The Association of Academies of Sciences in Asia (AASA)

TOWARDS A SUSTAINABLE ASIA

GREEN TRANSITION AND INNOVATION

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With 61 figures

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Synthesis Report of the AASA Project "Sustainable Development in Asia"

GREEN TRANSITION AND INNOVATION

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Abbreviations

AASA	The Association of Academies of Sciences in Asia
ADB	Asia Development Bank
ADRC	Asian Disaster Reduction Center
ASEAN	Association of Southeast Asian Nations
BAU	Business as Usual
BFA	Boao Forum for Asia
BOD	Biochemical Oxygen Demand
BP	British Petroleum
CAS	Chinese Academy of Sciences
CASS	Chinese Academy of Social Sciences
CCS	Carbon Capture and Storage
CDIAC	Carbon Dioxide Information Analysis Center
CDM	Clean Development Mechanism
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CRED-EMDAT	Centre for Research on the Epidemiology of Disasters. Emergency Events Database
CTI	Coral Triangle Initiative
DSM	Demand Side Management
EIA	Energy Information Administration of the United States
EKC	Environmental Kuznets Curve
EV	Electric Vehicle
FAO	Food and Agriculture Organization of the United Nations
FASAS	Federation of Asian Scientific Academies and Societies
FDI	Foreign Direct Investment
G7	Canada, France, Germany, Italy, Japan, United Kingdom, United States (Group 7)
GDP	Gross Domestic Product
GEO	Global Environment Outlook
GHGs	Greenhouse Gases
HEV	Hybrid Electric Vehicle
IAC	InterAcademy Council
IAP	InterAcademy Panel
ICT	Information and Communication Technology
IEA	International Energy Agency

IGCC	Integrated Gasification Combined Cycle
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
IPM	Institute of Policy and Management, CAS
KP	Kyoto Protocol
LCD	Low Carbon Development
MDGs	Millennium Development Goals
MEP	Ministry of Environmental Protection, China
NIEs	Newly Industrialized Economies
ODP	Ozone Depletion Potential
ODS	Ozone Depleting Substances
OECD	Organization for Economic Co-operation and Development
OWP	Organic Water Pollutant
PCI	Per Capita Resource Consumption and Pollution Discharge Index
PM_{10}	Particulate Matter with Particle Size below 10 Microns
PNA	Palestine National Authority
PPP	Purchasing Power Parity
R&D	Research and Development
REPI	Resource and Environmental Performance Index
SO_2	Sulfur Dioxide
S&T	Science and Technology
SDA	Sustainable Development in Asia (AASA project)
TFP	Total Factor Productivity
TI	Index of Total Amount of Resource Consumption and Pollution Discharge
TSP	Total Suspended Particulate
TÜBA	Turkish Academy of Sciences
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
UNPD	United Nations Population Division
WB	World Bank
WCED	World Commission on Environment and Development
WDI	World Development Indicators
WHO	World Health Organization

Foreword

Asia is not only the largest and most populated continent in the world, but also the region with the most diverse development models and most dynamic economies. In the past half century, Asia has been witnessing rapid economic growth and playing an increasingly more important role in world's political and economic arena. At the same time, Asia has developed the commonly-called "Asia Model", which has attracted worldwide attention. The Asia Model shows a new way for the developing nations or late-development countries on how to realize industrialization and modernization. All these achievements are made by Asian countries with a focus on the advantages of their late development, re-examination of their internal cultural values, active absorption of modern S&T and management experiences and constant exploration and innovation.

These social progresses have made great contributions to the realization of the UN Millennium Development Goals and have played a pioneering and demonstration role on what can be accomplished in today's world. However, Asia is facing big challenges. The most prominent one is that the rapid development of Asian economies is based on large input of production factors at the huge expense of natural resources and environment, which has been sharpening the conflicts in population, resources, environment, socio-economic development. The sustainable development in the region is being severely threatened and challenged. The rethinking and questioning of the Asia Model in the international community is growing especially in the era of post Asia Financial Crisis and Global Financial Crisis.

It is not only a common challenge for the governments of Asian countries, but also a common task for the Asian scientific communities to cope with the resources and environment crisis and to seek a new way of sustainable development in Asia. AASA, as a non-governmental and regional international scientific organization with 26 member academies, is mandated to initiate and conduct investigation on issues concerning S&T, economic and social development. As early as April 2007, AASA proposed to initiate a project on "Sustainable Development in Asia" (SDA) within AASA framework in the hopes to provide consultation and advice for national and regional governments in Asia and relative international organizations. This study proposal was approved at AASA board meeting held in Russia in August 2007 with the Chinese Academy of Sciences as the initiator. The project covers environment, energy,

resources and culture with the establishment of four working groups among AASA member academies.

Soon after, the SDA project was officially launched and implemented at different levels. The efforts include the clarification of the research content, emphasis, structure and division of tasks. Various meetings at the working level and international workshops have been held to coordinate the research activities and project progress: the first international workshop under this project was held in February 2008; the AASA Workshop on Sustainable Energy Development in Asia in November 2008; the AASA Workshop on Agricultural Culture and Asian Sustainable Development in August 2009; and the AASA Workshop on Environment and Resources in September 2009.

With the joint efforts of AASA member academies, the SDA project has now come up with a series of studies including four thematic reports, namely, "Towards a Sustainable Asia: Energy", "Towards a Sustainable Asia: Environment and Climate Change", "Towards a Sustainable Asia: Natural Resources", and "Towards a Sustainable Asia: The Cultural Perspectives" . Based on these four reports, a synthesis report has also been written entitled: "Toward a Sustainable Asia: Green Transition and Innovation". All these reports have looked deeply into the common issues and challenges for the Asian sustainable development from different perspectives.

The synthesis report is an integration and extension of the four thematic reports. It aims at the major resource and environmental challenges and issues in Asia in the general context of the challenges of financial crisis and climate change, and in line with green transition and innovation in Asia. Of its major findings, it includes: the diagnosis of key resource and environmental issues in Asia, such as water, minerals, land resource, environmental pollution, eco-degradation, energy and environment and climate change, the revelation and reflection of the diverse, different, complicated and severe nature of resource and environmental issues in Asia, the systematic analysis of the main driving forces and future trends of resource and environmental changes in Asia, the empirical analysis and discretion of current evolution of the relationship between environment and development in Asia with the establishment of theoretical and conceptual models, the initiation of principals, strategic framework, focus and advice for promoting the green development of Asia on the basis of summarizing Asia's advantages and disadvantages.

The synthesis report differs from other similar reports. It focuses more on the combination of theoretical and empirical research in the evolution of environment and development, on the combination of trends analysis in time series and comparative study at spatial scale, and on the combination of Asia's integrated analysis and regional and national differences. Besides, attempts have been made here on the innovative modeling of the evolutionary and theoretical relationship between environment and development, analysis of the driving

forces in environmental evolution, and utilization of newly developed composite index to conduct empirical research of Asia's environment and development relation in the evolution.

We hope the reports will be of good value to the facilitation of the green development in Asia, providing advice on dealing with the shortage of conventional resources, environment pollution and climate change, fostering new economic growth and enhancing Asia's competitive advantages. This is the first time that AASA has ever undertaken such a study, and it surely leaves grounds for more detailed study and analysis of various issues and challenges that Asian countries face in the future.

The SDA project is sponsored by AASA. I want to give my special thanks to all AASA member academies for their consistent support, advice and assistance, without which, the accomplishment of such an internationally interdisciplinary scientific project would be impossible. My thanks also go to all the members in the working groups, especially Professors Namık Aras and Yi Wang, co-chairs of this study, without whom, efficiency and quality of the study would not be guaranteed. I also need to thank United Nations Environment Programme (UNEP), InterAcademy Council (IAC) and InterAcademy Panel (IAP) etc. for providing us the references and various advice and inspirations. Last but not the least, I want to express my thanks to all friends and the institutions that have rendered us encouragement and assistance all the way along.

The SDA project features with a wide range of fields and a huge amount of data, some of which are still in their early stage of development. Any comments or suggestions from our friends and various international institutions are warmly appreciated.

Prof. Jinghai Li

President

The Association of Academies of Sciences in Asia (AASA)

September 20, 2010

Preface

Since the 1960s, the ongoing fast growth in Asia has created the so-called "Asian Miracle", and hence the "Asian Development Model". However, this development model is now confronted with new challenges: ①Some Asian countries are losing their comparative advantages. ②This model has largely been achieved at the expense of resources and the environment, exacerbating conflicts between economic development and environmental protection in Asia. ③Asian countries are faced with many global issues such as climate change. The exterior environment for Asia has undergone significant changes since it suffered the Asian financial turmoil in 1997 and the global financial crisis in 2008. Fending off trade protectionism, boosting domestic demands and fostering new growth areas have become the top priorities for the Asian countries. For the Asian Development Model to maintain sustainable growth in the face of current and future challenges, it is critical to introduce innovations for the transition to a green development model.

Given these challenges, the Project of Sustainable Development in Asia (SDA) was approved by the Association of Academies of Sciences in Asia (AASA) in August 2007 and formally launched in February 2008. It aims to bring together the Academies of Sciences in Asia to address the common issues on sustainable development of the region, including sustainable energy development, sustainable use of resources, environmental protection, climate change, cultural and social sustainability, and ultimately to provide decision-making advice and policy recommendations for the government agencies in Asia and relevant international or regional organizations.

This project was initiated by AASA, involving the member academies under AASA. Since the inception of the project, it has organized four international workshops, such as the First Workshop of AASA project of Sustainable Development in Asia (February 2008, Beijing, China), Workshop on Sustainable Energy Development in Asia (November 2008, Beijing, China), Workshop on Environment and Resources in Asia (September 2009, İzmir, Turkey), and Workshop on Agricultural Culture and Sustainable Development in Asia (August 2009, Beijing, China). The SDA project conducted studies through thematic research, synthesis research and consultancy under the joint funding of AASA, IAC, IAP and member academies of AASA. Four thematic reports and one synthesis report have been produced after more than two years

of hard work.

The Synthesis Report, titled "Towards a Sustainable Asia: Green Transition and Innovation", presents an integration of the outputs of the workshops and meetings, and the findings of four thematic reports with assessments of the major challenges and opportunities that the Asian Development Model is faced, as well as the major drivers and possible trends of the environmental and resources change in Asia. In addition, it discusses the theory of the evolutionary relations between environment and development in Asia and conducts empirical study in this regard. Finally, the significance, preconditions and development pathway for the green transition in Asia are clarified, and proposals are made on the principles, strategic framework, priorities and policy recommendations on green development in the region.

Distinct from other related international or regional reports, this Synthesis Report features "Three Integrations": ①Integration of theoretical and empirical studies. On the basis of developing conceptual framework, appropriate resource and environmental indicators are selected to conduct empirical study to validate the reliability and rationality of the findings. ②Integration of comparisons of temporal and spatial scales. While analyzing the future trend of relevant indicators or variants over time for different countries or areas in Asia the report also compares the differences between different countries and areas within Asia and between Asia and the rest of the world. ③Integration of similarities and differences in Asia. The report focuses on the overall trend of changes in Asia while presenting the spatial differences between/among various countries and areas in the region.

Structure and Major Exploration of the Report

The Synthesis Report consists of five chapters. It mainly features four innovation aspects:

(1) The report integrates such concepts and hypotheses as Intensity-of-Use Hypothesis, Environmental Kuznets Curve (EKC) Hypothesis, Decoupling and Dematerialization into the framework of three inverted U-shaped curves on the evolution of environment and development. It also divides the evolution of the relation between environment and development into four stages, while defining the major drivers at each stage.

(2) On the basis of analyzing the evolution of the relationship between environment and development in Asia and validating the theory of three inverted U-shaped curves, the report applies three composite indicators (i.e., REPI, PCI and TI) to quantitatively assess the REPI, PCI and TI of 63 countries worldwide, including 19 Asian countries between 1994 and 2007. This has not only revealed the position of the Asian countries in the world and their gaps with the countries in other regions, but identified the trend of these variables and their relationship with per capita GDP, indicating that improved

resources and environmental performance will rest with various factors such as technological change, institutional arrangement and economic restructuring.

(3) With the IPAT formula of environmental impact, the report examines the drivers of environmental change in Asia and the trend of these drivers, suggesting that the resources and environmental pressures will continue to grow in the future. The report concludes that only by taking strong actions and accelerating the green transition of Asia's economic development model can the energy security and environmental protection in the region be fundamentally improved.

(4) The report points out that enhancing resources and environmental performance provides the precondition and basis for Asia's green development and that green innovation is the key to ensuring green development in Asia. Lastly, by examining the evolutionary stages of the relationship between environment and development in Asia, together with the preconditions and opportunities for green transition, the report proposes the basic principle, strategic framework, focuses and priorities, as well as the policy recommendations for green development in Asia.

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We would like to thank many experts from the member academies of AASA who have contributed their input and discussions. We also highly appreciate the reviews and advice and suggestions of this report from Prof. Namık K. Aras, Prof. Seung Mo Oh, Prof. Luguang Yan, Prof. Woojin Lee, Prof. Gensuo Jia, Prof. Cahit Helvacı, Prof. Lei Shen, Prof. Andrei V. Tabarev, Prof. Dr. Mehmet Özdogan, Prof. Baichun Zhang, Mr. Jinhua Zhang, and Ms. Ling Thompson, and Ms. Jung Ah Choi from the Secretariat of AASA for her close coordination and help.

Due to the limit of the report length, not all the findings have been included in the final text. The contents of the report can in no way be taken to represent the views of the government agencies which have provided financial assistance to the project or the research institutions to which the authors are affiliated. Comments and suggestions on the report are highly appreciated.

Study Group on Green Transition and Innovation

September 2010

Executive Summary

Transition of Development Model and Sustainable Development in Asia

Asia is increasingly becoming a major political and economic regional power with more important global influence after having experienced nearly half a century's rapid economic growth and surviving the impact of the regional and global financial crises. Since the 1960s, the rising and rapid development of Japan, East Asian Tigers, as well as emerging economies such as China and India, has created the so-called "East Asian Miracle" and "Asian Development Model". Although no unified cooperation model has been put in place for the Asian countries due to their differences in political, economic, cultural and resource endowment aspects, the process for regional economic integration is accelerating and will continue to play a critical role in leading the global economic recovery.

The success of an Asian development model does not necessarily mean that it is a paragon. This model is generally regarded to have been achieved by constantly expanding the scale of production with the input of various factors and by promoting exports with favorable policies. It was in the late 1980s and early 1990s that rethinking on the "East Asian Miracle" and "Asian Development Model" began. Particularly after the shock of the Asian financial crisis in 1997 and the global financial crisis in 2008, some long-standing conflicts and problems of the Asia's economic development model have become more prominent, posing unprecedented challenges on the sustainability of this model.

At present, the Asian development model is confronted with three major challenges: ①The external environment in Asia has undergone significant changes. Since the outbreak of the global financial crisis in 2008, export-oriented Asian countries have suffered from severe impacts amid the gloomy consumption markets and rising trade protectionism in European and American regions; ②The traditional comparative advantages of some Asian countries in economic development are diminishing with the gradual decrease in the workforce and rising resources and environmental costs, and the unsustainable over-dependency of their economic growth on the input of production factors; ③As Asia features a very limited carrying capacity of resources and environment, the extensive economic growth model has brought about a large number of resource and environmental problems while it has to address new challenges such as global climate change. As a result, Asia must seek new drivers, create new needs and change its development model to achieve sustainable development. Opportuni-

ties and challenges will co-exist in the next decade, which is identified as a key period for Asian countries to transform towards a new development model.

New development targets have to be defined firstly for the transition of the Asian development model. In the long run, in a bid to achieve stable and continuous growth of Asian economies and to take the lead in the post-financial crisis era in the global economy, Asian countries are required not only to address the environmental and resources problems, but to adjust the old economic structure, create new growth areas and enhance their competitiveness against a backdrop of evolving domestic and international situations. The transition of an Asian development model, therefore, has to be comprehensive, and a new model that is green, low-carbon, smart, innovative, cooperative, and inclusive needs to be created through system innovation. This will not only challenge the wisdom, courage, confidence and patience of Asian countries, but test the willingness of the Asian countries to work together and achieve a win-win situation.

Green Transition is Key to Transform the "Asian Development Model"

Green transition, or the transition towards a green development model, is a core component to addressing the above three challenges, as well as a realistic choice to transform the development model towards a sustainable Asia. In general, innovation is recognized as an essential tool to achieve green transition.

Green Transition

Legal, administrative and economic instruments are needed to achieve green transition and green development in Asia. It is also necessary for Asian countries to adjust the energy and economic structures, gradually transform the extensive economic growth model, establish a moderate consumption model and environment-friendly and equal trading pattern through technological change and innovation, so as to address sustainability issues in terms of resources, energy, environment and poverty reduction, to mitigate and adapt to climate change, and to ultimately achieve sustainable industrialization, urbanization and modernization in Asia. Transition towards a green development model will not only break through the bottleneck of limited environmental carrying capacity in Asia, meet the severe challenges of resources and environment in the region, but will keep in line with international development trends and promote a global sustainable development process.

The major tasks for green transition and green development in Asia include:

Giving top priority to tackling the scarcity of strategic resources and conventional environmental problems in Asian countries. Emerging economies and other developing countries in Asia are required to place top priority on constantly improving resources and environmental performance, secure the safety of freshwater, food, energy and major mineral resources supply, invest in environmental infrastructure; reduce pollutants discharge, speed up the process of environmental control under the framework of an international

environmental regime, accelerate the efforts of surmounting the stage of intensive use of resources and energy and pollution discharge, halt the trend of deteriorating environmental quality in Asia, and achieve economic growth at a resource and environmental cost well below that of developed countries at the same stage of income level.

Addressing the long-term severe challenge of global climate change. It is of critical importance for Asian countries to implement low-carbon development strategies that fit in with their actual domestic conditions, develop long-term institutional arrangements and roadmaps to reduce carbon emissions, actively carry out international cooperation in a principle of "common but differentiated responsibilities", constantly improve energy use efficiency, gradually expand the use of low-carbon energy, develop low-carbon technologies and industries, attempt to decouple green development from greenhouse gas emissions to achieve the target of controlling global warming.

Creating new economic growth areas and enhancing the international competitiveness of Asia. Great efforts should be made to promote the green transition of Asia, seek new sources for cleaner and sustainable growth, integrate the advantage of developing countries in Asia as latecomers to innovation, develop green and emerging industries, create new jobs, conduct cooperation on green development, promote technological progress and enhance the green and low-carbon competitiveness of the products and industries, fend off trade protectionism and break through the "green trade barriers" set by the developed countries.

Green Innovation

While innovation has become a core component of development strategy for various countries worldwide, green innovation will serve as a key target for innovation, as well as the precondition for transforming towards green development in the future. A new technological and industrial revolution that is green, low-carbon, intelligent and sustainable is most likely to take place in the next one to two decades. As a core element driving the revolution, green innovation will define the future trend of innovation and the fundamental pathway of industry transition.

Innovation calls for the guidance of policy, which, in turn, will drive the birth of a new scientific and technological revolution. In the green development area, green technological development, green consumption market and green legislation and policies constitute the drivers of green innovation. In particular, environmental regulations and policies have a strong impact on green innovation. Environmental standards, environmental, financial and taxation policies, to some extent, can promote green technological innovation. Take the best practice in China during the period of the National Eleventh-Five-Year Plan (2006-2010) for example. It has made great strides in technological, equipment and engineering development in such areas as clean coal power generation, renewable energy, high-speed railway, and environmental protection. There is no doubt that China can make significant contributions to addressing climate

change and sustainable development globally in the next decade and beyond if it follows the policy of energy efficiency and pollution reduction.

In the course of green innovation, different priorities need to be identified for different countries. This is because these countries have different conditions, and their issues to be addressed and their advantages in innovation also vary. Overall, as Asia has not completely broken away from the material-intensive stage, technological change will play a crucial role in reducing resource consumption and a negative environmental impact. The major task for green transition and green innovation in Asia, therefore, is to achieve stable and continuous reduction of environmental impact intensity, or to give top priority to improving resources and environmental performance.

Innovation does not only involve technological, but also institutional, policy, administrative, and even cultural dimensions. While institutional innovation and administrative innovation were often used to support technical innovation in the past, they should become major components of green innovation in the future. In addition, as green innovation involves a system engineering process, different innovation activities should enhance their interaction and coordination, strengthen cooperation in the context of open competition, and reduce the risk of technology change to generate system innovation and offer systematic solutions.

Challenges and Favorable Conditions for Green Transition in Asia

Despite the fact that the transition from the old to the new Asian development model is of great urgency and will bring with it opportunities for each country, it will only be achieved over a long period and at high cost.

Apart from the differences of various countries, the challenges for green transition in Asia are mainly reflected in the following two aspects: ①The dilemma between the development stage, the inertia of existing development model and international labor division pattern, and economic transition. As mentioned above, many Asian countries are still at the stage of energy and material intensification and industrialization, during which it is difficult to shift the trend of resources and energy intensification in the short term. Meanwhile, to meet the overwhelming needs of improving per capita income and raise living standards, these Asian countries are faced with severe challenges in achieving green transition in the course of fast growth and boosting domestic demand. ②Achieving green development calls for comprehensive transition in terms of policy, technical, administrative and cooperation aspects, as well as the tradeoff between different development and policy targets. As a result, an incremental process is needed to achieve overall improvement.

It should be noted that many favorable conditions have already been put in place for the green transition of Asia, including development foundations, opportunities and best practices. Asian countries should grasp the chances, fully leverage their own advantages, more proactively address the existing or

potential challenges in sustainable development, innovate for the development concepts and explore appropriate development pathways and priorities to achieve sustainable growth, which is of great significance to promote the green transition of Asia. These favorable conditions include:

• Strong government commitment and political will. Highly efficient and powerful government is one of the major root causes for Asia's economic success, and also provides a strong basis for Asia's green development. More and more Asian countries have recognized the concept of green development and begun to put it into practice.

• The cultural tradition of hard-work and thrift. Asia's traditional culture that advocates diligence and frugality, and its emphasis on man and nature in harmonious coexistence has been playing a significant role in promoting East Asia's rapid economic development. It can also provide an important ideological and financial support for the green transition (including green development and green innovation) of Asia, shaping a moderate consumption model that is different from western countries and that meets the actual resources and environmental conditions and needs for energy conservation and pollution reduction in Asia.

• The largest potential green consumer market in the world. Whether tackling the resources and environmental problems and climate change, or addressing the financial crisis creates a huge demand and market for Asia to develop green economy while providing new opportunities for green innovation.

• Development of renewable and new energies. Relative abundance in renewable energies, such as hydropower, solar energy, wind power, biomass and geothermal energy, has provided favorable conditions for the development of green energy in Asia. So far, significant progress has been made in terms of renewable and new energy development in Japan, Rep. of Korea, China and India, among others.

• Increasing innovation capacity. With its strong technical human capital, increased investment in R&D and its innovation capacity, Asia has already acquired a leading position in R&D, application and industry development in terms of energy conservation and pollution control, electric vehicles and other low-carbon technologies.

• Best practices in sustainable development. Asian countries have developed different models and best practices that balance environmental protection and economic development according to their own conditions in the course of promoting sustainable development. These success stories can be shared within Asia.

• Increasingly open environment and enhanced regional cooperation. While an increasingly open environment has provided possibilities and opportunities for Asia to introduce state-of-the-art green technologies and expertise, learn from the best practices and reduce the costs of green transition, the expanding regional cooperation makes it possible for Asian countries to establish a sound bilateral and multi-lateral environmental cooperation mechanism, strengthen infrastructural development in energy and other areas,