green New Deal" and "green recovery." In response, major advanced countries and economies launched, in succession, stimulus packages and follow-up strategies and policies to accelerate the deployment and planning for the development of emerging technologies and industries and to create new driving forces and growth points for a new mode of economic development. Their objectives are to combine short-term economic recovery with long-term green transition and sustainable development through technological, industrial and system innovation, so as to achieve multiple objectives, including creating new industries and job opportunities, establishing competitive advantages, safeguarding resources security and dealing with environmental pollution and climate change.

The United States is giving priority to clean energy in its emerging industrial development with a key strategy of investing in "climate-friendly energy sources" and opening new energy sources through S&T approaches. The European Union is striving to combine short-term measures for stimulating economic recovery and job opportunities with its medium-term strategy aimed at transition towards a low-carbon and resource-efficient economy. Regarding low-carbon development as "a new industrial revolution," the EU is strongly promoting low-carbon technologies and related industries and thereby accelerating its transition to high energy efficiency and low-carbon emissions. In Japan, a policy framework, Green Economy and Social Change, was announced with the objective of building a low-carbon society. The Japanese government will promote environmental protection and the development of new energy industries by enacting a series of plans and legislation, such as an innovation plan for environmental and energy technologies, and an action plan for a low-carbon society. In the Republic of Korea, a Framework Act on Low Carbon Green Growth and the Five-Year Plan for Green Growth have been introduced to achieve energy-efficiency and emissions reduction, increase job opportunities and the creation of new engines for economic growth by developing technologies for environmental protection and renewable energy source development. Some emerging economies, such as Indonesia and South Africa, have also formulated their green economy plans or are making efforts to green their major industrial sectors.

2. Green innovation is the key and the driving force for green development and transition.

To realize green development and transition is, in essence, to change the traditional development mode through innovation. This green innovation, which is necessarily comprehensive, involves multiple dimensions, such as technology, policy, institution, organization, culture and management, covering both macroscopic and microscopic levels. Sometimes, it is even revolutionary or radical. So, instead of taking place overnight, the transition toward green development will be a process of systematic changes

subject to restraints and influences of multiple factors. Nevertheless, green innovation is the key and plays a leading role in promoting efficient use of resources, pollution control and emissions reduction. From a global perspective, green innovation shows the following trends: changes from incremental innovation of individual technologies, techniques, products and processes to large-scale, radical and systematic innovation in an integrated, overall and in-depth way; transformation from offering support with end-of-pipe solutions to providing backing to a scheme to control a full life-cycle process covering production and consumption; a change from simply stressing technological innovation to a multi-dimensional approach (that includes technology innovation); and changing from individual innovations at the micro level, such as those in technology, business model and management, to integrated innovation in overall social structure, organization and institutions, and even culture.

3. Green development and transition is an inevitable path for China.

Since the 1950s, China has basically embarked on a road of extensive economic growth. Its high-speed economic development has come at high cost in terms of resources and the environment. While China's GDP has increased by 15 times over the past 30 years, its energy consumption has grown by nearly four times, and its major resources consumption and greenhouse gas emissions per unit of GDP are much higher than those of developed countries. A large proportion of China's resources and energy consumption and carbon emissions are now accounted for by goods for export, but it is difficult for China to continue this economic growth mode featuring high investment, high consumption, high pollution, low output and low net benefit. It also highlights the vulnerability of its energy and environmental security. On the one hand, China is facing the long-term challenge of climate change, and is subject to increasing worldwide pressure for emissions reduction, which will have a direct impact on China's modernization process. On the other hand, China's is facing distinct challenges in terms of resources and the environment. Domestic supplies of some strategic resources, including high-quality energy sources such as oil and gas, and key mineral resources such as iron, copper and aluminum, have long been falling short, increasing the country's dependence on import. At the same time, its environmental pollution problems have become even more complicated and diverse, so it is facing the pressure of large-scale ecological degradation. China has a long way to go in changing its economic growth mode: it must explore a new path suitable for China's conditions and characterized by resource efficiency and environmental friendliness.

To accelerate the transformation of its economic growth mode and promote scientific development, since 1996, when China began to enforce its sustainable development strategy, the Chinese government has put forward a series of strategies concerning green development, including embarking on a new path of industrialization, building a conservation-oriented society, building an innovative country, advancing ecological civilization, and giving impetus to a green economy and green low-carbon development. It has also introduced a series of major policy measures and action plans, including the introduction of constraint indices in terms of energy and environment into the 12th Five-Year Plan. China has made remarkable progress in green low-carbon development, with energy efficiency, emissions reduction and climate change adaptation as its core, leading to steady upgrading of its capacity in sustainable development.

Equipment (upper) and products (lower) of green technology for making printing plates developed by CAS scientists.

To address the severe pollution derived from traditional forms of coal utilization and at the same time secure energy resources, CAS scientists have been seeking greener ways to utilize coal.

4. Formulating China's green development strategy and green innovation plan from a global perspective.

To meet and cope with environment and resource challenges both at home and abroad, and in line with the international trend for green development, China should speed up its steps in green development and transition by relying on green innovation (including innovation in S&T, policy, institutions and management) and by so doing put itself in a strong position for international competition and gain additional leverage for development. However, China's development in terms of S&T capacity, policy tools, and system and institutional arrangement, do not meet the current and potential demands of green development and transition. These difficulties are aggravated by the increase of complicated, changeable and uncertain elements in the external environment, and the overlay, interaction and co-existence of resource and energy problems both within and outside China. This means that China's sustainable development must have its roots firmly planted in our own country while keeping the whole world in view, namely "think globally and act locally." While focusing on domestic problems in sustainable development, efforts should also be made to upgrade capacities of international engagement to address global issues in this regard and promote global sustainable development.

In light of the requirements of national green development and transition, S&T support is needed in the following aspects:

- Make a comprehensive strategic plan for China's green development and transition, including strategic objectives, tasks, priorities and countermeasures; identify the roadmap and priorities that suit China's national conditions; coordinate the policies of various governmental departments and the actions of stakeholders; and offer evidence of the need for green development and transition;
- Accelerate institutional innovation; give full play to the integrated role of legislative, economic and S&T instruments, especially the development and application of market-based policy tools; and safeguard the green development and transition;
- Strengthen green S&T innovation, industrial innovation and product innovation; upgrade green S&T innovation capacity; promote industrial development in environmental protection and energy sources; and offer S&T support to green development and transition;
- Formulate a global strategy and measures for green development and transition, including such areas as energy, resources and environmental security, strategy and policy for international cooperation to cope with climate change,

and technological cooperation in sustainable development; actively participate in global environment governance and decision making; and offer guidance for China's and global green development and transition.

III. China's S&T Community Should Play a Key Role in Promoting Sustainable Development in this Country

Complex issues in environment and development place new and high demands on China's sustainable development studies. Researchers are required to examine and draw up a blueprint for China's sustainable development from a global perspective, search for new strategies and measures to accelerate economic growth, assure China's energy and environmental security, address global climate change and strengthen international cooperation. The Chinese S&T community must seize the historic opportunity of a new round of S&T revolution, enhance its capacity in indigenous innovation and sustainable development, and take favorable positions for future development and competition, so as to contribute to the modernization and green development of the country with a population of over 1.3 billion. We should fully cooperate with the international S&T community to make concerted efforts for building a sustainable future for the world.

With the objective of promoting full integration of sustainable development with the S&T revolution, scoring original research results and making breakthroughs in key technological areas, we should make a scientific forecast and judgment on the possible directions in which the future S&T revolution will head, strengthen foresighted deployment, and enhance studies of strategic priority issues and major interdisciplinary and cutting-edge research. We should offer systematic solutions and policy options for such areas as strategic energy and resources planning, eco-environment conservation and development, and the growth of strategic emerging industries. We should work to take up favorable positions for the new S&T revolution and international S&T and economic competition. We should support China's socioeconomic sustainability by making good preparations for a new round of S&T revolution which will foster green, smart and sustainable development.

As a national research organization, CAS shoulders the strategic missions of serving the country, promoting public interests and national security, and producing outstanding research achievements, talents and ideas. It has made important contributions to China's sustainable development. As early as in the 1980s, CAS took part in advocating sustainable development theory, and offered important scientific evidence for national sustainable development policy by continuously conducting strategic and policy studies in this regard, putting forward measures for different regions to adapt to climate change and suggestions on major function-oriented zoning. It has also implemented interdisciplinary studies on theories, methodologies and instruments, and development and demonstrative studies on key technologies. In addition, it has offered strong backing to China's sustainable development by scoring major innovative achievements in various fields, including advanced industrial technologies for energy saving and environmental protection, clean coal utilization, transformation of low- and medium-yield cropland, ecological rehabilitation and recovery, comprehensive environmental governance, desert control technology, and remote sensing technologies.

In line with the most urgent problems facing China's sustainable development in the next 10 or 20 years, CAS will stick to its strategic position and shoulder its strategic mission of producing outstanding research achievements, talents and ideas. It will continuously make first-class research findings, foster first-class innovative personnel and offer new ideas to support scientific development by implementing the development strategy of building the academy in a democratic, open-minded way, through human resource development and by taking advantage of its diversity of scientific disciplines. It will lead China's sustainable development by striving to be the "vanguard" and "bellwether" of the sixth S&T revolution and giving full play to its role as an engine for China's S&T development.

CAS has accomplished outstanding achievements on ecosystem research. The picture shows a manipulation experiment based in Duolan of Inner Mongolia.

Focusing on key S&T issues of fundamental, strategic and future importance for China's overall and long-term development, CAS will make plans in the eight important basic and interdisciplinary areas, such as sustainable energy and resources, advanced materials and intelligent manufacturing, ubiquitous information networking, ecological and high-value agriculture and biological industry, generally applicable health, ecological and environmental conservation, space and ocean exploration and national public security. Efforts will be made to promote important research outputs and enhance competitiveness in the future. Regarding research for green innovation, a host of research projects have been planned, including: advanced nuclear fission energy; development and testing of key technologies for deep-sea scientific exploration equipment; carbon budgets and related issues; an innovation system and modern agriculture demonstrative engineering for molecular pack breeding; key technologies and demonstrative research of clean, efficient and cascade utilization of low-grade coal; key technology R&D and application demonstration for deep resources exploration; development of major new drugs and a new strategy for major disease control; energy-storage cells; methanol to olefins; and coal to ethylene glycol. Deployment has also been made in interdisciplinary and cutting-edge fields. We will endeavor to integrate research forces, research facilities and monitoring and analytic networks in sustainable development so as to make them public science resources accessible to, and reliable by the whole society. International partnerships will be strengthened to fully tap global innovation resources in an open environment.

We will build a high-level training center for innovative professionals. Sticking to the principle of combining training and recruitment and giving importance to innovation practice, we will produce S&T leading lights and flagship teams capable of overcoming major S&T difficulties and with significant academic prestige. We will recruit high-caliber overseas talents and outstanding academic backbones through various means. We will select and employ outstanding young scientists and strengthen international cooperation in talent training. We will produce a high-level and sustained source of talents for social development by adhering to the philosophy of "pooling the entire strength of CAS for the development of CAS universities and combining most CAS institutes with university departments," and the principle of unified student recruitment, unified education management, unified degree-conferment, and close cooperation between CAS universities and CAS institutes in terms of leadership, faculties, management and training systems. We will build high-end think tanks and advisory teams by joining forces with other parts of China's S&T community and giving full play to the comprehensive and interdisciplinary advantages of CAS Members and experts in research institutes. We will continuously conduct studies into roadmaps for S&T development, information analysis and services. We will provide scientific ideas and systematic recommendations for the nation's macroscopic policy making by conducting consultative studies on major issues, including: national strategic employment on S&T development; development of strategic emerging industries; solutions to complex social contradictions in the period of social transition; ways to overcome bottleneck issues in resources and eco-environment; and China's strategy for international competition. We will foster a new academic ecosystem for innovation that is dynamic, inclusive, harmonious, open and interactive. We will establish an innovation alliance with large enterprises, provincial science academies and universities, foster regional innovation clusters and promote integration between science, technology and economic development. We will improve a modern system of research institutions, give full respect to the innovation initiatives of S&T workers, and set up a major output-oriented evaluation and resource distribution system. We will realize optimum benefits by enhancing the sharing of our research and education facilities.