Key Scientific Issues for Regional Sustainable Development in Northeast Asia

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Abstract: Within the context of global climate change, achieving sustainable development in Northeast Asia will require in-depth research into the key scientific issues from both theoretical and empirical perspectives. This paper assesses that the main issues to be addressed are: (i) researches on the structure, function and differentiation disciplines of the vast and complex regional resources-environment-socio-economic system that is Northeast Asia and on how the region can respond and evolve. (ii) Failing to find a mode for sustainable development is one of the most serious restrictive factors to development in Northeast Asia. (iii) Development of cross-border regional socio-economic models for sustainable development is essential. And (iv) the strategies above require cross-border technical support platforms to guarantee a consistent approach to regional sustainability in Northeast Asia.

Key words: Northeast Asia; regional resources-environment-socio-economic giant complex system; sustainable development; key scientific issues

The countries in Northeast Asia are not only geographically adjacent, but also have long-standing historical, cultural and economic relationships. They form an organic, environmentally complex region, which is given systematic integrity through the hydrological cycle, atmospheric circulation and regional socio-economic system. Within the context of global climate change, achieving sustainable development in Northeast Asia will require researching, in-depth, the key scientific issues from both theoretical and empirical perspective.

1 Resource-environment-socio-economic system in Northeast Asia

According to the theory of systematic dynamics Northeast Asia is a region that has an organic integrity built around resources, environment and social-economic system. They are interdependent and interact with each other as a regional ecological economic system, and have specific structure, function and interactive mechanisms (Jiang et al. 2002). For regional sustainable development, natural resources form the material basis, the environment is important supporting foundation, and society and economic system provide the active power that manage the level and phase of that development. There are positive and negative feedback mechanisms in this vast and complex resources-environment-socio-economic system. As an example, pollution generated with economic and social development could adversely affect the environment while that same economic growth and social development can strengthen the human capacity to improve environmental quality. It is the inter-relation of this regional resources-environment-socio-economic system that determines the status and level of regional sustainable development and the structure and function of the regional eco-economic system (Dong et al. 1999, 2002).

To address global climate change, the issues around
the structure, function, and differentiation disciplines of the vast eco-economic system of Northeast Asia, its feedback mechanisms, and its corresponding dynamic evolution pattern are the basic scientific issues. It is important for each country in Northeast Asia to implement an international cooperation strategy and promote international regional sustainable development (Figs. 1 and 2).

2 Regional resources-environment-socio-economic differentiation pattern

Based on regional resources-environment-socio-economic differentiation disciplines and previous researches on geography, ecology and economy, northern China can be classified into five eco-economic belts and 23 eco-economic zones by GIS spatial analysis and geographic methods. We adopted a Digital Elevation Model and used data about land use, temperature, precipitation and aridity provided by the Data Center of Resources and Environmental Sciences, Chinese Academy of Sciences and statistical data for the main economic and social indicators in 2009. This research highlights the structure, functions and major contradictions involved within the given regional eco-economic system, and provides a theoretical basis for developing policies on regional sustainable development in line with local conditions.

2.1 Regional differentiation pattern for natural factors along latitude and longitude

Within Northeast Asia there is steady gradient variation in a latitudinal direction for temperature, heat and some vegetation factors and in a longitudinal direction for water, other vegetation factors and human activities.

2.1.1 Thermal radiation decreases gradually as latitude increases

There is a significant latitude effect in terms of thermal radiation in Northeast Asia. The temperature and sun’s thermal radiation become weaker from south to north. That is why the different types of regions were shown as Temperate Zone and Frigid Zone.

2.1.2 Precipitation decreases gradually from southeast to northwest

Precipitation decreases gradually in Northeast Asia from the west coast of the Pacific to the hinterland of the Central Asian continent. The region can be classified into humid zone, sub-humid zone, semi-arid zone and arid zone.

2.1.3 Three-dimensional differentiation pattern for vegetation and ecological landscape

Using latitude, the south-north variation in vegetation is characterized by a distribution of temperate deciduous broadleaved forest, temperate mixed forest and polar tundra. Using longitude, the east-west variation in vegetation is characterized by forest, steppe and desert. There is also a vertical zone differentiation pattern of broad leaved forest, mixed forest, coniferous forest, alpine brushes, alpine meadow and alpine tundra, based on temperature drops by 0.6 °C as altitude increase by 100 m and precipitation changes as altitude increases. For example, the vertical zone of the Changbai Mountains is as follows:

- 600 m–1600 m: coniferous forest and deciduous broadleaved mixed forest region of temperate zone;
- 1600 m–1800 m: mountainous cold coniferous forest region;
- 1800 m–2000 m: cold elfin forest region (**Betula ermanii**); and
- Above 2000 m: alpine tundra region.

2.1.4 Circular gradient variation pattern of land use from eastern coastal to western inland

Along with longitude, latitude, altitude and precipitation the spatial pattern of land use in Northeast Asia shows a circular variation pattern from the central area of Mongolia...
and Northwest China to coastal areas. The land cover of central area is characterized by barren area that transform as one travels geographically outwards. Semi-shrub, cultivated lands, grassland, forest land appear in sequence (Fig. 3).

2.2 The response and adaptation to climate change: gradient change in ecological transect

Northeast Asia is sensitive-response to global climate change. The natural factors and human activities take on obvious gradient change from south to north. Remote sensing monitoring for CH$_4$ emissions between 2003 and 2005 indicates that the wetlands of the Lena River basin and the paddy fields in southern China are the two main CH$_4$ emissions areas globally. It is useful to analyze their emissions rules and provide scientific proof for drawing regulatory measures (Fig. 4).

2.3 Regional differentiation regularity as human activities decrease with increasing latitude, and increase with increasing hydro-thermal resources

2.3.1 Population density

Population is concentrated in the Temperate Zone and the eastern coastal areas. The Northern Frigid Zone and inland arid regions have very low population densities. They are the “bottom land” in terms of population and urbanization (Fig. 5).

The population density is less than 5 persons km$^{-2}$ in the northern parts of Far East region of Russia, only three persons for Primorsky Kray and one person for the Republic of Sakha. In northern China, population density is much higher with more than 100 persons km$^{-2}$ in most areas. It is higher than 500 persons km$^{-2}$ in coastal regions where population and cities are densely distributed and are subject to increasing population pressure.

2.3.2 Economic geographical differentiation pattern

Generally, economic density decreases from south to north, while affluence in terms of GDP per capita decreases gradually from north to south. Economic development decreases from east to west in China, though it increases from east to west in Russia. In the Far East region of Russia, economic density is low, with less than 0.05 million USD km$^{-2}$, while economic density is more than 0.05 million USD km$^{-2}$ in northeast China, rising to more than 0.15 million USD km$^{-2}$ in coastal areas and south China. GDP per capita is more than 3000 USD in most areas of Russia, whereas it is less than 3000 USD in most areas of China. The less-developed areas are identified as the inland and trans-boundary areas around Mongolia, Sino-Russian border areas and Sino-Mongolian border areas. It is important to have a strategy to promote development of the trans-border areas in order to realize sustainable development in Northeast Asia (Figs. 6 and 7).

2.3.3 Eco-economic pattern in north China

Regional resources-environmental-socio-economic spatial differentiation pattern in north China is shown in Fig. 8. North China is classified into five eco-economic belts and 23 eco-economic zones (Dong et al. 2002).

Belts I is the Northeast Eco-Economic Strip, which includes 11 Forestry and Forestry Processing Industrial Eco-Economic Zone in the north of the Daxinanling Mountains region, 12 Agricultural-Mining Industrial Eco-Economic Zone in the mountainous and hilly region of
northeast China, and I3 Comprehensive Eco-Economic Zone in the central plain of northeast China.

Belt II is The North Eco-Economic Strip of China including II1 Mountainous Eco-Economic Zone in the north of Hebei, II2 Comprehensive Eco-Economic Zone in the northern plain of China, II3 Comprehensive Hilly Eco-Economic Zone in Shandong, II4 Agricultural-Energy Industrial Eco-Economic Zone in the Loess Plateau, II5 Guanzhong-Hanzhong-Yellow River Valley Comprehensive Eco-Economic Zone, and II6 Shan-Gan-Ning Loess Hill And Gully Agricultural Eco-Economic Zone.

Belt III is the Inner Mongolia Plateau Eco-Economic Band, which includes the V1 Agricultural-Mining Industrial Eco-Economic Zone in Xining valley and plateau around, V2 Husbandry-Salt Mining Eco-Economic Zone in the Qaidam basin desert region, V3 Husbandry Eco-Economic Zone in the Yellow River bend of Qinghai-Tibet Plateau, and V4 Cold Husbandry Eco-Economic Zone in the Yangtze and Yellow River basins of the Qinghai-Tibet Plateau.

3 Driving forces of sustainable development in Northeast Asia

3.1 Natural Factors

Northeast Asia located in high latitude areas. As outlined in the IPCC’s latest report on global climate change “Climate and Environmental Change in China: 2012”, rising temperatures are likely in Northeast Asia and hydro-thermal conditions will significantly increase. This will allow the agricultural production zone to expand northwards, which will be a powerful natural factor influencing sustainable development in Northeast Asia in the long term.

3.1.1 Changes in thermal conditions will promote regional agricultural development

In the context of global climate change, precipitation and temperature will rise significantly in Northeast Asia and this will result in more favorable conditions for agriculture. The crop cultivation line for the region will move further to the north, the agricultural impact of low temperature is greatly reduced, crop production is expanded, crop maturation periods are shortened and crop grain yields increase. Consequently, there will be long-term benefits for the development of the main crop producing areas in...
Northeast Asia.

3.1.2 Population and urban development
Climate warming, humidification and improved living conditions promotes the concentration of population and urban development. The change in hydro-thermal conditions in Northeast Asia means that there will be a more humid climate and that the natural environment will be more conducive to human habitation. The improvement of human climate comfort levels in the long term will increase the attractiveness of this area and draw further human activity into the Northeast Asia region. It will promote tourism and trade, and this can lead to the expansion of logistics and other economic activities. It will have a positive impact on the growth of regional population, population agglomeration and urbanization.

3.2 Human Factors
Human activities such as industrialization, urbanization, population growth and agriculture involve the exploitation of environmental resources. This has an impact on environment change, land cover change and regional development modes, and increases greenhouse gases emissions. Human factors are one of the most important short-term drivers of climate change and regional sustainable development.

(1) Population growth has profound impacts on the regional resources-environment-socio economic system.

(2) Industrialization is one of the most important factors requiring a plan for sustainable development in Northeast Asia.

(3) Urbanization is the most important pattern of human activity, which has a great impact on the living environment of Northeast Asia, and increases pollutants and emissions.

(4) Agriculture increases cultivated land within the region, affecting patterns of land matrix and leading to environmental change.

4 Cross-border regional socio-economic sustainable development modes

4.1 Periphery centralization strategy
4.1.1 Factor movements, advantage reciprocity and rapid development
China and Russia will cooperate in the development of peripheral regions including the Northeast China, Inner Mongolia and Baikal Lake region, and Far East region. These nations will construct ecological cities, ecological industrial parks and demonstration areas of eco-economical cooperation and export-led Free Trade Areas. This will be based on concepts of ecologic economy and circular economy built around regional natural resources, human resources and industrial advantages. It will attract international labor-intensive industries and international capital transfer, eventually realizing a sustainable development strategy for peripheral areas focusing on resources, technology and industries.

4.1.2 Overseas processing oriented investment
As leading industries invest in Russia, some industry sectors such as equipment manufacturing, electronic information, light industry, textile industry, food industry, medicine industry, building materials industry and chemical industry are well placed to exploit Russian market opportunities by exporting capital, technology and services.

4.1.3 Ecological economy, circular economy and ecological urbanization modes
Rivers, vegetation and the environment in border areas are fragile and sensitive. Poorly planned resource exploitation and economic development will lead to irreversible environmental consequences. Therefore, we must consider the protection of the environment first and change the traditional mode of economic development by focusing on the development of eco-agriculture, eco-industry and eco-tertiary industry. This will promote a recycling economy through the four levels (enterprise circulation, industry circulation, regional circulation and social circulation), and construct ecological cities and towns along five principles (safe city, circular city, green city, convenient city and harmonious city).

4.2 Mechanism of win-win and cooperation framework
On the basis of equality and mutual benefit there needs to be international cooperation to provide a supportive environment for scientific research, finance, intermediary, commerce and laws for technological innovation enterprises in China and Russia. Through an organizational form like two bases, it would promote different kinds of communication and cooperation and accelerate industrialization and internationalization of scientific and technological achievements. The cooperation focuses on energy supply, new materials, new techniques, environmental protection, information, aviation and aerospace, electromechanical integration, photovoltaic conversion, the chemical industry, materials surface treatment, automation and the technologies that are needed for the markets of China and Russia.

The joint construction mode of risk investment companies: Jointly establishing risk investment companies is an effective way to address the problem of risk in the cooperation between China and Russia. Its main role is to help Chinese private business, especially small and medium scale enterprises to develop trade with Russia, and to facilitate development, production and the promotion of products for the Russian market.
5 The support platforms building for regional sustainable development in Northeast Asia

5.1 The E-Science platform of information and network system

The E-Science Platform (Fig. 9) aims to build virtual scientific research environments for the scientific disciplines through information network technologies to enable the free flow scientific information across borders (Zhu et al. 2010). The functional system of the E-Science regional sustainable development platform in Northeast Asia comprises three levels: the base layer is E-Science General Function Layer, the middle layer is the Earth Scientific E-Science Common Functional Layer, and the top-level is the Functional Layers of Information Scientific Investigation (Sun 2008). Currently, the following organizations have signed the Northeast Asia Joint Scientific Expedition and Cooperative Research platform: the Institute of Geographic Sciences and Natural Resources Research, Pacific Institute of Geography, Far Eastern Branch of The Russian Academy of Sciences and Institute of Geography of the Mongolian Academy. The aim is to construct an international, interdisciplinary and widely distributed Geo-science collaborative research platform. In the future the platform will be addressing some of the challenges that arise during the process of regional development such as resource allocation, global and regional collaboration and the awareness of scientific research personnel.

5.2 The ecological network system platform

We suggest the establishment of an eco-network system platform for Northeast Asia and Central Asia based around existing ecological experimentation and observation stations located in each of the member countries. It will monitor the major impacts of global climate change on regional ecosystems, and ecosystem responses. This will enhance the capacity to monitor the structure, function and responses of the ecosystem in the context of global change, especially concerning greenhouse gas emissions and human activities, and will provide scientific support to regional planning and for developing responses to climate change.

5.3 Regional sustainable development research centre of Northeast Asia and Central Asia

We propose the establishment of a regional sustainable development research centre for Northeast Asia and Central Asia. This will unite the major research institutes and universities in that region, enhance scientific and technological exchange and cooperation in the field of sustainable development, explore the scientific rules and solutions for many strategic issues such as global climate change, resources, environmental crisis and regional sustainable development, and promote joint action on regional sustainable development within the framework of Shanghai Cooperation Organization.

5.4 Regional sustainable development forum of Northeast and Central Asia

A forum on regional sustainable development in Northeast Asia and Central Asia should be organized once every year or every two years by the Resources, Environment and Sustainable Development Research Center of North-
East Asia and Central Asia to explore the international scientific issues around regional sustainable development in the context of global climate change. This forum can offer a scientific basis for policy development in Northeast and Central Asia that promotes sustainable development and joint development through international research cooperation.

6 Scientific issues requiring further exploration

The Northeast and Central Asian regions form a vast and complex system with resource, environmental, economic and social sub-systems. There are a number of important scientific issues around sustainable development that require regional co-research and responses.

(1) The long-term observation for the impact of the global climate change in Northeast Asia and Central Asia and the study for the relevant adaptation strategies;

(2) Dynamic monitoring of the evolution of the structures, functions, effects and mechanisms of major ecosystems in Northeast and Central Asia;

(3) Optimal allocation for sustainable utilization of water resources in Northeast and Central Asia;

(4) The dynamic monitoring and comprehensive treatment of desertification;

(5) The dynamic mechanism and the main driving factors of evolution and its measurement of regional resources-environment-socio-economic complex system in Northeast and Central Asia;

(6) High-tech innovation and exploration of new energy sources and new materials;

(7) Exploration for the modes of “circular economy” and “ecological city”;

(8) The mechanism and modes of international cooperation and sustainable development.

References


