

TRANSDISCIPLINARY RESEARCH FOR SUSTAINABLE DEVELOPMENT IN CHINA: SOCIAL–ECONOMIC–NATURAL–COMPLEX ECOSYSTEM AND ECOPOLIS DEVELOPMENT

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Summary

Springing from 3000 years of human ecology thinking that “humans and nature are one,” sustainable development in China is designing and remaking technological processes, institutional structures, and the harmonious functioning of human-dominated ecosystems. A campaign of ecopolis development is currently spreading throughout China. It is aimed at improving structural coupling, metabolism processes, and functional sustainability through cultivating an ecologically vitalized landscape (ecoscape), totally functioning production (eco-industry), and systematically responsible culture (eco-culture).

It is a healthy sustainable development process within the carrying capacity of local ecosystems that takes place through changing production modes, consumption behavior, and decision instruments based on ecological economics and systems engineering. The key for planning it is ecological integration to make trade-offs between economic wealth and environmental health, between material and spiritual civilization, and between natural and human eco-cybernetics. Integration, demonstration, seeking the views and participation of citizens (see *Actor Participation and Knowledge Dissemination in Transdisciplinary Research*) and using scientists and technicians as a catalyst are the key to its development. The social-economic-natural complex ecosystem theory has been used, and some case studies of the application of these comprehensive methods are presented.

China is experiencing rapid growth in urbanization and industrialization. The pace, depth, and magnitude of this transition, while beneficial to local people, has placed severe human ecological stresses on both local physical and cultural conditions and regional life-support ecosystems. Sustainability can be assured only with an understanding of the complex interactions between environmental, economic, political, and sociocultural factors and with careful planning and management grounded in ecological principles.

1. Introduction

Remarkable social and economic progress has taken place in China since 1978, including effective family planning with a sharp decline in and stabilizing of population growth; a transition from a planned economy to a market economy with a priority on stimulating productivity; institutional reform in ownership and management especially in rural development; acceleration of urbanization and industrialization especially in coastal areas that has resulted in a remarkable improvement in the material life of its citizens; plentiful supply of food and goods, and services due to sustainable food production and tertiary industrial development; democratic progress in most aspects of social life, with people able more freely to express their opinions, desires, and requirements than they could up to the 1980s; a policy of opening up to the world in technological transfer, personnel exchange, economic investment, and international trade; pilot studies of eco-development such as eco-agriculture, eco-industry (E.I.), and ecopolis from both top down and bottom up.

China is basically a landlocked country, more than two-thirds of it mountainous or hilly. Water and farmland per capita, at only 7% of the world average, are the two limiting factors for China's development. The large population base of 1.3 billion and the uneven spatial and seasonal water distribution have increased the stress on survival and development. These severe natural and social stresses, together with China's rapid economic development since the early 1980s has exerted a positive influence on the environment. For example, the flow of the Yellow River, the second largest river in China, began to stop in 1972 due to intense human activity in its upper and middle reaches. The frequency, duration, and distance of the stopping of its flow have increased year by year and begun earlier every year since 1972. The flow stopped for an average of 21 days per year in the 1970s, 36 days in the 1980s, and 122 days in 1995. Cessation of flow began 85 days earlier in 1996 and 102 days earlier in 1997 than it did in 1995. As a result, water for sustaining the ecosystem and agricultural use has given way to urban and industrial use,

which has caused severe problems of regional ecosystem degradation. The area of desertification is now about 27.3% of the total area of China. In the ecotone belt between agriculture and grazing in north China, desertification increased from 45.3% to 52.7% in 10 years. About 20% of the total grassland area is degraded. About 18.6% of the total area of China suffers soil erosion. The soil erosion ratio in the Yangtze River basin was 20.2% in 1957 and had increased to 41% by 1982, which is the real reason for the high frequency and severe consequences of the flooding disasters in the area in the 1990s.

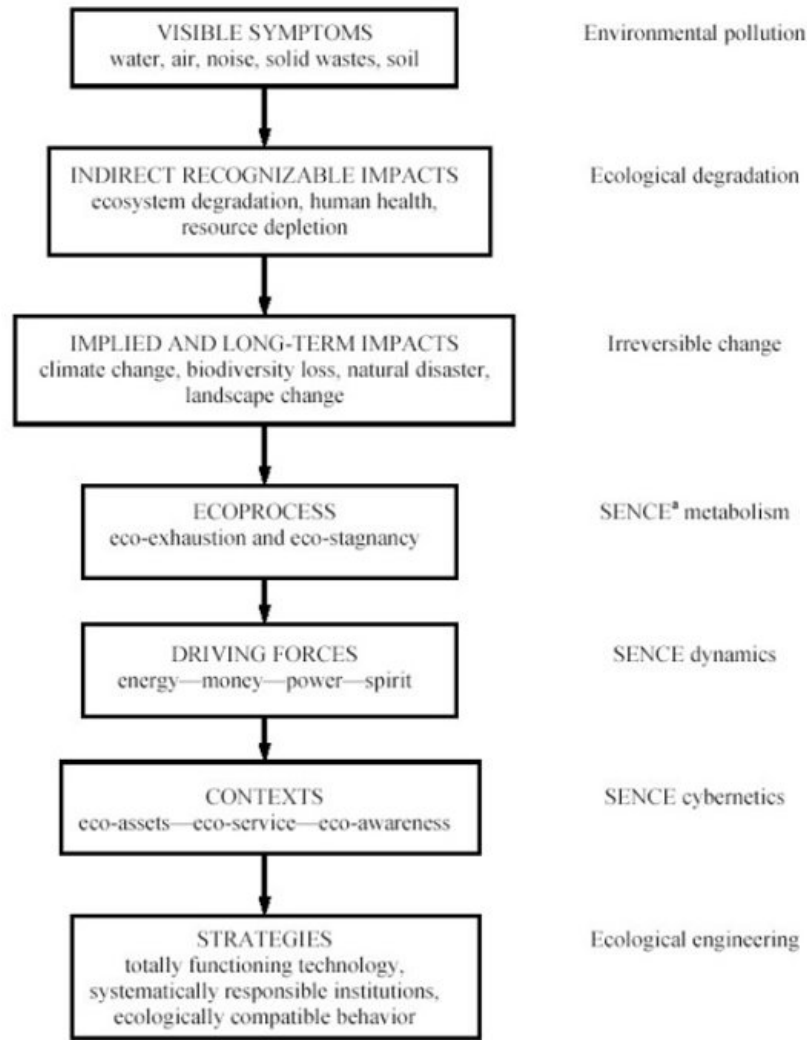
The worsening water shortages and loss to flooding are only surface problems. Their real cause is deforestation and the decline in water-retaining capacity in watershed areas. Though the forest coverage ratio in China has slightly increased, the area of natural forest and mature artificial forest has reduced dramatically: according to the fourth national forest survey, the area of mature forest in 1994 was 20% less than in 1984, and 60% less than in 1977. Since 1970, the wetlands of the three-river plain in Heilongjiang Province have been reduced by 60%, and 37.9% of the chernozem soil belt suffers from soil erosion. The wetland in the Liao River delta has been reduced by 50%. The total lake areas in the middle and lower reaches of Yangtze River have been reduced by 34%, with Dongting Lake, the largest lake in China, reduced in area by 50%. The frequency of floods in the Dongting watershed was only once every 41 years from C.E. 285 to 1868, while there were eight floods in the last 40 years of the twentieth century.

In recent years, huge efforts have been made by the central and local government in environmental protection and nature conservation to implement Agenda 21 in China, and investment in environmental protection has been increased up to about 1% of the country's total gross domestic product. However, although the physical environment in towns and cities such as in Beijing, Shanghai, Guangzhou, and Shenzhen has significantly improved in recent years, the total life-support ecosystem is still under threat and has worsened in some regions.

The urgent physical environmental problems are just symptoms threatening people's health. The long-term ecological impacts such as eco-asset loss, decline in eco-service function, and low eco-awareness of policy makers, industries, and citizens are more vital issues threatening the survival and sustainability of the next generation's regional and global life-support ecosystem. People used to deal with environmental issues in a reductionist way, which often created more problems than it solved. For example, in the Haihe River basin, many reservoirs were built in the upper reaches in the 1950s and 1960s to control flooding and contain water for the city of Beijing. This completely halted its flow to the Bohai Sea through the city of Tianjin, and it has become a static polluting channel. We refer to these urgent environmental issues as the compound ecosystem risks of the rapid economic development in transition countries (see Figure 1).

An investigation was conducted in Beijing, Shanghai, and Guangzhou in 1995 as to the main causes of the nation's environmental problems. Inappropriate behavior, unreasonable institutions, and backward technology were ranked as the first three main reasons. Surprisingly, 39.5% of the respondents listed inappropriate management caused by low population quality, rather than population quantity or resource shortage as the main obstacle to sustainable development, while 34.7% of the respondents ranked unreasonable institutions first. In fact, although population and resource stress is much

higher in Japan than in China, Japan is much advanced than China. The lethal ecological challenge faced by China is how to promote ecologically sound institutional reform, technological transition, and behavioral/cultural enhancement while dealing with integrity with ecological complexity.



* SENCE = the social-economic-natural complex ecosystem

Figure 1. Compound ecological impacts of rapid economic development in China

In dealing with this complexity, people used to consider physical “being” rather than ecological “becoming,” and pay much attention to engineering structure, economic growth, and social benefits while neglecting the system’s context. It is precisely this synergistic function that allows the economy, society, and the physical environment to interact to sustain a harmonious human ecosystem. According to Lao Dan (known in the West as Lao-tzu, or Laozi), a famous ancient Chinese philosopher, this sustaining function is “a thing which seems to issue forth from nowhere, and yet it penetrates everywhere.” It is “formless, shapeless, vague, indefinite, imperceptible and

indescribable, always changing, and reverting to the state of nothingness.” To measure this nothingness, the critical issue is how to imagine the complicated interactions, how to simplify and integrate the diverse relationships, and how to develop a practical instrument for promoting sustainable development. Based on 3000 years of human ecological thinking that “humans and nature are one,” the social–economic–natural complex ecosystem (SENCE) has been developed to model this nothingness from the internal and external, the upper and lower, and the long and short terms.

Section 2 connects modern ideas about sustainable development with ancient Chinese philosophies of human ecology that have made human ecology the basic theory for transdisciplinary research for sustainability in China. Section 3 outlines the general principles, while Section 4 shows how they are applied in landscapes and in industrial development, and Section 5 reports several empirical pilot studies.

2. Human Ecology Thinking on Sustainability in China

Since the origin of civilization, humankind has been gaining much ecological knowledge in dealing with human–nature relations through learning and exploration and has formed an indigenous human ecology perspective adapted to local eco-conditions (see *The Relationship between Scientific, Technical, and Moral Knowledge in Classical Antiquity*). But as an independent discipline, human ecology did not emerge until the 1920s when urban social ecology, originated by what is known as the Chicago school, became more influential in America. It was later revived by the enthusiasm of systems ecology and environmental study in the 1960s when the environment and energy crises were besetting the world; and finally it has been much in vogue in dealing with global change and sustainable development since the 1980s.

Although human ecology as a discipline in China is a product of the late twentieth century, human ecology as a systems approach to the human–nature relationship may date back 3000 years. The development and interaction of Confucianism, Taoism (also spelt Daoism), and Buddhism form the basis of this thinking. In contrast with the mechanics mindset that dominated early industrialized societies, ecological thinking in ancient China emphasized systems nexus and dialectical thinking, suggesting that humans and nature are one (*tianren heyi*). *Tian* (heaven or nature), *di* (earth or resources), and *ren* (people or society) and their relationships have been investigated for thousands of years and affected the economy, politics and culture of ancient China. The most fruitful period was from the Spring and Autumn period (770–476 B.C.E.) to the Warring States period (720–221 B.C.E.), when schools such as Confucianism, Taoism, Legalism, yin-yang, and the Logicians flourished. The basic ideas of *daoli* (the natural law of the universe), *shili* (methodologies of planning and management of human activities), and *qingli* (principles of human behavior towards the environment) are introduced here.

2.1. Daoli: The Ecology of the Human–Nature Relationship

Yin-yang and the five elements is the main theory on the structure and origin of the universe including the relationships between people and nature. The theory originated from the *bagua* (the eight trigrams). The first book on *bagua*, the *Yijing* (often written *I-Ching*), was compiled in the Zhou dynasty (about 2000 B.C.E.). It was later combined

with the *Yizhuan* (written by students of Confucius) to form a new book, the *Zhou-Yi*, which means the variations in the universe. The ideas in the *Zhou-Yi* were widely applied to politics, warfare, Chinese medicine, architecture, etc.

Yin-yang is a theory on the relationship and rules of things and phenomena. The word *yang* originally referred to the sun or heaven, while *yin* referred to the moon or earth. Yang now is taken to mean male, positive, hot, bright, dry, hard, etc; while yin represents female, negative, cold, dark, damp, soft, etc. The interaction between yin and yang produces all things and phenomena in the world and maintains a specific balance. The interdependence and transformation between yin and yang result in the dynamics of nature and human society.

The theory of *wuxing* (the five elements) divided nature into five agents: wood, fire, soil, metal, and water. They form and restrain each other. *Wuxing* theory was used to explain the networks among nature, society, and the human body. All natural phenomena and human activities are part of this network and connected with each other. Any component that is either too strong or too weak will negatively affect other components as well as itself through feedback. For example, misleading behavior towards nature will be punished by nature. Social change and dynasty succession were also related to the five elements.

The holistic view implied in the theory of yin-yang and the five elements claims that humans are nourished by nature, grow up as the seasons change, exchange energy and materials with the environment and thereby are always affected by nature. Meanwhile, humans are also able to adapt and transform the environment. An excellent example of the application of the holistic ecological view (see *Holism in the Sciences*) can be found in traditional Chinese medicine, where the human body is considered to be a functional system closely connected with its environment. Thus the interaction between the body and its physical and social environment and interactions between the body's organs, tissues, and feelings are always emphasized in the process of diagnosis. Disease is considered to be a disorder of the body's functioning caused by six natural ecological factors (wind, cold, hot, damp, dry, and fire) and seven feelings induced by social-ecological factors (delight, anger, worry, sadness, longing, terror, and fright). Patients are cured ecologically through adjusting the yin and yang relationship between their body and the environment, and between the different subsystems of the body, through functional cultivation rather than structural operation, through multi-objective herbs rather than mono-objective antibiotics or chemical drugs, and through active exercise rather than passive treatment (see, for example, *Huangdi neijing* [Yellow Emperor's Inner Scripture]). In every Chinese city, from early morning every day the parks are full of citizens doing various kinds of exercises. This may be the main reason why the average Chinese life expectancy has increased by 30 years since 1950 despite relatively poor living conditions and incredible heavy environmental pollution in most Chinese cities.

2.2. Shili: The Ecology of Human Activities

There is no human activity that is not related to the natural environment. Xunzi (Hsün-tzu), a philosopher of the Warring States period, pointed out that it is the

responsibility of humans to create a culture in the process of exploiting nature. A series of principles about human activity were proposed thousands of years ago. The Legalists stated the methods of management of the country, emphasizing power, law, and tactics (Han Fei Zi). Sun Wu (usually known in the West as Sun-tzu, or Sunzi), the most famous strategist in ancient China, summarized strategies and tactics in warfare, emphasizing the role of the weather, geography, economy, and relationships among people in warfare (*Sunzi bingfa* [The Art of War]).

China is basically a landlocked country, more than two-thirds of it mountainous or hilly. The ecological disasters of flooding, famine, and pest outbreak have beset the Chinese for at least 3000 years, and these have partly been caused by overloading the carrying capacity of the land in densely populated area of the middle reaches of Yellow River basin. To survive in a marginal environment, people have had to adopt a strategy of being in accord with rather than fighting natural forces, by integrating production and developing an elaborate technology orientated to self-reliance and efficient use of the resources of their native ecosystem. There was no waste in ancient China, either in towns or in the countryside, since all waste was biodegradable and could be used as fuel, forage, or fertilizer in the local natural and human ecosystem.

An example is Chinese agriculture. With a 7000-year history, Chinese agriculture has been nourishing nearly one-fourth of the world's population with only 7% of the world's arable land while maintaining sustainable production and soil fertility, where a holistic human ecological view has been important. The long and widely accepted traditions of agro-ecological engineering played a key role in maintaining this densely populated land. Its purpose was to design and maintain a sustainable agricultural ecosystem by enhancing the mechanism of material regeneration and recycling, maintaining ecological integrity and self-reliance. Measures include intercropping, interplanting, total metabolism farming (a combination of cropping, husbandry, fishery, forestation, and agro-products processing), integrated pest management, soil cultivation through organic and green manure, and biogas systems. There were thousands of villages in China where agriculture was sustainable for centuries and people enjoyed a country life in harmony with nature, with cities, and with each other.

2.3. *Qingli*: Ecological Ethics of Human Relationships

Humans were considered the dominant force in the world. Xunzi argued that water and fire have energy but no life, weeds and trees have life but no feeling, animals have feelings but no ethics, and humans have energy, life, feelings, and ethics. Therefore they are the noblest (Xunzi).

The sociability of humans was given much attention in Chinese thinking about human ecology. Individuals, as members of a population, community, and family, should meet the collective requirements and be constrained by social responsibilities such as tenderness, justice, kindness, and so on. The value of individuals is determined by their morality and contribution to the whole community including their offspring.

Confucianism and Taoism were the two main streams of ancient Chinese thought. Both focused on self-cultivation. Confucianism paid more attention to social responsibility and

ethical relationships, while Taoism concentrated on inner character and people's harmonious relations with nature. Xunzi argued that, to lead a happy life, people should cooperate with each other and form a social organization, and that ethics and regulations were thus absolutely necessary. Since there was no limit to human demands, conflicts and competition were inevitable, but they should be reduced by education.

Confucius was not only a great thinker but also an outstanding teacher. There were two goals in his teaching: one was passing on knowledge about the human–environment relationship, the other was cultivating morality. This education played a key role in maintaining the stable and self-regulating structure of Chinese society and families.

The principle of *zhongyong*, a philosophy common to Confucianism and Taoism, claimed that the contrary would result when a thing developed to extreme. Therefore, it recommended being *zhonghe* (appropriate, harmonious, neither too hurried nor too slow), *yongchang* (taking things easy and moderate, adapting to nature), and *mingcheng* (showing good sense in natural laws and social activities). The great ability of the Chinese people to tolerate difficult times was influenced by the idea of *zhongyong*.

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Biographical Sketch

Dr. Rusong (R.S.) WANG, Professor, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, gained his Ph.D. in systems ecology from the Chinese Academy of Sciences in 1985. He has held the positions of secretary-general, Ecological Society of China; first vice president, SCOPE/ICSU; vice president, International Society of Human Ecology; board member, International Society for Ecology and International Society for Ecological Engineering; and vice president, Chinese Society for Ecological Economics. Dr. R.S. Wang has been working on integrative methodology for urban and human sustainable development since 1981, especially ecological engineering, planning, and management. He has been the director of the Department of Systems Ecology, a key laboratory of the Chinese Academy of Sciences, for 10 years. He developed the Social–Economic–Natural Complex Ecosystem theory and Pan-Objective Ecological Programming methodology, which combines ancient Chinese ecological thinking with modern ecological technology and has been successfully applied in urban, rural, and regional development in China. He has organized or co-organized several large integrative ecological research projects, including the Sino-German cooperative ecological research project on the Tianjin urban ecosystem; the European Union’s project of eco-compatibility of industrial process; the Sino-Japanese cooperative project on the Yangtze Delta ecosystem; the Beijing-Tianjin and Yangtze Delta urban/peri-urban ecosystem; the ecopolis planning in Hainan Province, Yangzhou, Rizhao, and Dafeng city; the decision support system for urban ecological regulation and the environmental impact assessment of the Three Gorges Dam. He has published more than 120 scientific papers and 15 books on urban and human ecology, including *Principles and Methodologies for Urban Ecology*; *Human Ecology in China*; *Human Systems Ecology*; *Wealth, Health and Faith: Sustainability Studies in China*; and *Decision Support System for Urban Ecological Development*. He is the co-editor-in-chief of the *Journal of Acta Ecologica Sinica*, and the *Journal of Urban Ecology and Environment*. His significant contributions in ecology and sustainable development have earned him 15 international and national awards or honors.