Chapter 1 Policy Recommendations to the Government of China

The 4th Annual General Meeting of the China Council for International Cooperation on Environment and Development (CCICED) Phase IV was held from November 10th to 12th 2010 in Beijing. The theme of the meeting was "Ecosystem Management and Green Development." This theme is an important means for exploring a new path for environmental protection in China—a path in which ecology and economy come into a more harmonious relationship.

The council members are pleased to see that a roadmap to "green transformation" and "people-centered" development during the 12th Five Year Plan period and beyond was put forward by the recently concluded 5th Plenary Session of the 17th CPC Central Committee. The theme of this roadmap is "scientific development", and the main thread is to "accelerate the transformation of economic development pattern". We understand that to realize such a vision, the Chinese government will formulate strategic measures on adjusting economic structure and vigorously promote science and technology development and innovation. Also, we support the government in its emphasis that the fundamental purpose for transforming the country's economic development pattern is to ensure that all people can enjoy a better quality of life, and that the force driving such a transformation is deeper reform and opening up. Emphasis on inclusive development is a welcome addition since it is an essential ingredient for successful sustainable development.

In particular, the council members noted that the Chinese government has identified the building of a resource-conserving and environment-friendly society as an important approach to promote the shift in the country's economic development pattern. On the one hand, the Chinese government hopes to "green" its economy by consuming less natural resources and better protecting the environment, while on the other hand, it aims to reduce the over-dependence of economic growth on natural resources, and to mitigate environmental damage through green transformation. In order to implement this approach, China has started exploration for a new path of environmental protection that features minimum envi-

ronmental cost, good benefits, low pollution and sustainability. People naturally should have high expectations for this new path since it is an innovation in terms of both philosophy and methodology.

The council members speak highly of the efforts and substantial achievements of the Chinese government over the past year: at a time when the world was coping with the post financial crisis period, China managed to maintain rapid economic growth, promote green development and continue its focus on creating an ecological civilization. We understand that for the 11th Five Year Plan period China has met the targets ahead of time for SO_2 and COD reductions; and that the energy target is also likely to be achieved. The attainment of these targets is a major step towards optimizing the economic structure and improving environmental quality in some areas of China. Issuing the National Plan on Ecological Functional Zones is an important step in supporting the country's green development by identifying resource availability and environmental carrying capacity as a key factor in determining the development direction of each specific region.

We look forward to seeing further progress being made in tackling climate change now that the concept of low carbon development has been widely accepted within China. Certainly the successful Shanghai Expo has become a highlight in the exploration for low-carbon cities and green development. Moreover, the Chinese government's commitment to support the faster development of seven strategic emerging industries, featuring clean, green and low-carbon development, along with the various pilot programs on low carbon economy are additional encouraging evidence of China's commitment to pragmatic action on energy and environment concerns.

The concepts of green economy and green development gained international recognition during the financial crisis and will gain more attention in the post-crisis period as nations try to find new engines for growth. However, the council members note that, despite the plethora of approaches to promoting green development, one issue in this context has not gained as much attention as it deserves, either within China or elsewhere: the protection of ecosystems and enhancing their ecological function and services. Certainly China has undertaken major initiatives to restore forests, grasslands, wetlands and to designate nature reserves and protect species and other components of the country's natural capital. Yet much more remains to be done and the situation will grow more urgent with rising domestic consumption and continuing high rates of economic growth.

Ecosystems serve as the foundation of the subsistence and development of human beings, as well as all other forms of life on the planet. This natural capital, which is comprised of the richness of species, their diverse habitats, and the genetic resources that ecosystems

hold, can provide various services. For instance, ecosystems provide resources for economic and social development, they satisfy people's spiritual need to enjoy nature, and support and regulate the physical environment upon which mankind depends.

Harmonious relationships between people and nature are at the core of green development. It is development underpinned by healthy ecosystems and sound eco-services. Development that damages biodiversity and exceeds ecological carrying capacity is unsustainable. 60 percent of the world's ecosystems are being degraded, while the global ecological footprint per capita is overwhelming the world's biological carrying capacity. Already in 2007, the footprint was 50 percent larger than the Earth can sustain, which poses serious challenges to the green development goals being pursued by the international community. Therefore, in this International Year of Biodiversity, and at a time when green development is becoming a world trend and China enters its critical stage of green transformation, the council members consider it exceedingly important to focus on the issue of ecosystem protection and ecological services.

After years of tremendous efforts, in particular the continued restoration and enhancement of forest and grasslands, China has achieved considerable progress in ecological protection and recovery, and has laid a fairly solid basis for social and economic development as well as for ecological security. But the council members also note the conflict between the country's limited resources and ecological carrying capacity and the increasing economic and social demands being made on natural systems of all types. This conflict is resulting in continued ecological degradation, serious environmental pollution that affects ecological functions, and a weakened basis for green development. The council members voice their special concern over the frequent natural disasters that have plagued China this year, such as droughts, floods, landslides, typhoons and earthquakes. These disasters have rung alarm bells. They have exposed the fragility of the country's ecosystems and, in some instances, the desperate need for enhanced eco-services. In the future, climate change will place even more pressure on already overworked ecosystems.

Both theory and practice show that improved ecological management can help protect biodiversity and enhance ecological services. CCICED has two task forces reporting this year. One studied key ecological factors in terrestrial ecosystems (forest, grassland and wetland), and the second examined the sustainable use of China's marine and coastal ecosystems. Other studies were carried out regarding soil pollution, conservation of aquatic ecosystem services, the need for mainstreaming biodiversity conservation, and on the status of China's ecological footprint.

Based on the discussions during the Annual General Meeting and the results of the task

forces and other studies, the CCICED AGM 2010 proposes the following policy recommendations to China's central government.

1.1 Change Views and Management Approaches Regarding Ecosystem Services and Management, and Update the National Strategy on Ecological Protection and Rehabilitation

Serious problems exist in ecological protection and development in China, starting with the difficulty in protecting those values of ecosystems which are hard to price or are presumed to be simply a part of nature's abundance. A great deal of attention is given to the *provisioning services* (e.g., the production of food, fibre and other economic products) that ecosystems provide. But other functions and services of ecosystems are often undervalued or neglected. These other functions include *natural regulatory services* (e.g., flood control by forest ecosystems, climate regulation by type of land cover, pollutant absorption by wetlands), *support services* (e.g., natural regeneration of soil) as well as *cultural services* (e.g., high quality of life benefits such as recreation, knowledge). This problem exists not only in China but also elsewhere. The coming climate changes will stress and impact all of the services provided by natural ecosystems, creating a new urgency for improved ecosystem management at the present time.

In terms of management approaches, the mandates of regulating agencies are basically divided by sectors related to economic goods and jurisdictions. This approach is not well suited to the holistic and trans-regional nature of ecosystems. The implementation mechanism is largely "top-down", with the government playing a guiding role, while the spontaneous engagement of communities and the general public remains seriously inadequate. In addition, the overlapping of mandates among different regulating authorities blurs their responsibilities, powers and interests related to ecosystems. As a result, these agencies may implement sectoral laws, regulations and policies on ecosystems, and focus on problems like low efficiency, poor performance, and economic development of ecosystems, while neglecting, to varying degrees, conservation aspects and while avoiding the tackling of problems related to integrated management of the overall ecological system and of the interlinkages among ecosystems.

The council members therefore recommend that **China should change its views and approaches regarding the use of natural capital; set healthy ecosystems and highly functional eco-services as a key goal; and take a holistic ecosystem management approach. The council members further recommend that with these changes, key goal**

and management approach in mind, China should update the national strategy on ecological conservation and development in an effort to enhance the overall economic and social value of China's natural capital.

(1) Change views and recognize the holistic and multi-functional nature of China's ecosystems from a scientific development point of view. Scientific research and public education about ecosystems should be strengthened to raise the awareness of both policy makers and the general public about the multiple services and high value that ecosystems and their biodiversity can provide. This should lead to greater public participation in ecosystem protection. Of critical importance is the introduction of the ideas that improvement of ecosystem management could bring about multiple benefits of economic development, poverty alleviation, as well as job creation. It is of critical importance that both the quantity and quality of ecosystem services are improved at the same time.

In addition, management approaches should place as much attention on the functions of ecological regulatory processes, cultural enjoyment and ecological support as on the supply function of ecosystems. The former functions should be well protected, improved and given long-term attention. The goal for ecological conservation and development should be a healthy and resilient ecosystem with continuously improved eco-services. Biodiversity conservation should be mainstreamed into development strategies, and into the general efforts for ecological protection. A holistic and integrated view of ecosystem management embracing the linkages from China's mountaintops to its seas should be upheld as a basic approach in ecosystem management.

(2) Introduce National Medium and Long Term Strategic Guidelines on Ecological Protection and Development, and establish a coordinated action framework. During a nation's development, science and technology provide the driving force, education is the basis, talents are the key, and natural capital the roots. By drawing upon the modality of national guidelines on science and technology, education and human resources development, and taking into consideration the National Plan for Ecological Development (1998-2050), the National Guidelines on Ecological Conservation (2000-2030), and the results of the recently completed Macro Environmental Strategy Study, China should draft National Medium to Long Term Strategic Guidelines on Ecological Protection and Development.

The Guidelines can integrate various functions of the ecosystem and help the government to manage the country's ecosystems holistically. Consequently, the problems brought about by the current separated and jurisdiction-based management system will be resolved. Bearing in mind the National Plan on Ecological Functional Zoning, the Guidelines should incorporate the protection of all ecosystems, including forest, grassland, soil, wetland, rivers,

lakes, seas, and groundwater, as well as the endeavors of biodiversity conservation, ecological preservation and pollution control. The umbrella Guidelines should also identify the medium to long term targets and tasks for ecological protection and development in China. Based on the proposed Guidelines, subordinate plans or measures targeting specific types of important ecosystems should be developed.

(3) Establish a more comprehensive cross-sector and trans-regional coordination mechanism and an effective ecosystem management system. For an integrated use and management of ecosystems to be feasible, China should take a long term view and work towards the establishment of an administrative body that holds more fully the powers for regulating ecological conservation and development, with the current need being the establishment of an effective inter-ministerial and trans-regional coordination mechanism. Many problems such as: overlap of mandates; blurred responsibilities, powers and interests; coordination difficulties; and high management costs will have a better chance to be resolved.

At the central government level, a cross-sector and trans-regional coordination mechanism needs to be established that focuses on the entire ecosystem management and trans-regional river basin systems. It is important to streamline the responsibilities between central and local; between different ministries; and between upstream and downstream jurisdictions. At the local level, particularly in middle and western regions of China, it is important to establish an inter-provincial and intra-provincial ecosystem management coordination mechanism that becomes the decision-making body for ecological development, planning and management. This mechanism will facilitate inter-agency coordination and prevent unilateral and uncoordinated decision making.

The responsibility for biodiversity conservation and ecological preservation should not be limited only to national authorities on forestry, environmental protection, land and resources, and water resources, but also should be mainstreamed into the portfolio of the economic, industrial and agricultural agencies.

(4) China should encourage wider participation of the general public, enterprises, communities and NGOs in ecosystem management. Among other means this can be accomplished through education and awareness raising, market mechanisms such as eco-compensation that links their incomes with ecosystem health. Of critical importance is the creation of incentives, such as eco-product labeling and certifying process, to encourage the private sector to get involved and manage certain ecological services, foster certain new sectors, strengthen enterprises' social responsibilities, and reduce their ecological footprint. It is important to engage communities and individuals, especially those living in and directly exploiting natural ecosystems, to raise their awareness of the importance of the ecosystem

health, explore sustainable community action mechanisms, improve information disclosure, and alter their behaviors. Ecosystem service and management should be included into school curriculums and education programs. One critical path is to engage NGOs in ecosystem management and ask them to lead, support, monitor and implement the system themselves. A combination of both top-down and bottom-up approaches would help form a stronger force in ecosystem protection.

1.2 Strengthen Environmental Management and Allow Key Terrestrial Ecosystems to Recover

More than 96% of the Chinese population lives on 34.9% of the land territory. Continuous and fast growth of economic and social activities brings about huge demands for multiple services from the country's terrestrial ecosystems, including its forests, grasslands, wetlands and other freshwater aquatic systems. In 2007, China's ecological footprint per capita was lower than the world average, but it is still 2 times the biological carrying capacity of the country's ecosystems. Meanwhile, the ecological deficit is annually becoming larger. There are many daunting challenges ahead in protecting and recovering ecosystems and their services. In spite of increasing forest coverage, most of China's forests remain inadequate in total volume, imbalanced in distribution and poor in eco-services; the overall grassland and wetland quality continues to deteriorate despite improvement in certain areas; soil problems, including soil erosion, desertification, salinization, nutrient impoverishment, and soil pollution, have become increasingly serious. In some areas, soil has been so badly polluted that it becomes a threat to ecological safety, food safety and human health. Furthermore, water ecosystems provide much poorer eco-services than before and their biodiversity has decreased. The status of endangered species is deteriorating, genetic resources are being lost. The Chinese government needs to strengthen terrestrial ecosystems management and enhance their functions, so as to form a sound natural underpinning for sustained and stable economic growth and a better life for the people.

Therefore, the council members recommend that: **China should regard the terrestrial ecosystems as a whole; use systematic and coordinated approaches to improve terrestrial ecosystems management; introduce relevant laws and regulations, plans, policies, and measures; and grant more financial support to ensure success of these measures. The measures will help the important terrestrial and their associated aquatic ecosystems to rehabilitate.**

(1) Amend or draft protection and recovery plans on important terrestrial ecosys-

tems. In light of the proposed National Medium to Long Term Strategic Guidelines on Ecological Protection and Rehabilitation, sub-plans on specific terrestrial and freshwater aquatic ecosystems should be formulated on the basis of geographical distribution and ecological boundaries. These sub-plans should be mutually supportive and linked. It is important to establish a dedicated prevention, supervision and rehabilitation planning and management system that deals with social and economic activities with possible serious ecological concerns, such as mining and large infrastructure projects.

(2) Strengthen legislation on ecosystem management. The legal system for ecosystem management should be continuously improved. The following actions are needed: a) Revise the more than 20-year-old Environmental Protection Law, to better coordinate ecosystem management with pollution control, as well as to update principles, views and provisions. b) During the legislative improvement of related laws and regulation, China should safeguard the holistic nature of ecosystem protection. c) In the legislative upgrading of economic laws and regulations, it is important to factor in the requirements of natural systems and "green" such pieces of legislations. d) On the basis of a comprehensive review of existing biodiversity protection laws and regulations, facilitate the convergence between international conventions and domestic regulations. An umbrella law on biodiversity conservation should be mapped out in order to fully implement the National Biodiversity Protection Strategy and Action Plan (2011-2030) and to comply with the Convention on Biological Diversity, thus fulfilling China's international commitment to biological diversity protection. e) Strengthen the enforcement of ecosystem management laws and regulations.

(3) It is important to strengthen the capacity of the society and ecosystem in the event of natural disasters. Natural rehabilitation should be given more priority over human intervention, so as to strengthen the ecosystem's own capacity in coping with natural disasters. Preservation and protection should start from the beginning of social and economic activities. Where appropriate, watersheds, rivers, lakes should be equipped with more capacity in flood control, with reinforced hydraulic infrastructure. It is important to establish various systems in disaster-prone areas, including assessing, monitoring, emergency response and contingency plans, as well as post-disaster reconstruction process.

(4) Increase long term input for the protection and management of terrestrial ecosystems. The long term nature of ecological preservation and recovery requires long term financial support and stable policies of the government. China should increase long term financial input by exploring and leveraging multiple investments and financing channels, and formulate a stable policy environment. Existing ecological programs need to be continued, including those aimed at converting farmland back to forest/grassland, at preserving virgin

forests, at treating the source of sandstorms affecting Beijing and Tianjin, at restoring grasslands from overgrazing, at conserving water and soil and for protecting wetlands, lakes and river aquatic ecosystems. The channels and total sum of financial support should be guaranteed in order to consolidate the progress achieved so far. Greater attention needs to be paid to refining the ecological objectives of each of these program areas, with better guarantees that the stated goals will be fully met.

For the ecologically fragile regions in central and western China, plans should be developed, and new ecological programs introduced to cover, river basins and their source water areas, seriously eroded areas, key ecological-function conservation areas, and China's extensive network of nature reserves. These new programs should be planned by the central government, implemented by the provinces, and supported by stable financial resources, such as financial transfers by the central government, specialized funds, and ecological compensation schemes.

In addition, China should foster ecologically-dependent industries and markets, and build an evaluation and auditing system to oversee the collection, distribution and use of ecological funds, ensuring the effectiveness of these funds.

1.3 Place Marine Ecosystem Management High on the Policy Agenda and Promote Sustainable Ocean and Coasts Development

China has a vast marine territory with a coastline over 18 000 km and around 6 900 islands larger than 500 m^2. Its territorial seas and exclusive economic zones cover an area of 380 000 km^2 and over 2 million km^2 respectively. The ocean is a strategic base for food, energy and water resources and an important extension of terrestrial production and activities. It also bears the brunt of many land-based unsustainable practices such as waste dumping, excessive land reclamation, and agriculture, and industrial pollution. The sea is also a significant driving force for economic and social progress as well as a foundation for sustainable development.

China's ocean is currently facing challenges at an unprecedented scale including serious marine ecological degradation, drastic depletion of marine resources and continued decrease of marine ecological capacity. And what makes it worse, if China's marine environmental management today cannot meet such challenges, how will tomorrow's challenges be addressed? They will be much greater since the exploitation of marine natural resources and proposed future economic development in the ocean and coastal areas will rise. There is much room for improvement and only limited time to do so.

However, at present China's ocean ecological and environmental status has been worsening. Offshore environmental pollution in many ocean areas is heavy. In 2009, the offshore polluted ocean area exceeds 50% of the total offshore ocean area. The offshore ocean ecosystem has been severely damaged. Compared with the 1950's, China has cumulatively lost some 50% of coastal wetlands, 57% of the mangrove areas, 80% of its coral reefs, with more than two thirds of the coast eroded. The length of eroded beaches is more than 2 500 kilometers. Ocean ecology and environment disasters have frequently happened, for instance, red tides have occurred 79 times annually on average from 2001-2009, with the red tide area reaching 16 300 square kilometers. Ocean biological resources have declined severely. Overfishing dramatically reduced the fishery; and at the same time, land reclamation destroyed the spawning ground of fish or the habitats of their larvae/juveniles, resulting in resource exhaustion of some fishery species. The ocean ecological carrying capacity is declining at an increasing rate. In a word, China's ocean is currently facing challenges at an unprecedented scale.

But China's ocean ecological and environmental management has significantly lagged behind the demand for improving the degraded ocean ecology and environment. An umbrella national law on the sea is still absent; a comprehensive strategic plan that incorporates the impacts of rivers and coastal land use on the sea is also lacking; and there is a number of institutional deficiencies in China's marine environmental management system. For instance, different marine resources or ecological factors are managed by different agencies. As a result, it has not been possible to carry out management of the ocean and coasts from a comprehensive or holistic point of view. The most critical case in point is the serious ecological situation of the Bohai Sea, which suffers from high levels of resource exploitation, coastal reclamation and development, and from land-based sources of pollution.

The Chinese government needs to pay more attention to growing problems of China's seas and coasts, including the major contributions to these problems from inland and coastal land and river development and use. Better protection of the marine environment should be a more important part of its environment and development portfolio as soon as possible.

The council members recommend that: **taking into account the impacts of development in river basins and coastal lands on China's ocean and coastal ecosystems, and of marine effects on cities and terrestrial areas, the government of China should develop mechanisms to reduce the impact of land-based sources of environmental and ecological problems in the seas of China. China should strengthen marine ecological protection and scientific sustainable development as the basis for all present and future economic development in the ocean. China should also strengthen global and regional ex-**

changes and cooperation on marine ecosystem protection. Only in these ways it will be possible to guarantee sustainable use of the ocean, with continued growth in the contribution of the ocean economy to China's GDP growth. Currently there is no green development strategy for China's sea. The most obvious and immediate case in need of such a strategy is the Bohai Sea.

(1) Set up and improve the legal system of marine management. The central government should initiate the legislation process for a Basic Law of the Sea of the People's Republic of China as soon as possible. This Law should be designed to serve as the basis for marine development and management, marine economy development and ecological protection of the sea. It should be the fundamental law promoting sustainable use and development of the sea. Moreover, there is a need to draft the Coastal Zone Management Law of the People's Republic of China and the Bohai Sea Environmental Management Law of the People's Republic of China. The supporting regulations, methods, rules and standards of the Marine Environmental Protection Law should be formulated or improved at the earliest date. In all laws concerning use of the sea, China should abide by the principle of holistic ecosystem management and set substantial protection and rehabilitation of marine ecosystems as a goal.

(2) Map out a national strategy and plan on marine ecological protection as soon as possible. Drawing upon the China Ocean Agenda 21, China should consider formulating a new China Strategy on Marine and Coastal Sustainable Development. This new strategy will map out the basic principles, guiding philosophy and strategic targets in the next 20 years, and detail the key tasks for coastal and marine economic development, marine environmental protection and resource preservation. The strategy should prioritize such issues as sea enclosure and land reclamation, addressing marine eutrophication and its impacts such as toxic red tides and green algae blooms, as well as fishery development issues in light of the overfishing pressure.

(3) Establish a coordination mechanism for the marine environment with participation by relevant agencies including those with marine mandates, and some with terrestrial and freshwater mandates. In the near future, there will continue to be multiple players in the field of marine management and it is not yet realistic to set up a unified agency with full powers over marine issues. It is thus necessary and appropriate to set up a National Ocean Committee for the time being, which coordinates and draws upon the powers of relevant authorities in order to facilitate better management of marine and coastal affairs. Considering the current serious marine environmental problems, the main tasks of the Committee should include formulating a national strategy on marine development, promot-

ing communications among relevant agencies, and coordinating major marine affairs that involve different agencies, sectors and regions. Among these tasks, the first priority should be solving the ecological problems in the Bohai Sea.

(4) Introduce an ecosystem-based approach to marine management. The ecosystem should be viewed as a whole, and the following comprehensive measures need to be taken in marine management: a) formulate an ecosystem-based sea zoning plan; b) evaluate ecological safety and environmental capacity of offshore waters, and identify off-limits for sea reclamation, identify ecologically sensitive and fragile areas as well as key regions of ecological safety, and mark the protected areas on the sea; c) in addition to maintaining existing protected areas of the sea, new marine nature reserves, special protected zones and marine parks should be established for typical and representative ecosystems as well as for protecting rare and endangered species; through this means a network of protected areas on the sea will be formed; d) in islands and areas rich in typical marine ecosystems, affected by invasive species or sensitive to climate change, ecological recovery programs should be carried out; set up demonstration areas of marine preservation, and recover the capacity of the seas for maintaining biodiversity and strengthening resilience against marine disasters and climate change; e) establish conservation and recovery systems for marine species under the ecosystem-based ocean management framework; f) expand sea farming in an environment-friendly way, promote the carbon sink functions of fishery and improve ecosystem capabilities; g) introduce the approach of determining an inland pollution cap based on the receiving capacity of the sea, and when technically and economically feasible, formulate upstream-river mouth pollution control plans; reducing agricultural and industrial pollution loads on the ocean should be high priorities; and h) strengthen mud and sand regulation by dams and minimize negative effects of delta erosion caused by sudden decrease of mud and sand volume.

(5) Build up the early warning and emergency response system of serious marine pollution incidents. According to relevant international practices, China should set up and continuously improve the early warning and emergency response system of serious pollution incidents on the sea. Under the proposed National Marine Committee, China could establish Leading Group on Emergency Response to Major Marine Pollution, with the responsibility for setting up an emergency response mechanism and coordinating actions of relevant agencies in the wake of serious incidents of marine pollution. In the meantime, China should establish mechanisms on notification of major marine pollution, for evaluation of potential environmental risks, and for improving early warning and information sharing issues. China also should improve emergency response mechanisms for regional marine pollution, streng-

then supervision and management of potential pollution sources, and ensure the implementation of emergency response measures.

(6) Set up an integrated environmental monitoring and analysis system that covers both the land and the sea. China should combine the work of upstream, river mouth and sea monitoring; set unified monitoring indicators and technical standards; build an integrated monitoring system that covers air, river basins, the sea and coastal areas, and set up an information sharing system. In the short term, China should add NO_x as a new indicator for air monitoring and control, and total nitrogen and phosphorus as new indicators for water monitoring and control over the river basin. In addition, China should carry out scientific research on river basin-ocean linked ecosystems and deepen understanding of the marine ecosystems, laying a sound scientific basis for better marine management. In the populous and economically prosperous coastal areas, China should create an integrated research and monitoring network comprised of environmental monitoring facilities, research institutions, laboratories, outdoor observatories, and ecological recovery demonstration projects.

1.4 Promote Scientific Innovation, Improve Technological Support, and Strengthen Capacity Building on Ecosystem Management

Currently, one prominent problem in ecosystem management is the lack of scientific support and weak management capacity. Relevant policies on ecosystem management and the implementation process of these policies are not well supported by scientific results. This can be seen in the following aspects. First, China does not have adequate monitoring of its main ecosystems and their changes. Hence timely, accountable and transparent data on ecosystems is limited for researchers, policy makers, supervisors and the general public. Second, each relevant agency has its own independent network of ecosystem monitoring and research, and the data and results gained are neither commonly applicable for decision-making nor readily available to other agencies. Third, basic research, applied research and technological development on ecosystem services and management remain weak and they cannot satisfy the needs of decision-making and policy implementation. Fourth, China lacks a mechanism for the scientific results to be successfully applied in policy-making and implementation. What we see right now is that large amounts of available scientific results cannot be applied in daily work, and policies and plans on ecosystem protection and recovery are not well founded on scientific studies. As a result, such policies and plans are either impractical or poorly implemented.

Therefore, in light of the main problems and demands, China should carry out streng-

thened monitoring, research and demonstration activities on ecosystem management and restoration/recovery, develop an optimized ecosystem management model that suits China's realities and provides scientific support to ecosystem monitoring, evaluation, demonstration projects and decision-making. This optimized model is badly needed since it is an indispensable factor in improving ecosystem management in China.

The council members recommend that: **China should set up and continuously improve a measurable, verifiable and reportable monitoring and evaluation system on China's ecosystems to cover the whole country and in particular the key ecological regions. More input should be given to scientific research and capacity building on ecosystem management.**

(1) Set up an improved national observation and research network on the ecosystem. The central government should improve the outdoor observation and research network for regional ecosystems and biodiversity studies, support the network by long-term and stable financial resources, unify relevant technical and data standards, and establish a basic database and national digital atlas for biodiversity and ecosystems. These measures will help provide key scientific data, develop key technologies, and improve management of ecosystems and their services.

(2) Carry out regular evaluation on the status of China's ecosystems, and set up monitoring and evaluation systems for adaptive management of ecosystems in key regions. Comprehensive evaluation of China's ecosystems should be carried out every five years in order to illustrate a full picture of the ecosystem and support the formulation of the Five Year Plans. These evaluations should utilize the results of various censuses and surveys on forests, grasslands, wetlands, oceans, soil, water and biodiversity; make use of the national observation and research network on ecosystems, and apply remote sensing, modeling and other technologies. By doing these activities, an objective understanding on the changing ecosystems and their eco-services will be gained. Furthermore, China should establish an air to ground monitoring system for key ecosystems and have systematic and non-stop monitoring in these regions. Such monitoring systems will not only help to follow closely the trends of ecosystem change and record the progress China is making, but also to expose existing problems. This monitoring could then be the basis for developing solutions to the problems and contribute to better protection and recovery of ecosystems.

(3) Carry out basic studies on and develop key technologies of ecosystem services and management, and promote the application of the results gained. China should study the features and regional distribution of the main types of degrading ecosystems in order to define the mechanisms and patterns of their degradation. Based on these studies, key tech-

nologies for ecological recovery should be developed, and their application promoted. Technologies for recovering different ecosystems and in different regions should be developed. It is important to establish a green accounting system for ecosystem services, link this system to the national system of accounts, and incorporate relevant indicators into performance evaluation system. Scientific and technological studies should be carried out to study the impact of climate change on ecosystem adaption and mitigation, as well as the impact on ecosystems from new energy exploitation and new technique applications. Meanwhile, it is necessary to review different management models and apply the management systems that suit the localities best. In this way, the country's ecological preservation efforts can be more effective and sustainable.

1.5 Attach Greater Importance to Weak Links, Step up Efforts in Key Fields, and Help Promote the Green Transformation of Economic Development Pattern during the 12th Five Year Plan Period

The 12th Five Year Plan period is critical for China's efforts towards an all-round well-off society. This period is also a pivotal time to transform the existing economic development pattern, and it brings strategic opportunities for green transformation and green development. Council members have full confidence in China achieving the targets towards green transformation in the next five years put forward by the 5th Plenary Session of the 17th CPC Central Committee. However, it is clear that there will be both foreseeable and unexpected difficulties and challenges during the process of green transformation. In the next five years, China will face heavier resource and environmental pressures, people's call for a good ecological environment will become stronger, the country will face more challenges in tackling climate change, and it will be more difficult to achieve environment and development targets due to diminishing marginal utility.

The council members therefore recommend that: **China's core mission in the field of environment and development during the next five years is to integrate environmental protection with the transformation of economic growth pattern; to achieve success in both improving environmental quality and promoting green development; and to explore a new path for environmental protection. To fulfill this mission, it is necessary to not only step up efforts on traditional priorities and strengthen policies and programs that have proved to be effective, including the energy conservation and pollution reduction program, but also give more attention to weak links that require immediate actions, including ecosystem management, rural environmental protection, soil pollution**

prevention, and the inclusion of climate change mitigation and adaptation targets into ecosystem management initiatives. These actions will help give full play to the role of ecological protection in promoting the green transformation of economic development pattern.

(1) Step up efforts in key fields and promote the green transformation of economic development pattern. Efforts should be made in the following aspects: set up mandatory objectives for improving environmental quality and promote nationwide; carry out environmental impact assessments more strictly and systematically; adjust industrial structure and regional distribution; raise environmental standards, tighten environmental enforcement and force the industrial structure to adjust both by improvements in upstream sectors and end-of–pipeline measures; promote environmental product certification and encourage green consumption; introduce environmental economic instruments, guide the traditional enterprises to "green" themselves and foster emerging and green industries; deepen environmental information disclosure programs and encourage public participation in green development; and provide technical and scientific support to green development through environmental innovation and technological application.

(2) Boost rural environmental protection across the board and bridge the gap between urban and rural areas in terms of ecological civilization. Currently, rural environmental degradation stands out as a prominent problem. Compared with the urban and industrial areas, rural areas have become a weak link in China's environmental protection work, affecting the living standards and equitable sharing of development results in rural areas.

In the 12th Five Year Plan period, the Chinese government must greatly strengthen environmental protection in rural areas and try to make breakthroughs in this regard; a) formulate an environmental protection plan for the rural areas and move rural environmental issues higher on the agenda of national environmental work; b) improve the legal system of rural environmental protection, accelerate the legislative process on animal husbandry pollution control, non-point pollution control, soil pollution control and agricultural waste recycling; c) step up infrastructure building for rural environmental protection, provide more guidance on environmental management and disseminate pollution control technologies; d) expand the coverage of "award for treatment" policy (a policy that financially rewards the villages doing a good job in environmental treatment), raise the amount of such awards and study the feasibility of introducing "award for prevention" policy (a policy that financially awards the villages that successfully prevent environmental pollution and degradation); e) set up rural environmental supervision institutions from the central government down to the grassroots level and improve rural management capacity across the board; and f) strengthen education

and publicity, raise awareness and recognition of rural environmental issues.

(3) Strengthen soil environment protection and safeguard public and ecosystem health. Soil pollution poses a great threat to food safety, public health and ecosystem integrity. The Chinese government already attaches a great deal of importance to this issue but needs to implement a comprehensive action plan during the 12th Five Year Plan, including prevention, restoration and remediation, and supervision. There is an urgent need to: a) commission a national soil environmental protection plan; b) issue a law on soil environmental protection and pollution treatment, to introduce standards, and to establish national and local guidelines for soil protection and environmental quality; c) set up a national monitoring system for soil protection, allocate responsibilities and establish a liability and accountability system; d) establish a funding mechanism for soil pollution prevention and reclamation; e) strengthen scientific research for soil pollution management and study and develop reclamation techniques and equipments; f) establish a pollutant watch list by regions and food products; g) establish, monitor and evaluate the supply chain for food safety; and h) study and act on the carbon sink and water resource protection potential of soil, and strengthen soil's role in climate mitigation and adaptation.

(4) Focus on priorities, and incorporate the target of improving various ecological services and the principle of holistic ecosystem management into the daily work of ecological protection and development during the 12th Five Year Plan period. The approach of holistic ecosystem management is something new; there will be many challenges ahead in ideological, institutional and legal terms to be addressed in order to put it into practice in China. With so much preparatory work to be done in order for integrated management to be successful, it will be a fairly long time before full implementation of this approach takes place. In the coming five years, China should first raise the awareness of this holistic and integrated ecosystem management approach among policy makers and stakeholders, and formulate and promulgate the National Medium to Long Term Strategic Guidelines on Ecological Protection and Development as well as specialized plans on key ecosystems. Then China should implement this approach first in key and vulnerable ecosystems like the soil and the sea. Pilots could be first established in important areas such as Bohai Sea and other priority ecosystems and sub-regions. In addition, China should also strengthen scientific research, technological development, management model demonstration, and monitoring system development in order to better support the holistic approach of ecosystem management.

(5) Expedite the process of legislation on ecological compensation, and improve relevant policies and mechanisms. There are many useful tools that can be introduced in China, but among them ecological compensation, which has been studied and piloted for

many years and initiated into legal procedure, is particularly important for both ecological preservation and pollution control. China should issue the State Council Regulation on Ecological Compensation as soon as possible, and promote the widespread establishment of ecological compensation schemes. In light of the current status of the country's ecosystems, there are several key tasks in this regard: a) establish a non-profit compensation fund for forests, grasslands and wetlands; b) the central government should grant sufficient budget to national nature reserves under the framework of the national ecological compensation scheme; c) gradually incorporate the forests and grasslands restored from farmlands into the scheme; d) establish marine ecological compensation mechanisms, carry out compensation demonstration for key marine programs, including sea reclamation projects, as well as for oil spills and protected areas. Compensation should also be piloted in places where inland activities have affected river mouths and sea; e) establish eco-compensation mechanisms for mining projects; and f) ecological compensation scheme for freshwater ecosystems.

(6) Implement green regional development strategies by taking into account resources and environmental capacity, biodiversity conservation needs, and establish within China regional cooperation mechanisms for ecological protection. Over the past two years, China has issued a number of regional development strategies and plans, which will be essential to bridge the development gap among the different regions and to foster new growth engines. It is equally pivotal, however, to strike a balance between regional rejuvenation and green transformation: a) regional strategies and plans should conform to the National Plan on Ecological Zoning, and the development direction of a region should be determined by its resource and environmental capacity so that pollution and ecological damage will not come together with the industries that gradually transfer to these regions; b) in the richer eastern region, ecological preservation should be a priority and optimized development strategy should be implemented; while in the ecologically vulnerable west, a green development strategy should be introduced, focusing on ecological innovation and giving greater attention to biodiversity conservation. These strategies will help build a resource-conserving and environment-friendly society; c) in light of the current status of the environment, it is not enough for one local government alone to curb the degrading trend of the ecosystem and substantially improve environmental quality, but rather coordination and cooperation among the localities is needed. It is desirable to review experience so far and establish a comprehensive cooperative mechanism on regional ecological protection and joint pollution prevention, control and treatment.

Chapter 2 Ecosystems and China's Green Development

2.1 Introduction

2.1.1 Ecology, Economy and Development

China is among the world's most ecologically diverse countries, with one of the planet's highest concentrations of biodiversity. Its natural capital has sustained ancient civilizations and supported the rapid development of China under its current political and economic system. But the stresses are showing—from past draw-downs of this natural capital, from the more recent export-driven economy, and from meeting the domestic needs of 1.3 billion people. During the recent past there has been a string of natural disasters, including some that illustrate the fragile state of some ecosystems, including landslide areas in western China, the Bohai Sea with its red tides, the drought impacts in Yunnan and the floods of 2010. As noted in China's 2010 report on the Millennium Development Goals, only limited progress has been made on Goal 7, Environmental Sustainability. Even though there have been substantial efforts and expenditures, there is evidence of continued ecological decline of many types: in the soil, in lakes, rivers and wetlands, on-going problems with grassland desertification, and in China's marine and coastal areas. Therefore, at its 2010 Annual General Meeting, CCICED will focus its recommendations on policies to improve Ecosystem Management and Ecological Services within China.

These recommendations will come forward at an important moment globally. 2010 is the International Year of Biodiversity, intended to highlight the need to stop the erosion of biodiversity and ecological services worldwide. At the United Nations the Secretary-General has launched a High-Level Panel on Global Sustainability with the goal of setting out a blueprint for low-carbon prosperity. Within the G20, it is at a time of significant institutional change to support financial reform and international decision making, plus efforts to realize

the 2009 commitment that future economic progress should be based on Green Growth. Also, there are the important on-going negotiations towards an operative global climate change agreement, including the UNFCC October 2010 meeting in Tianjin, China. For the global community there never has been a more important time for trying to build a harmonious relationship between environment and economy.

China is at a transformative stage in its overall economic and social development, moving towards a more balanced relationship between its exports and meeting domestic needs, encouraging greater efficiency and value added approaches, stimulating rural development and tertiary industries, and seeking improved quality of living for all citizens. Environment and ecological factors are important in all these objectives. Thus China is seeking a new path of environmental protection much more closely aligned to its economy and social goals. This approach will need to be transformative in its own right while taking a scientific development approach, meeting key goals for reducing poverty and for providing the conditions for an " all round, well-off" society. China has signaled its aspirational goal of becoming an "Ecological Civilization" living in better harmony with nature. Within China the 12th Five Year Plan will be implemented starting in 2011. It will be a plan that emphasizes Green Development. (Box 2-1 for definitions of this and other terms used in this Paper). The October 2010 17th Communist Party of China Congress has emphasized that "the building of a resource-saving and environment-friendly society should be a focal point in the transformation of the economic development mode."

2.1.2 CCICED Studies and Issue Paper Outline

This year two task forces, one covering ecosystem management and ecological services—primarily focused on forests, grasslands and wetlands; and the second on sustainable use of China's ocean and coast, present their final reports at the CCICED Annual General Meeting. In addition, findings are presented from special studies and other reports on: soil pollution, safeguarding ecological service of China's water resources, China's ecological footprint, and mainstreaming biodiversity into China's decision making. The CCICED studies have informed this Issues Paper and provide the basis for developing Council recommendations on improvement of ecosystem management and ecological services.

Box 2-1 Some "Green" Definitions

Biodiversity is the variability among living organisms from all sources including *inter alia* terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (Convention on Biological Diversity).

Biocapacity measures the area of biologically productive land and water actually available to provide renewable resources and absorb CO_2 waste (WWF and Global Footprint Network).

Ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment, interacting as a functional unit. Humans are an integral part of ecosystems (Millennium Ecosystem Assessment).

Healthy Ecosystem is one that is sustainable—that is, it has the ability to maintain its structure (organization) and function (vigor) over time in the face of external stress (resilience) (Costanza and Mageau, 1999).

Ecological Integrity exists when ecosystems have their native components (plants, animals and other organisms) and processes (such as growth and reproduction) intact (Parks Canada). Also, an ecosystem that can function unimpaired in the provision of ecological services (various sources).

Ecosystem Management **(in Chinese context)** is the combination of management activities and all the laws, regulations, other institutions, education and public behavior that contribute to sustainable provision of ecological services (CCICED Task Force on Ecosystem Services and Ecosystem Management Strategy).

Functional Ecological Zoning is the designation of zones based on ecological criteria, for uses compatible with these criteria (various sources describing agro-ecosystems, coastal management, and river basin planning).

Ecological Services are the benefits that people obtain from nature (G. Daily, 1997).

Ecological Footprint measures how much land and water area a human population requires to produce the resource it consumes and to absorb its wastes (Global Footprint Network).

Ecological Debt is the consumption of resources from within an ecosystem that exceeds the system's regenerative capacity (New Economics Foundation).

Green Growth results from the change from a development model treating environment protection as an economic burden to a model that recognizes environment protection as a driver for global and national economic development (OECD).

Green Economy involves reconfiguring businesses and infrastructure to deliver better returns on natural, human and economic capital investments, while at the same time reducing greenhouse gas emissions, extracting and using less natural resources, creating less waste and reducing social disparities (UNEP Green Economy Initiative).

Green Development is unified and harmonious development of the economy and environment, a positive path of people-centered sustainable development (Hu Angang, 2003).

Natural Capital is the land, air, water, living organisms and all formations of the Earth's biosphere that provide us with ecosystem goods and services imperative for survival and well-being (IISD).

The Issues Paper[1] covers ecological challenges and prospects in the context of green development strategy. It identifies some of the major shifts required and defines the magnitude of tasks ahead. The paper surveys global and Chinese trends regarding the greening of development and economic growth. This is followed by a section on the challenges faced by China on how to protect and raise the level of various types of ecological services. The Paper then examines progress on China's key efforts to protect ecosystems (including three types under major threat) and services, and future needs. This section concludes with observations on China's ecological debt burden. From this base of knowledge, eight key issues are highlighted for greater attention.

Throughout the Paper the focus is on key ecological-economic relationships in China. As noted in 1987 by the Brundtland Commission Report,[2] the world's ecology and economy are interlocked. Changing one invariably affects the other. Thus, ecological services are very important for economic and social gains. Fortunately, numerous opportunities for improvement exist.

2.2 Global Green Initiatives

2.2.1 Green Development

Green Development is a phrase used in many ways throughout the world. Often it is related to spatial planning and development, with an emphasis on the built environment, communities, and land use.[3] In this context it is implemented at a regional, landscape or urban spatial scale. There also are important specialized considerations such as the idea of Green Development Mechanism (GDM), brought forward in the context of finding improved international financial mechanisms for protection of ecological services and biodiversity. GDM would function as the ecological counterpart of the Clean Development Me-

[1] This is the ninth CCICED Issues Paper produced since 2002 for presentation at the Council's Annual General Meeting. Previous issues papers and other documents such as task force reports are available online at http://www.sfu.ca/international-development/cciced/contact.htm and http://www.cciced.net/encciced/. The Issues Paper is produced by the CCICED Chief Advisors, Dr. Arthur J. Hanson and Prof. Shen Guofang, and the Chief Advisors Group, and with inputs from others linked to the Council's work. It is an input to the Council and does not necessarily reflect the views of the Council Members or of CCICED

[2] *Our Common Future. Report of the World Commission on Environment and Development.* Oxford University Press

[3] Rocky Mountain Institute, Alex Wilson, et al. 1998. *Green Development: Integrating Ecology and Real Estate.* Wiley; US Environmental Protection Agency Smart Growth and Partnership for Sustainable Communities (with Dept of Transportation (DOT) and HUD, Housing and Urban Development) http://www.epa.gov/smartgrowth/index.htm

chanism (CDM) of the Kyoto Protocol.[4] And, very importantly, green development is implicit within the poverty reduction approach of the Millennium Development Goals (MDG), especially Goal 7 (Environmental Sustainability).

Others believe the term should be more broadly linked to sustainable development, placing emphasis on the market, regulatory and other instruments that will bring about a transformation to sustainability. The ideas of Green Growth and Green Economy, as promoted by the OECD, the G20 and some countries such as Korea[5] are consistent with this broader idea of Green Development. Indeed, Green Development should subsume Green Growth, Green Economy as well as Low Carbon Economy and Circular Economy when considered in the Chinese context.

Over the past year there have been a number of significant statements and initiatives relevant to green development. Some of the most significant are briefly reviewed below, with their ecological connotations.

2.2.2 "Growth-Friendly" and Green Growth Economic Recovery

A sense of optimism for green development arose in the aftermath of the 2008-2009 global financial crisis with the strong commitments made by the G20 and others to fueling the return to economic growth through environmentally-sustaining efforts such as renewable energy and innovations in industrial development. To some extent this spirit remains, and a variety of initiatives are underway. However, the momentum has been far from sufficient, as evidenced at recent global gatherings. Furthermore, considerable uncertainty remains about the future trajectory of economic growth and development in every part of the globe. China remains the leader in economic growth, and is considered among the top nations in terms of orienting stimulus spending towards environmental matters including vital shifts towards renewable energy such as solar and wind power. Some nations such as Korea[6], the USA and Germany are making major commitments towards Green Growth strategies.

2.2.2.1 G20 toronto summit june 2010 declaration

The recent Toronto G20 meeting was notable for its "growth-friendly" approach: "The G20's highest priority is to safeguard and strengthen the recovery and lay the foundation for

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[4] This idea has been developed for discussion at the Convention on Biodiversity Committee of Parties meeting in Nagoya in October 2010. See A. James and F. Vorhies. June 2010. *Green Development Credits to Foster Global Biodiversity*. Nature 465 (869). http://www.nature.com/nature/journal/v465/n7300/full/465869b.html

[5] See *Overview of the Republic of Korea National Strategy for Green Growth.* April 2010. UNEP. http://www.korea.net/detail.do?guid=46116

[6] UNEP. April 2010. Korea's National Strategy for Green Growth. http://www.unep.org/PDF/PressReleases/201004_UNEP_NATIONAL_STRATEGY.pdf

strong, sustainable and balanced growth, including strengthening our financial systems against risks." There was remarkably little detail on environment and development issues in the June 2010 G20 Declaration although the following statement was included: "We reiterate our commitment to a green recovery and to sustainable global growth". Also, taking into account the Gulf of Mexico oil spill disaster, that "we recognize the need to share best practices to protect the marine environment, prevent accidents related to offshore exploration and development, as well as transportation, and deal with their consequences". The G20 members also affirmed the need to continue working towards fossil fuel subsidy reductions where feasible to do so, and noted the need for renewed commitment to the UN Millennium Development Goals, and to establish a working group on development to be followed up at the Seoul G20 Summit in November 2010. There was no specific mention in Toronto of the commitments that might be needed to protect biodiversity or ecosystem services even though 2010 is an important time for focusing on this topic.

2.2.2.2 OECD green growth and UNEP green economy initiative (GEI)

At the May 2010 meeting of the OECD Ministerial Level Council the Interim Report of OECD on Green Growth[7] was discussed. Several key points were concluded by the Ministers:

"Green growth is gaining support across countries as a paradigm to bring about economic growth and development while responding to environmental challenges, such as climate change, biodiversity loss and unsustainable use of natural resources. We stress the importance of accelerating our shift toward green growth through cost efficient policies, with due attention to structural changes throughout the transition process and ensuring the necessary policy coherence. We are resolved to ensure that measures taken to pursue green growth are consistent with our international trade obligations. It is vital to encourage green innovation and worldwide diffusion of environmental goods and services as well as environmental technologies, including resource-and energy-efficient technologies, in both developed and developing countries…We acknowledge the importance of avoiding, removing or reforming policies that may undermine the transition to a green growth economy, such as environmentally harmful subsidies".[8]

In the next stage of work on OECD's Green Growth Strategy there will be an attempt to better understand green growth in relation to four priority challenges: "biodiversity and ecosystem services, climate change, sustainable materials management and sustainable use of

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[7] OECD. June 2010. *Interim Report of the Green Growth Strategy: Implementing our Commitment for a Sustainable Future.* http://www.oecd.org/document/3/0,3343,en_2649_37465_45196035_1_1_1_1,00.html

[8] http://www.oecd.org/officialdocuments/displaydocumentpdf?cote=c/min (2010)6/final&doclanguage=en

natural resources, including forests and water." However in the comprehensive Interim Report there is very little detailed consideration of either biodiversity or ecosystem services. This reflects the general focus of green growth on topics such as industrial pollution, technology innovation for addressing various industrial processes and infrastructure development, indicators, plus important financial topics such as tax and subsidy reform, and economic stimulus packages from an environmental impact perspective.

The Green Economy Initiative[9] of UNEP started as a response to the multiple crises of environment and economy and the need to redirect investment towards environmentally friendly initiatives within a range of sectors including "clean technologies, renewable energies, water services, green transportation, waste management, green buildings and sustainable agriculture and forests." "Initially envisioned as a two-year project, the GEI has been expanded to include a number of related UNEP and UN-wide initiatives focused on providing macroeconomic evidence for significantly increasing investments in the environment as a means of promoting sustainable economic growth, decent job creation, and poverty reduction." The main body of work under the initiative will be launched in December 2010, but numerous reports are already available.

2.2.3 UN Millennium Development Goals (MDGs)

At the UN General Assembly review of MDG progress in late September 2010, China's tremendous efforts were highlighted along with its willingness to share this experience. However, overall global progress is lagging, with the threat that the goals will not be achieved. Goal 7, Ensuring Environmental Sustainability, has been particularly difficult to achieve, even for China. The MDG 2010 National Progress Report for China indicated that Goal 7, Target 5 ("Loss of ecosystems, change of land use, and the unsustainable use of water are reduced") has been only partly realized, and for Target 7 ("Climate change and pollution no longer threaten biodiversity" no progress has been made.

2.2.4 Energy, Environment and Climate Change

At the G20 Toronto Summit the final Declaration noted that "Those of us who have associated with the Copenhagen Accord reaffirm our support for it and its implementation and call on others to associate with it. We are committed to engage in negotiations under the UNFCCC on the basis of its objective provisions and principles including common but differentiated responsibilities and respective capabilities and are determined to ensure a suc-

[9] http://www.unep.org/greeneconomy/AboutGEI/tabid/1370/Default.aspx

cessful outcome through an inclusive process at the Cancun follow-up to Copenhagen." However major differences still exist between nation groups, and therefore progress in international negotiations remains slow.

Fortunately, progress is happening at the level of individual countries. Low Carbon Economy has become a much more accepted idea throughout the world, including at the Shanghai World Expo where it was promoted by many nations through their national pavilions. China is now seen to be a key player in Low Carbon Economy innovation, especially through its efforts supporting wind and solar energy, electric vehicle development, and its various pilot efforts such as low carbon cities and sectoral initiatives. The role that ecosystems can play in carbon sequestration is getting increased attention in many countries including China.

2.2.5 Biodiversity and Ecosystem-based Management

In 2002 a commitment was made at the Johannesburg Earth Summit to stem the loss of biodiversity by 2010, and also to move towards ecosystems-based management of resources and environment. The progress on these goals has been assessed almost continuously since that time, especially via the conceptual effort of the Millennium Ecosystem Assessment (MA) and through action of the Convention on Biological Diversity (CBD). Biodiversity and ecosystems have been in the spotlight particularly at the October 2010 CBD Committee of the Parties Meeting in Nagoya, Japan. The news was not good. According to the 3rd Global Biodiversity Outlook, the global goal set in 2002 has not been met. The Outlook notes that:

"There has been insufficient integration of biodiversity issues into broader policies, strategies and programmes, and the underlying drivers of biodiversity loss have not been addressed significantly"… "There is a high risk of dramatic biodiversity loss and accompanying degradation of a broad range of ecosystem services if ecosystems are pushed beyond certain thresholds or tipping points"… "Most future scenarios project continuing high levels of extinctions and loss of habitats throughout this century, with associated decline of some ecosystem services important to human well-being".[10]

It is important to realize that many available improvements exist for policies, tools and mechanisms designed to protect ecosystems, ecological services and biodiversity. The root causes of why these improvements are not adequately applied need to be addressed. These causes include poor land and water use efficiency, ineffective market mechanisms and environmentally-perverse subsidies, limited application of multiple use and strategic planning,

[10] http://www.roap.unep.org/pub/GBO3-final-en.pdf

inequitable sharing of benefits, limited awareness of ecosystem and biodiversity values, reluctance of local and central governments to promote and enforce conservation measures, failure to provide adequate alternative opportunities for those engaging in unsustainable practices, and limited participation by private sector interests.

There are other problems as well. Certainly a lot more attention is being paid to creating ecosystem-based management (EBM) of natural resources and environment. Yet the efforts have had rather limited success. This has particularly been the case with the oceans, where most fisheries management takes place using analytical methods that generally rely only in a limited way on ecological knowledge. The global trend is towards EBM in words but with the reality that successful implementation is limited.

Another looming concern is climate change and its impact on ecosystems, biodiversity and ecological services. Ecologists speak in terms of vulnerability and resilience. Others often place emphasis on climate change adaptation—whether speaking of human activities or of ecosystems and species. As forests of one type die off from disease, fires or pests linked to climate change, other species will colonize and new ecosystems become established. Climate change has important implications not only for ecological services but also for the direct impacts on people and economic activities, including those associated with natural disaster magnitude and frequency. Grim projections exist for the oceans as a consequence of ocean acidification, effects on ocean productivity (especially phytoplankton) and of shifts in ocean currents.[11]

The WWF regularly publishes *The Living Planet Report* which establishes the level by which **humanity's demands exceed our planet's capacity to sustain us. It is based upon available biocapacity and the overall ecological footprint of all nations. The 2010 Report indicates that it would take 1.5 Planet Earths to support our current level of demands on a sustainable basis.**[12] **In other words, we are in a serious ecological deficit situation. This deficit is not evenly distributed. The largest deficits occur in the financially well-off parts of the world. China, while still having a relatively low per capita ecological footprint, has crossed-over into a deficit situation and in 2007 would require the equivalent of 2.2 China's to provide for its consumption of food, timber and fibres.**[13]

This brief overview of a biodiversity and ecological future fraught with relentless challenges arising from human activities and from the unraveling of natural cycles is both frigh-

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[11] Alanna Mitchell. 2009. *Sea Sick: the Hidden Crisis in the Global Ocean.* University of Chicago Press

[12] *2010 Living Planet Report.* WWF International. Released October 13, 2010. http://assets.panda.org/downloads/lpr2010.pdf

[13] *2010 China Ecological Footprint Report*. WWF China and CCICED draft report

tening and inequitable in terms of the consequences for ecological services. It is the poor within societies that are likely to pay the greatest price, and it is some of the most fragile ecosystems and their associated biodiversity, such as certain deserts, coastal and lake wetlands, coral reefs, and permafrost that are most vulnerable. The most fragile of ecosystems often have important supporting and regulating functions, even if their direct economic benefits appear relatively low.

2.2.6 International Progress on Ecosystems and Green Development

In almost no field of ecosystem protection is adequate progress being made, especially for many of the developing countries and for areas of the global commons. Green development is not yet fully embraced or operational. The following five points are important conclusions about the current state of progress.

(1) ***Green growth focuses most attention on pollution control, energy use, and environmental infrastructure rather than on dedicated strategies for protecting ecological services and ecosystems.*** With the continued uncertainty regarding global economic recovery and the late stages of economic stimulus, there is considerable reluctance for making the new investments still needed for national transitions to Green Economy and Green Development strategies and action. However, there are exceptions, including China and Korea, Brazil, parts of Europe and North America. But definitely the hoped for shifts to new engines of growth have not been without problems and the transition is very slow. Furthermore, the impacts of stimulus funding have included rising demand for energy in order to produce steel and cement for infrastructure (China), significant environmental impacts from funded projects (many countries); biofuel production rises have led to continued demand on forest land conversion for palm oil (Southeast Asia). Globally, environmental targets are not being met, with the two most important goals—climate change mitigation and biodiversity preservation—being further than ever from being met.

(2) ***Ecosystem-based management (EBM) is being incorporated into natural resource and environmental strategies at national levels throughout the world, but with limited success generally.*** It may be unrealistic to expect that EBM can become accepted and workable for all situations in the short run. But the consequences are that many ecological services are at risk, and that systemic failures will occur in river basins, regional marine and coastal ecosystems and other threatened ecosystems. A significant danger is that tipping points will be reached as ecosystem integrity is reduced to the point where there are sudden detrimental changes. The replacement of predatory fish in the seas by simpler ecosystems dominated by jellyfish is an example. Desertification of grasslands is another.

(3) ***Green Development demands healthy ecosystems delivering diverse services.*** If ecosystems are in a state of decline, then development will be unsustainable since environmental conditions, and longer-term economic growth and social well-being are threatened. There have been many wake-up calls about ecological decline, and regrettably in the years ahead we are likely to witness more. Pakistan's floods, the harsh drought in China's southwest in early 2010, the forest fires in Russia and the oil spill disaster in the Gulf of Mexico demonstrate the challenges faced in maintaining healthy and productive ecosystems, and in guaranteeing the services of nature that safeguard our existence.

(4) ***The transitions to new policies, tools and mechanisms appropriate for green development are still at an earlier stage than they should be.*** As the global economy struggles to regain its lost ground there is a danger that opportunities will be lost for fundamentally restructuring the relationship between ecology and economy. If that happens, then necessary transitions will be very difficult to achieve in any country. More rapid progress over the coming five years is essential.

(5) ***Many decision-makers and scientists have expressed particular concern over the fate of coastal areas and seas.*** These areas are facing particularly difficult challenges including damage from the cumulative effects of overdevelopment near cities, coastal ports and sea traffic, offshore development, overfishing and loss of coastal natural habitats, land-based sources of pollution and the very serious threats arising from climate change. While the most dramatic current example has been the Gulf of Mexico oil spill, the pressures on marine ecosystems is widespread, including most parts of Asia.

2.3 China's Green Development

2.3.1 Building Blocks for Green Development

China is in the fortunate position of being able to proceed with ambitious environmental goals attached to its financial stimulus effort, and also with its longer-term efforts to address its ecological-environment issues. For example, China expects to have a National Biodiversity Strategy and Action Plan covering the next two decades in place this year. The country continues to invest in environmental improvements at an unprecedented level as it proceeds with its economic and social development. Last year CCICED proposed that China should embrace the concept of Low Carbon Economy. And a half decade earlier, CCICED highlighted the need for promotion of Circular Economy. These ideas have been accepted and are being implemented in ways that are drawing the world's attention. They are building blocks for Green Development.

Stewardship of its natural heritage is not a new theme in China, and important gains have been made in the last two decades. These gains have been especially important in re-forestation, grasslands conservation and the institution of new environmental management approaches such as functional ecological zoning in some coastal waters, restoration of wet-lands, biodiversity protection including both species and habitat, efforts to set aside more than 15% of China's land and freshwaters as nature reserves, pollution control, and urban green space development.

But there is a disturbing sense that no matter how much effort and money has been spent on these and other initiatives, China's green development still lags behind the "brown" and "black" development which leaves polluted rivers and soils, and degraded ecosystems throughout the country. The services provided by nature are under ever-greater threats, in-cluding those from so-called non-consumptive activities such as recreation and tourism, and from the rising levels of material consumption that accompany rising income levels in China. In other words, the ecological debt being incurred through today's rapid development in China is on the increase. As well, the rise in China's ecological footprint has implications for vulnerable ecosystems throughout the country and for the rest of the world.

2.3.2 Green Development Strategy

The Minister of Environmental Protection (MEP), Zhou Shengxian, has outlined "China's New Road for Environmental Protection" based on shifting the relationship between environment and economy to become much more positive, and based on green economy, investment and development.[14] Green development should nurture ecosystems and protect their associated biodiversity. It should incorporate principles of green economy such as elimination of environmentally perverse subsidies, and should embrace policies for functional zoning, habitat protection, strict development supervision and other means of ecological spatial planning, management and restoration.

There are many more sectoral, local and national considerations to be taken into account in understanding the dynamics and significance of ecological changes. Hu Angang, a leading scholar and commentator on China's economy and environment relationship, believes that the peak of decline in the country's natural capital occurred in the early 1980's at a cost equivalent to almost 30% of GDP, but also that the situation has improved since that time, although still unacceptably high, at around 5% in 2001 and perhaps much lower now.[15]

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[14] http://english.mep.gov.cn/Ministers/Speeches/201007/t20100707_191840.htm

[15] See China Dialogue 26 June 2006. http://www.chinadialogue.net/article/show/single/en/134-Green-development-the-inevitable-choice-for-China-part-one

However, these figures mask a grim reality. The apparent drop in natural capital loss using the GDP measure is probably a statement of China's dramatic GDP increase during the 30 year period rather than of ecosystem health. Therefore Hu Angang and others have called for a Green Development approach to be followed consistently across the many sectors of the economy and in national level guidance.

Within China the 2002 UNDP China Human Development Report, 'Making Green Development a Choice', provided valuable insights into the definition of Chinese green development. The Report suggested that "Green development stresses unified and harmonious development of the economy and environment, a positive path of people-centered sustainable development." Nine elements were proposed (Box 2-2). All of these concepts are in one form or another important policy approaches in China today. But they have not yet fully arrested ecological decline.

In addition the UNDP Report recommended the following actions: (1) take advantage of the market mechanism to put forward integrated environmental and economic policies; (2) institutional innovation to establish a cooperative and interactive mechanism between government and the society on common action needed to protect the environment; (3) develop green industries and green consumption; and (4) take the environment into full account in technical innovation. Considerable progress has taken place on each of these points since 2002. However, the pace of economic growth has been even more rapid than their implementation.

Box 2-2 Nine Green Development Elements for China (UNDP China Human Development Report, 2002)

1. Effective control of population growth;
2. Raise per capita income level and improve income distribution and reducing poverty;
3. Increase efficiency of water use; effective water pollution control and restoration of water ecology;
4. Provide strict protection of arable land and guarantee the amount of arable land under cultivation;
5. Seek sharp rise in energy utilization rate and further reduce coal's proportion in energy consumption;
6. Reduce CO_2 discharge and provide effective control of air pollution in cities;
7. Improve the ecological system; increase forested area; and expand timber standing stock;
8. Restore degraded grassland and expand protection of water and soil from loss and erosion;
9. Strengthen national natural disaster safety net; establish emergency response and rescue system.

The continued effort that will occur during the 12th Five Year Plan and beyond should bring about quite dramatic mid-term progress. By gaining valuable experience of new approaches to environmental management and, because its economy has continued to prosper, China can invest significantly in environmental improvements at the same time as its economic and social development. Therefore, green development is not only a feasible path but a necessary one since otherwise China's economic advantages will be curtailed or even overwhelmed by environmental problems.

2.3.3 Green Development and Ecological Civilization

Chinese leaders, including President Hu Jintao, have called for patterns of development that can lead to an "Ecological Civilization". While this highly aspirational goal may seem very difficult to achieve in the short run, it is a very proper and essential goal for longer-term prosperity and quality of life. It will be the outcome of societies that can successfully implement development that cares for the environment and recognizes—even enhances—the value of services provided by nature. Ecological Civilization will require a comprehensive and transformative approach to green development where there is:

(1) Protection and enhancement of ecological services;

(2) Consumption patterns that maintain low to moderate ecological footprints;

(3) Healthy ecosystems that can provide for healthy communities and healthy people, sustainable economic growth and livelihoods.

Even though these three points are well recognized at present by national and provincial level governments, there are significant tug of wars between these needs and those of short-term development goals that carry a heavy ecological price tag.

2.4 Ecosystems and Ecological Services in China

2.4.1 Ecosystem Services Today and in the Future

The 2005 Millennium Ecosystem Assessment (MA)[16] concluded that Nature's Services are vital and save costs otherwise incurred directly in economic development, and that sometimes these services are irreplaceable at any cost. A notable effort to quantify the value of ecosystems, their associated biodiversity and the services provided is the UN-

[16] http://www.millenniumassessment.org/en/index.aspx

EP-sponsored TEEB (The Economics of Ecosystems and Biodiversity) study.[17] The study leaders believe that the ratio of benefits of conserving ecosystems or biodiversity compared to the costs of doing so range from 10:1 to 100:1. The old expression that "an ounce of prevention is worth a pound of cure" thus holds for ecosystem health as well as for public health and other risk-based concerns. It is sensible to enhance and protect natural capital so that Nature can continue to work on our behalf.

Chinese ecosystem services, like those in many other countries have been subject to monetization exercises, based on various methodologies such as those pioneered by Robert Costanza.[18] Chen Zhongxin and Zhang Xinshi calculated the total value of 17 categories of ecosystem services in China to be 77 834×10^8 *yuan* per year.[19] They indicate this to be about 1.7 times China's 1994 GDP. And the total ecosystem services of China contribute 2.7% of the planet's total. The breakdown of these services are: 72% from terrestrial ecosystems and 28% from marine ecosystems. Forests contribute 20% of the services, grasslands 11%, wetlands 34%, and coastal ecosystems are 16%. These values are from the end of the last century. Since that time there has been much more attention has been paid to carbon storage as an ecological service, which might change some of these values significantly. Overall, any gross national compilation of ecological services must be viewed with caution, since such services often are underestimated, and some really cannot be accurately monetized.

Ecological services in China and elsewhere are best understood by following the logic of the MA and TEEB. Most fundamentally, a society requires livable conditions that are ecologically controlled. The ecological goods and services are of two basic types: Provisioning and Cultural Services that provide goods required in society or cultural benefits; and Supporting and Regulating Services associated with ecosystems and habitats (Figure 2-1) There has been a tendency worldwide to pay more attention to, and to invest in provisioning services. These generally are services for which economic values can be assigned and a great deal is known about how to maintain them, even though often they can decline due to overexploitation or for other reasons. Often supporting and regulating functions are not assigned credible economic values, or they are neglected, or poorly understood.

There is a major dilemma in terms of the relationship between these two fundamental categories of services (TODAY in Figure 2-2). Both international and past Chinese experience suggests that placing high demand on ecosystems for provisioning services leads to a decline in supporting and regulatory services, especially those which are difficult to value in

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[17] TEEB, The Economics of Ecosystems and Biodiversity http://www.teebweb.org

[18] Costanza, R., et al.1997. *The Value of the World's Ecosystem Services and Natural Capital.* Nature, 387: 253

[19] Chen Zhongxin and Zhang Xinshi. 2000. *Value of Ecosystem Services in China*. Chinese Science Bulletin, 45 (10): 870-876

economic terms. But China is at a stage where it is essential to use many of its ecosystems at high levels of intensity. Therefore the key future need is to change this relationship between these types of ecological services (FUTURE in Figure 2-2), and also to restore or prevent degraded ecological conditions. It is the basic challenge facing environment and economy, and the success of green development.

Figure 2-2 requires some further explanation and examples. Ecosystems range from those that are still largely in natural condition to those which are seriously degraded, for example some of the badly eroded landscapes of the Loess Plateau, or seriously polluted lake ecosystems. Many of China's ecosystems are very intensively used, including rice fields, aquaculture ponds and heavily fished ocean areas. But many areas are used either episodically or at a relatively low level of intensity, for example some grazing lands and reforested areas.

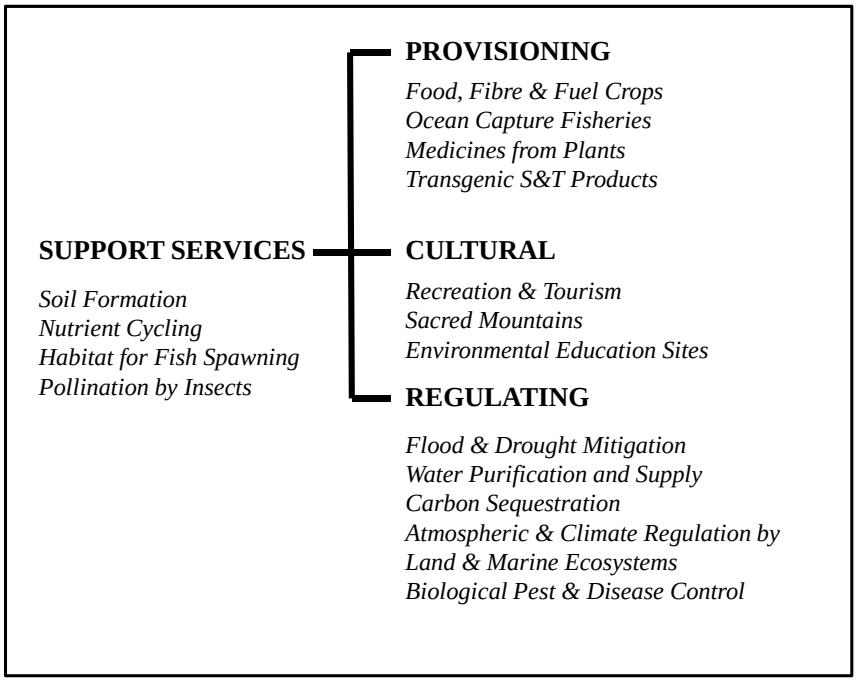

Figure 2-1 Types and Examples of Ecological Services

Source: Adapted from Millennium Ecosystem Assessment and other studies.

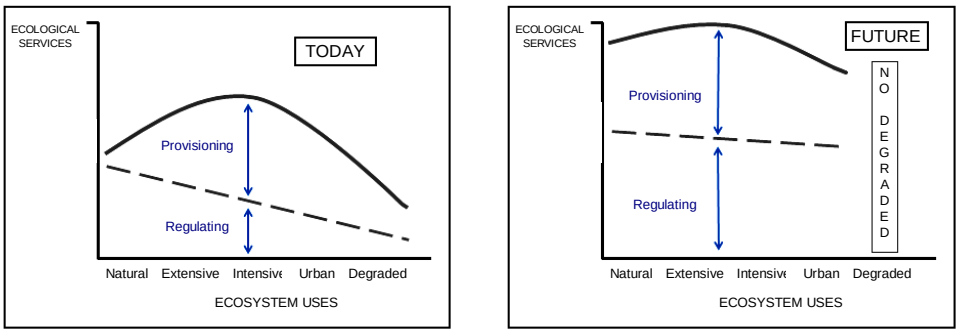

Figure 2-2 Ecological Provisioning and Regulating Services for China – Today and in the Future

Source: Modified and further interpreted from CCICED Ecosystem Task Force scenario modeling.

Given the demands on all resources in China, it is likely that the shift in the past decades has been to the right on the horizontal axis, with more lands under intensive use and some new sources of degradation (e.g., due to pollution) even as government programs seek to reduce the amount of degraded lands. The important point is that maximum provisioning benefits come about through intensive land use. However, the tendency is for supporting and regulating ecological services to decline with human use. The decline is particularly marked, of course, in the case of degraded ecosystems, but loss of these ecological services generally is considerable for intensively used ecosystems such as those related to agriculture and forestry. The Yangtze River Great Flood of 1998 damage is an example.

For China to improve its situation in the future will require actions that will run quite contrary to international experience. It is a reality that China will require even more intensive use of at least some of its terrestrial and aquatic ecosystems, given the growing size of its population and the proposed increases in domestic per capita consumption. Thus the curve for various provisioning ecological services will rise. Some of these services will be related to tourism and other cultural needs, but they will also include increases in food supply such as meat and fish products, which are environmentally-demanding. But the need is for structural and regulating ecological services to be enhanced rather than reduced, including in ecosystems that currently are extensively or intensively used, or are in a degraded condition. Also, ecosystems are in urban areas.

The challenge for China then is not only to recognize and enhance the protective ecological services from natural ecosystems, but also to raise their value in the other types of ecosystems. This will mean restoring existing degraded areas in ways that ensure their ecological functions and biodiversity are returned to better condition, and preventing the forma-

tion of additional ecologically-degraded areas. And it will require an unprecedented commitment and shift to ecologically-sound resource use and environmental practices throughout the full range of China's ecosystems, whether these are committed to agriculture, grazing or forests, extractive industries, urban and suburban land use, industrial areas or in China's mountains, deserts and seas. Only in this way can there be a truly sustainable and systemic safeguarding of China's ecological services.

There are a number of implications of China's current focus on green development for improvements in ecosystem management and ecological services[20]. One is the funding of payments for ecological services (PES), called eco-compensation mechanisms in China.[21] These have blossomed into a variety of initiatives, although it cannot be said that they either form a comprehensive system, or are functioning in an optimal fashion yet. The second point is the massive investment in science and technology research and development, especially related to energy efficiency and renewable energy, but extending into many other areas including ecologically sustainable agriculture, the extensive ecosystem research network (CERN) supported by the Chinese Academy of Science[22], and the growing support for climate change ecological initiatives. However, these efforts are still not sufficient to address the great need for transformative thinking and action in the overall relationship between rapid economic growth and sustainable ecological needs that is the most critical aspect. Without fundamentally altering what has become a paradigm of excessive ecological cost to sustain current economic growth levels, long-term decline in both economy and ecology is likely.

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[20] Numerous recent studies have been undertaken concerning China's Ecological Services and their value. See, for example: Biao Zhang, Wenhua Li and Gaodi Xie. 2010. *Ecosystem Services Research in China: Progress and Perspective*. Ecological Economics 69 (7): 1389-1395; UNDP China Website – Biodiversity and Ecosystems Services. Projects. http://www.undp.org.cn/modules.php?op=modload&name=News&file=article&catid=11&sid=396&topic=22 Millennium Ecosystem Assessment. *Integrated Ecosystem Assessment of Western China.* 128 pp. http://www.millenniumassessment.org/documents_sga/Western%20China%20SGA%20Report%20 (English).pdf; ESPA. 2008. *China Ecosystem Services and Poverty Alleviation Situation Analysis and Research Strategy*. Final Report to DFID. 84 pp. http://www.nerc.ac.uk/research/programmes/espa/documents/Final%20Report%20China%20-%20annex.pdf; Chen Zhongxin and Zhang Xinshi. 2000. Value of Ecosystem Services in China. China Science Bulletin 45 (10): 871-876; C.Y. Jim and W. Chen. 2009. *Ecosystem Services and Valuation of Urban Forests in China*. Cities 26 (4): 187-194; Jianguo Liu, Shuxin Li, Zhiyun Ouyang, Christine Tam, and Xiaodong Chen. 2008. *Ecological and Socioeconomic Effects of China's Policies for Ecosystem Services.* Proceedings of the National Academy of Sciences USA 105 (28): 9477-9482. http://www.pnas.org/content/105/28/9477.full.pdf+html

[21] Michael Bennett. 2009. *Markets for Ecosystem Services in China. An Exploration of China's 'Eco-Compensation' and Other Market-Based Environmental Policies*. Forest Trends. http://www.forest-trends.org/publication_details.php?publicationID=2317

[22] Shenggong Li, Xiubo Yu, Ping Yang, Guirui Yu, Renguo Feng and Xuliang Zhuang. 2010. *Chinese Ecosystem Research Network: Progress and Perspectives.* Ecological Perspectives. 2010, 7 (2): 225-233

2.4.2 China's Ecosystems Under Pressure

China's ecosystems are under serious pressure and sometimes growing threats. These are not new findings. Indeed there has been a remarkable effort over past decades to address some of the key problems, which has been partially successful in restoring landscapes and in protecting at least some of the iconic species such as the Giant Panda. In recent years the unprecedented investment in new forests, grassland restoration, and in river basin management has demonstrated that ecological restoration and ecological construction can be successfully undertaken. The tremendous commitment to setting aside nature reserves to the extent that some 15% of China's lands now have such a designation is a major achievement. The marine and coastal areas also have received attention, for example in cities such as Xiamen and Dalian, and in the designation of some marine protected areas, and through conservation measures such as the closure of all fisheries during spawning season in parts of the Yellow Sea.

Rapid economic growth over the past 30 years has brought about severe decline in ecosystem conditions in many parts of China, even with the major efforts to reduce damage. Much of this damage has shifted from local situations to become systemic problems. An important example is the cascading effects from the flow of nutrients off agricultural fields and from other sources such as automobile emissions into China's rivers, lakes and groundwater, then eventually to the estuaries and the sea, causing red tides and green algal blooms of great proportion and economic damage. The signs of systemic damage related to climate change are widespread, for example, in the shifting patterns of water availability for maintaining ecological services. New problems are being uncovered, especially widespread extent and types of soil pollution. Soil health is essential to human health and for maintaining the biogeochemical cycles of nutrients that underpin all terrestrial and many other ecosystems, including agricultural systems.

China's ecosystems are remarkably diverse and include the world's highest alpine conditions including ice fields, permafrost and major peatlands; some of the longest and most complex riverine ecosystems and associated lakes; tropical, subtropical and temperate zone ecosystems on land and sea; many islands; and a wide range of forest and grassland areas. China's agro-ecosystems are quite unique in terms of their diversity, and in the intensity of use and, in many cases, their antiquity and persistence. China is a mega-diversity country, with tremendous species and genetic diversity of global significance for many reasons.

Even in areas of low population density, such as the Tibet-Qinghai Plateau ecosystems and biodiversity can come under severe pressure. The biodiversity of the Plateau is under

considerable pressure not only from ecosystem changes but also from the direct actions of people, including overharvesting of medicinal species for specific high demand products in China (e.g., grassland damage on highland slopes during harvest of the caterpillar fungus which grows from the body of the larvae of the ghost moth) or to meet market demand for natural products abroad (e.g., Shahtoosh wool taken by hunting Tibetan antelope—the Chiru). The plateau pika is a small borrowing mammal in the Tibetan-Qinghai Plateau grasslands and high alpine desert. It is considered to be a keystone species, essential to the functioning of these ecosystems, aerating the soil of alpine meadows which contributes to plant species diversity. These pikas are an important food source for carnivores, and their burrows are inhabited by other species including birds and lizards. But the pikas are subject to mass control programs (by poisoning) since they are considered a pest in competition with grazing livestock. It is believed that populations are in decline.

China's ecological restoration and environmental protection efforts have included declaring large areas of the Plateau as Nature Reserves, including the massive Chang Tang Wildlife Reserve (an area the size of the State of New Mexico in the USA), part of the Central Tibetan alpine steppe eco-region which extends to the northeast as far as Qinghai Lake. Early activities such as the Household Restoration Program (HRP) were implemented in the 1980s with the idea of privatizing grazing lands through long-term grazing rights. The *Tuimu Huancao* program implemented in the mid-1990s and updated since then addresses grassland degradation by rotational grazing, and temporary or permanent grazing bans. These measures can lead to permanent resettlement, for example, in the Three Rivers Nature Reserve (*Sanjiangyuan*) in the headwaters of the Lancang (Mekong), Yellow and Yangtze Rivers. It is also important to recognize the significance of these programs in helping to lift millions of people from extreme poverty but at least some of the benefits may not be sustainable due to the gradual, continuing degradation of the grasslands and other ecosystems.

Despite concerted efforts, especially in the last decade, ecological restoration and protection efforts in this plateau do not appear to be succeeding to the extent needed. Thus the ecological services within this region are still vulnerable, with implications not only for the sustainable development of the region but also for national ambitions such as the further industrialization and expansion of other economic activities into the western region of China, and for water security, health of ecosystems and of communities, and level of economic activities in other parts of China, especially in the high population Yangtze and Yellow River Basins.

The population of China is highly dependent upon ecosystems not only for direct economic reasons, but also for cultural, spiritual, recreational needs, and for meeting life's daily

needs. Of these daily needs, water supply is the most essential, since the per capita availability of freshwater is far below the global norm. But access to land for the variety of needs in a modern economy is quite limited, especially in the coastal areas. Thus land reclamation and filling of coastal estuaries and bays is commonplace, even though it comes with a high ecological cost. The accumulation of wastes associated with the export economy of recent decades, the expanding nature of cities, and the interurban road, rail and other infrastructure places heavy demands on land and water resources, the ecosystems and wildlife. Construction of dams, coal mining and other extractive industries, even the massive effort for wind power and other renewable energy carry a significant ecological price tag. Indeed, at the moment there are no good calculations of just how large the overall price tag of ecological damage is likely to be. It will be a burden for future generations, and it is not certain how much of the damage will actually be irreparable, leading to option foreclosure in some areas including tourism, aquaculture and other economic ventures.

2.4.2.1 Forests and grasslands

The future ecological health of China depends on how well forest and grassland ecosystems are managed. These two main types of terrestrial ecosystems cover 20% and 42% of China's lands, respectively. The loss of forests in China started thousands of years ago, but accelerated during the last two hundred years, and especially over most of the 20th century. Over the past three decades, an impressive recovery has occurred, and China now is the leading nation in the world for reforestation. The targets for forest cover have been set at levels that will eventually see at least a quarter of China's lands in forest before mid-century. Restoration of grasslands has been much more problematic. Many continue to be overgrazed, or otherwise degraded. In spite of significant investment, the actual level of restoration remains relatively low. The programs are hindered by a number of factors: poor technical inputs including lack of specificity for local ecological conditions and limited local interest on the part of some communities, and the vast scale of the problem.

Certainly during the past 15 years a great deal of forest and grassland improvement has taken place in the organization of the key programs such as Grain for Green, Natural Forest Protection Project, and other eco-compensation activities.[23] These programs have multiple objectives, but are particularly focused on restoring ecological functioning and environmental protection purposes for watersheds. They also provide eco-compensation for low income farmers who otherwise might be carrying out marginal activities that would further degrade these watersheds. Thus the programs should be considered as among the most significant

[23] These programs and other information on forests and grasslands, including scenarios of future conditions under various assumptions are covered in some detail in the report of the CCICED Task Force on Ecosystem Services and Management Strategy

elements of Green Development in China, and indeed the world, at the present time.

The issue is how to increase their efficacy. For, while these restoration efforts are billed as ecological construction, they often resemble agricultural crops more than natural ecosystems. Many of the forests are plantations; grasslands bring in a limited number of species; and the carbon sequestration and nutrient and water capture in these ecosystems is sometime quite low. Most are not devised to optimize biodiversity conservation. It can be argued that it is important to start somewhere, and so, if the initial results are not as good as would be desired, these constructed ecosystems are at least somewhat better than the eroded and degraded landscapes they replace, and they set the stage for later efforts that can further improve ecosystems, including biodiversity. This may be an expensive and very long-term approach. It is clear that the process must be carried out in an adaptive fashion, similar in some respects to what has occurred in the USA (conservation reserve land management programs) and in Europe (multifunctional rural land management).

The range of incentive programs already available in China is remarkably comprehensive, with many designed on market-based principles.[24] While some initiatives have been worked out at a national level, others have a very significant provincial or municipal basis (Beijing-Tianjin Sandstorm Source Control Program). Since China is placing considerable emphasis on Payments for Ecological Services (PES) in which beneficiaries are expected to provide compensation to those, often poorer, jurisdictions where ecological improvements are needed. An example is the Dong River headwaters in Jiangxi Province which are being protected to provide reliable urban water supplies to Hong Kong and parts of Guangdong Province. While the principle is good, the reality is that fiscal transfers are often difficult to work out. Thus the central government has important roles in design, as the senior source of funds, and for mediation and regulation among the various interests. Standards for eco-compensation have not been formulated. Therefore there really is not a national system in place.

China has developed monitoring programs concerning the implementation of its forest and grassland programs, but these do not appear to fully address biodiversity or some other important considerations of ecological service functions. One of the most important of these considerations is the storage of carbon. This will be important in the future since carbon credits related to both forests and grasslands could be of major economic significance to China.

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[24] M.T. Bennett. 2009. *Markets for Ecosystem Services in China: An Exploration of China's "Eco-compensation" and Other Market-Based Environmental Policies.* Forest Trends and the Katoomba Group, Washington, DC. 86 pp.; Liu Guiyuan, Zhang Huiyuan and Wan Jun. 2008. *Chinese Policies and Practices Regarding Payments for Ecological Services in Watersheds.* Chinese Journal of Population Resources and Environment 6 (1): 36-43

It is feared that some of the lands currently believed to be carbon sinks may in fact become carbon sources, depending upon management practices and the continuity of conservation funding.

Despite these problems, China is making considerable progress on its forest and grassland problems, and there will be more success in the years immediately ahead. However many of the programs are at a level of maturity where it is necessary to consider redesign for broader ecological goals, and for greater effectiveness in implementation. The programs also will benefit from co-management arrangements with local communities, especially to ensure adequate distribution of benefits and to build initiatives compatible with local knowledge and interests.

2.4.2.2 Ecological role of water

Water concerns have been central to China's economy and to the well-being of its citizens for many centuries, with the result that historically its water engineers have been revered for their accomplishments such as the Grand Canal, and its farmers for their remarkable sculpting of mountainsides into paddies, and their development of integrated aquaculture systems. The harsh reality is that China has a remarkably low per capita availability of water to meet all needs, including those of its ecosystems, and that the water resource is maldistributed, generally with abundance in the South and scarcity in some semi-arid regions of the North. The potential exists that water conditions can be changed, for example, the unusual drought that afflicted parts of southwest China such as Yunnan in early 2010. And all too frequently there are floods and extreme storms, such as those in western China associated with the monsoon of 2010.

Western China in general is a region of great significance from a water ecological perspective, especially the Tibet-Qinghai Plateau. This vast region of China holds a great number of fragile ecosystems vital to the ecological services not only of China but of many other countries in Asia. It is with good reason that the region is called the Water Tower of Asia, with so many major rivers rising from it. The Plateau is also remarkable for its plant and animal biodiversity, for the great extent of bogs, peatlands, lakes, permafrost, glaciers and snowfields. And of course it is one of the most significant areas of China's grasslands. All of these ecosystems are under stress—from overgrazing caused by historically high levels of livestock and the shift to sedentary grazing; from the impacts of infrastructure development such as highways, and from extractive industries since the region is rich in minerals. Stresses related to climate change are well documented and are likely to increase over this decade, perhaps including fundamental changes in the pattern of monsoons, and in water flows. Whatever happens to ecosystems in the Tibet-Qinghai Plateau will be felt in downstream regions.

The World Bank recently published a very useful report on policy needs to address China's water issues.[25] However this report failed to provide much information on the ecological role of water in China, and how such needs can be met. It is estimated that only about 2% of China's water use is allocated to meeting ecological needs. In other parts of the world these ecological needs are highlighted as a major element of water management. For example, Canada has indicated that it does not have surplus water to export to the USA because of the amount required to meet domestic ecological needs. Of course these natural systems in turn provide ecological services to Canadian society—and benefits to other countries as well. Groundwater is replenished, forested watersheds stabilize water levels in rivers and lakes, and clean water is provided by filtration through healthy, intact ecosystems. Much of the available water is taken up for agricultural use in wheat, canola and production of animals, with the resulting agricultural crops then exported with a large component of "embedded water".

2.4.2.2.1 Vulnerable aquatic ecosystems and diminishing services

China has many vulnerable aquatic ecosystems including lakes, rivers and wetlands around the whole of the country. Particularly in the large cities and their surrounding areas, groundwater levels are dropping; in the countryside some aquifers are under threat either by water drawdown or from pollution. The efforts to address these problems are on-going but only partially successful to date. For example, the 2008 State of the Environment Report reveals that only about 55% of some 400 monitored sections of 200 rivers were of Class I to Ⅲ quality.[26] Below these levels pollution is moderate to extreme such as in the Yellow, the Huaihe and Haihe rivers. Taihu, the third largest freshwater lake in China, continues to experience major algal blooms and severe levels of pollution as a result of untreated sewage and industrial wastes.

Major efforts have been undertaken to address the problems, including diluting the pollution by diverting more water into it from the Yangtze River (Changjiang), and by expensive investments in pollution control equipment. Part of the problem has been administrative barriers between the two provinces and one municipality (Shanghai) in which the lake is located, for example between pollution sources in the upper level of the lake and lower reaches. Eco-compensation efforts are perceived to be one potential solution, and there are calls for a central commission to coordinate action on Lake Taihu. The two freshwater lakes larger than Taihu are located in the central Yangtze Basin—Lakes Dongting and Poyang. These lakes have extensive floodplains containing extremely important wetlands. Lake

[25] Xie Jian, A. Liebenthal, J. Warford, J. Dixon, Wang Manchuan, Gao Shiji, Wang Shuilin, Jian Yong and Ma Zhong. 2009. *Addressing China's Water Scarcity: Recommendations for Selected Water Resource Management Issues.* World Bank, 198 pp

[26] http://english.mep.gov.cn/standards_reports/soe/soe2008/201002/t20100224_186070.htm

Poyang through its "Mountain-River-Lake Development" has become a fair success story that is well studied and reported.[27]

There are many scientific stories of ecological change in the unique aquatic environments of the western region of China. One of the most puzzling has been the declining condition of Qinghai Lake, the largest inland saline lake in China, and location of one of the most important migratory bird sanctuaries in the country. Qinghai Lake would appear to be one of the barometers of ecological change, including impacts of climate change, and of grazing pressures. The lake level has declined substantially in depth, with areas of the surrounding lands desertification. Yet in this past five years the water level has risen (70 cm over that time after a drop of 370 cm between the 1950s and 2004), perhaps due to increased rainfall or reforestation efforts. This shift highlights the need for a much greater understanding of causal factors for ecological change in these ecologically sensitive systems. In the case of Qinghai Lake and other parts of the Qinghai Plateau there have been very ambitious efforts on the part of both the national and local administration to address ecological restoration.

2.4.2.2.2 Integrated river basin and ocean planning

After the Yangtze floods in the 1990s China's "32 character policy" was instituted.[28] The policy sets out actions intended to protect vulnerable ecosystems, communities and economic activities by restoring steep slope forests, wetland restoration, improving river works such as dredging and reinforcing embankments, and through the logging ban in many forested areas. In 2005 CCICED suggested adopting the "Living Rivers" concept for China's Yangtze River. This idea, linked to WWF's worldwide efforts on river ecology is gradually being adopted through the Yangtze Forum on Protection and Development. This Forum operates via the Changjiang Water Resources Commission (CWRC)[29] with a focus on Integrated River Basin Management.

Despite many good intentions, the challenges of applying integrated river basin planning in China are great. The Changjiang Commission and other efforts such as the Yellow River Conservancy Commission (YRCC) appear in theory to be ideal solutions. For example, the YRCC has some 40 000 staff including some 10 000 engineers and scientist. And 16 departments and 17 bureaus are involved. One of the key concerns is simply to ensure that water in the Yellow River (Huanghe) reaches the oceans. Yet to do this requires a number of

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[27] Lake Poyang http://www.adb.org/Documents/Books/Water_for_All_Series/Water_Poverty_Realities/Mountain_River_Lake.pdf

[28] http://assets.panda.org/downloads/mrwyangtzecasestudy.pdf

[29] The CWRC is one of seven river basin commissions under the Ministry of Water Resources. They work with the Ministry of Environmental Protection and with other ministries and local authorities and various public bodies and other organizations such as WWF who are "stakeholders" in water use

laws and technical measures for water allocation, and the development of improved water markets and pricing systems and water right transfers. The water pollution reduction and ecological restoration issues (including the Loess Plateau) are massive. Many of these efforts are linked to flood and drought control but they include a broader set of restoration goals that should help with maintenance and improvements of biodiversity in the uplands and in former wetland areas and in the Yellow River delta, where many more bird species and rare animals are on the increase.

The CWRC has noted the lack of environmental and ecological concern in relation to Yangtze water resource management, and the strong need for both real time and operational water resource management, and integrated approaches. This requires a very broad base of knowledge for prediction and assessment, especially for a basin where massive engineering initiatives such as the Three Gorges Dam and the South to North water diversion dominate decision-making. It is clear that China is starting to make water allocation decisions that include ecological needs, such as the decision to restore wetlands in the Yangtze. However these decisions are not yet comprehensive in the sense of defining and safeguarding all major ecological services. A prime example is the difficulty of linking river water quality to estuarine and ocean problems. Another has been the limited number of water quality monitoring stations and limited frequency of monitoring so that the full extent of pollution problems is not understood. But the major difficulty has been to engineer a shift in thinking towards integrated river basin management that includes ecological characteristics as a very fundamental part of its purpose. The CWRC has begun to make this shift through revisions to its Yangtze Basin Comprehensive Utilization and Development Plan. This will have to be a long-term, on-going effort guided by broad stakeholder input.[30]

Understandably most attention on water issues in China is focused on freshwater. It is also necessary to develop appropriate policies, planning methods and tools to ensure that ocean ecosystem uses are managed in an integrated fashion. There are some worthwhile examples of integrated management in place within China. China's *Sea Area Use Law* (in effect since January 2002) provides the basis for zoning according to uses and needs. The Xiamen municipal government started an approach for Integrated Coastal Zone Management (ICZM) in 1994 as a national demonstration project designed as a five-year effort.[31] A local

[30] D. Boekhorst, T.Smits, Xiubo Yu, Lifeng Li, Gang Lei and Chen Zhang. 2010. *Implementing River Basin Management in China*. Ecology and Society. 15 (2) Article 23 online

[31] A. Uychiaoco, et al. 2009. *Xiamen's Transition to Orderly Seas.* Case Study 1 (2). PEMSEA, Manila; Huming Yu and N. Bermas. *Integrated Coastal Management: PEMSEA's Practices and Lessons Learned*. UN Institute for Training and Research. Hiroshima Office for Asia and the Pacific

office of ocean management provided coordination and an interdisciplinary advisory group provided many types of technical inputs. This was intended to be a five-year effort, and during that time, through use of integrated environmental impact assessment coastal reclamation plans were reassessed leading to a marine zoning approach. Actions were taken to reverse ecological problems such as opening a causeway that blocked a lagoon that then became polluted.

Today Xiamen's coastal areas boast recreational uses, good economic development, and a rational basis for zoning of many ocean uses and needs. The examples include establishment of nature reserves for mangroves and various endangered species, ocean use licensing to control marine pollution and cleanup, protection of beaches and coastal scenic spots, and functional zoning for other purposes such as shipping and port use, aquaculture siting, and protection of biodiversity (e.g., an 18 km^2 reserve for protection of the Chinese white dolphin). This case is one of the best for cooperation at a local level, and China's Sea Area Use Law is based on the Xiamen experience. The problem has been how to implement the approach throughout China's maritime areas.

2.4.2.3 Two ecosystems needing greater attention

Maintaining the essential life support functions provided by some seriously threatened types of ecosystems should be a matter of grave concern. None are more important than the following three types: soil ecosystems; ocean and coastal ecosystems; and the ecosystems of the Tibet-Qinghai Plateau. While a great deal is known about some aspects of each of these types, their overall functioning and the full impacts arising from current levels of economic activities originating in China and from elsewhere, plus the impact of climate change, are not well enough understood, nor are policy actions sufficient. An overview of these three major but threatened ecosystems is provided below.

2.4.2.3.1 Soil ecosystems

Soil ecosystems often appear to be extremely resilient given the persistence of many agricultural practices (especially paddy cultivation and grazing) for millennia. However desertification continues to plague China, and grasslands, the single largest category of Chinese terrestrial ecosystems, appear to be difficult to restore by comparison to the relative success of reforestation. The damage to soils is widespread in urban and industrial settings, in mining activities and in agricultural areas where biocides and fertilizers are applied, often at high levels, and also where there is poor land cultivation and conservation practices.

Soil ecosystems are rich in microscopic life that are vital to biogeochemical cycling—the transformation of organic and inorganic materials into usable nutrients, the conditioning of rocks and minerals and plant material into a sponge that stores carbon and water,

and provides the basis for healthy forest and grassland ecosystems and the habitat for rich biodiversity.

The services provided by a healthy soil ecosystem often are taken for granted, with the presumption that they will continue to be present no matter what the level of stewardship and management. Farmers and herders may recognize the complexity of soil ecosystems and establish customary practices to protect them. And science has helped greatly, especially in reversing some of the obvious impacts of bad land use practices.

But in recent decades the task of maintaining good soil ecosystems has grown very difficult throughout China. Not only is there greatly increased pressure arising from the need to enhance agricultural productivity through application of chemical fertilizers and pesticides at high doses, there is also the issue of greatly increased grazing pressure—sometimes associated with the transformation of nomadic lifestyles to settled existence. With growing demand for animal protein that accompanies rising income levels, there are serious impacts on soils including compaction, soil and groundwater pollution from animal wastes and issues such as desertification.

Soil pollution is on the rise from a substantial number of sources in addition to agriculture. These sources include mining, industrial processing and wastes, recycling operations (including activities such as electronics recycling), urban development, transportation infrastructure including roads, railway, water projects, pipelines and electrical lines, energy use (especially from coal burning), atmospheric deposition of pollutants such as sulphur dioxide and nitrogen oxides leading to acidification of the soil in as much as a third of China, and from the improper disposal of garbage and hazardous wastes. The full extent of the problems is still not known, although the first national mapping of soil pollution has been completed.

There are heritage problems associated with soil pollution, including in the countryside where coking and other impacts of small smelters have had their primary impact on soil ecosystems. In cities, limited consideration is sometimes given to “brownfield” conditions during urban renewal around old factory conditions. But some of the most serious situations now come about as a result of new initiatives such as factories operating without due regard for air and water pollutions, illegal dumping of toxic or other wastes, mining practices that lead to soil and groundwater contamination, and the ongoing problems associated with unsustainable agricultural practices outlined above.

While there is a growing number of soil pollution cases brought to light and acted upon, the overall situation may in fact be worsening. There is no systemic approach in place to address soil ecosystem pollution. Furthermore, the national effort to address the problem as a comprehensive health issue—health of the ecosystem, health of food and water supply,

and health of people—is limited. Thus China is building an ecological debt in its soils of substantial but unknown economic dimensions, and with implications for the future functioning of the main biogeochemical cycles on which the people and biodiversity of China depend.

2.4.2.3.2 Ocean and coastal ecosystems

China is fortunate in having relatively diverse marine and coastal areas ranging from tropical to temperate zone ecosystems. Some are ice-covered in winter. But there is waters in the south suitable for mariculture of pearls, fish and shellfish, and both coral and mangrove ecosystems. The Yellow Sea is known for its fisheries and coastal aquaculture, while the East China Sea is an area of growing significance for oil and gas development. China's coastal zone has been the main site for China's opening up and remarkable economic growth over the past 30 years. There has been an unprecedented growth in shipping and in the number and size of ports and harbors. But the greatest shift in the recent past has been the migration of people to cities—which have grown in numbers, size and complexity, especially of infrastructure including remarkable achievements such as the bridge system connecting Shanghai and Hangzhou, and similar efforts underway elsewhere to form regional interconnected urban areas such in the Pearl River Delta region, Beijing-Tianjin, etc.. The massive investment in marine and coastal development has major economic benefits in both ocean and land areas. By 2020 it is projected that the revenue generated by the 5 main marine primary industries in China will account for approximately 7% of national GDP. The total marine revenue is even larger, in 2008 it accounted for 9.87% of GDP.

The main rivers of China have an important influence on ocean ecology as well as on the main coastal economies. As long as China's economic prosperity is tied to international trade the coastal cities are likely to do well since they play such a dominant role in manufacturing, financing and other aspects of this trade. The positioning of key cities and ports in naturally productive deltas of major rivers such as the Pearl and the Yangtze, or on the edge of major bays (such as the Bohai in the case of Tianjin) presents a number of dilemmas, especially in terms of ecological sustainability. For these areas also are very significant for migratory waterfowl, fish and other creatures such as the Yangtze Dolphin[32]. Furthermore having many cities on floodplains and in areas of risk due to typhoons, sea level rise, and salt water intrusion has created ongoing disaster prevention and response needs of considerable magnitude. Competition for coastal lands is considerable.

[32] The Yangtze Dolphin is a sad story of a species that declined and was lost in this mighty river as a consequence of habitat loss, illegal harvesting and other factors. See Samuel Turvey. 2008. *Witness to Extinction. How We Failed to Save the Yangtze River Dolphin.* Oxford University Press. 234 pp

A very significant portion of China's natural coastal ecosystems have now been replaced either through land reclamation, or by structural alterations such concrete barriers near ports, highways, and other infrastructure. While efforts to restore wetlands and other natural ecosystem features are often included in these types of coastal development, it is unlikely that they actually will provide sufficient benefits to protect biodiversity and productivity.

The ocean and coastal ecosystems of China are showing many troubling signs of stress and decline. Examples of problems include the following:

(1) Ocean eutrophication resulting from the excessive use of farm chemicals in the inland areas and other sources including nitrogen from the rise in automobile emissions, and from coastal aquaculture practices;

(2) More widespread and frequent occurrences of toxic red tides (caused by blue green algae blooms due to excessive availability of nutrients);

(3) Presence of offshore mats of green algae in certain areas such as in the site of the Olympic sailing events in Qingdao;

(4) Replacement of some 57% of the nation's coastal wetlands which support many ecological services, often with land fill intended for industrial, commercial and residential uses including port development;

(5) Chemical contamination of the Chinese seas, for example, the release of oil over an area of some 400 km^2 from a pipeline explosion in Dalian on 16 July 2010;

(6) Decline in size (and sometimes abundance) of key marine fishes such as the hairtail as a consequence of heavy fishing pressure;

(7) Decline in marine ecosystem biodiversity as a consequence of fishing intensity and methods, and from excessive harvesting or destruction of coral reefs, mangroves and coastal wetlands;

(8) Presence of invasive species in marine and inland waters distributed in ship bilge water;

(9) Acidification and warming of ocean water, and sea level rise associated with global warming.

These problems and others have been studied quite extensively in China but often are considered as individual, sectoral issues without full consideration of the inter-connected nature of seas, and the dominant role played by land-based sources of harmful changes. The rapidly increasing intensity of uses within the coastal zone is taking place without a fully developed approach towards integrated coastal zone management, or integrated management for intensively used areas such as the Bohai Sea.

The issues of China's ocean ecosystems are to some extent quite similar to those in other parts of the world. But the pressures are perhaps more intense in the case of China due to a combination of its large population, its success in developing provisioning services (especially China's mariculture which is the largest in the world), and China's ability to invest heavily in activities affecting ocean health and sustainability.

China will continue expanding the economic yields from China's oceans and coastal zone. Some of the possibilities include tapping into frozen methane hydrates from seafloor sediments (these hydrates are also found in land on the Qinghai Plateau), much more extensive use of the seas for offshore wind generation, construction of artificial islands and other infrastructure for human activities, genetically modified fish or other life forms for meeting future food, medicine or energy needs, and greater attention to recreational uses. In each case there are implications for the maintenance of biodiversity, for protection of the natural cleansing capacity of ocean ecosystems, for the protection of spawning and nursery areas, and for ensuring the overall health of large ocean ecosystems such as the many bays and estuaries, as well as deep water areas that are vital to recirculation of nutrients.

China's ocean management is fragmented with several agencies involved in key decisions, but not necessarily in a coordinated way. In particular, the land-based sources of marine pollution are problematic. There is limited consideration of the multiple impacts these sources may have on the oceans. Furthermore, authority is split between agencies such as the Ministry of Environmental Protection, Agriculture (and fisheries), the Ministries responsible for energy and for water resources, and the State Oceanographic Administration.

2.4.3 Key Challenges for Ecosystem Management and Services

This overview of the current situation reveals that major challenges for ecosystem management and protection of ecological services in China have not yet been resolved, even though laudable progress has been made on some aspects such as reforestation and soil erosion/desertification.

2.4.3.1 The first of these challenges concerns how particular ecosystem properties are addressed

(1) ***Scale issues*** are important because China has to deal with nested ecosystems, for example the problems of soil ecosystems are a subset of grassland concerns, industrial landscapes, and even of wetlands. Yet the quality of soils and soil ecological remediation is very much a local concern, with a considerable need for tailoring action to specific sites.

At the other end of the spectrum is the problem of addressing in a consistent fashion the problem of ensuring the value of large nature reserves such as those found in the Tibet-Qinghai Plateau, and the best approach for management of large ocean areas such as the Yellow Sea.

(2) ***Ecological resilience*** determines whether an ecosystem under stress is capable of continuing to function in a reasonable fashion. Some systems may do so quite well, depending on particular factors that may or may not be well understood. There are numerous examples of situations where ecological change occurs rather suddenly when some boundary is reached, for example sudden shifts of species composition and abundance in the ocean due to factors such as temperature, oxygen availability, larval survival, overfishing, or loss of food supply. Ecological resilience appears to be figuring more prominently in Chinese policies, as exemplified by the setting aside of large land areas as nature reserves, and in the many current efforts for ecological construction and restoration, including vital areas such as wetlands, brownfield sites and reforestation.

(3) ***Cumulative effects of development*** are still not well enough accounted for—either in environmental assessment processes or in development plans. This is a major problem for soil ecosystems where industrial pollution of soil continues to build up. It is also an issue for groundwater and in lakes where agricultural and industrial chemicals accumulate, and now there are additional concerns associated with pollutants from auto emissions, which can be converted from an atmospheric issue to surface and groundwater problems, before ultimately ending up in marine ecosystems, contributing to eutrophication.

2.4.3.2 The second set of challenges is systemic concerns that involve multiple ecosystems

There is a lack of institutional capacity to handle problems that originate in one ecosystem but have a significant impact in other ecosystems that may be quite distant. The failure to address the range of problems associated with land-based sources of marine pollution is a significant and growing issue. Other examples include the maintenance of ecological conditions to support migratory waterfowl and other birds, marine and freshwater mammals such as the Yangtze Dolphin; and the transfer of invasive species through water systems that are increasingly connected. Conservation ecology theory suggests paying a great deal of attention to developing ecological corridors that in effect become safe “highways” for species on the move, for example herds of large mammals in western China, and on north-south routes for migratory birds. Often these needs can be met by systems of nature reserves, or by ensuring that human activities are curtailed at times when necessary to protect migrating animals, or to ensure their access to food or breeding habitat.

Systemic concerns also include the need for greater attention to the ecological func-

tioning of biogeochemical cycles, including carbon cycles, the maintenance of soil organic material, and in general the nine Earth systems described by Johan Rockstrom and others of the Stockholm Resilience Centre.[33]

Failure to account for these systemic problems in decision making means that environmental externalities persist at ecologically dangerous levels, for example in the case of agricultural fertilizers that now pollute local surface waters and groundwater, but also affect coastal ecosystems.

2.4.3.3 The third set of challenges is the pressing need for workable integrated management strategies, plans and actions for dealing with ecosystem protection and use, particularly at regional levels

While there has been some progress in the case of water basins via a number of mechanisms including the Yangtze River Basin Commission, decision making is still dominated by sectoral bodies. The problem is particularly difficult for the oceans where impacts of development and resource exploitation tend to be felt throughout the ecosystem, but where responsibility is fragmented, or cause and effect difficult to determine. There is no national coastal development effort, and efforts to build integrative frameworks for specific areas such as management of the Bohai Sea[34] are limited in their scope and capacity. For large terrestrial regions some progress has occurred when development and ecological considerations are linked, for example in addressing environmental management and ecological restoration in the Loess Plateau. Whether or not it will be successful in the short run on the Tibet-Qinghai Plateau is difficult to answer due to the complexity of the ecosystems and development objectives. This is a region where integrated management must be used to anticipate dramatic ecological changes related to climate change in addition to other impacts of human use.

2.4.4 Ecological Footprint

The ecological footprint of China, although still relatively low on a per capita basis, is increasing rapidly, with much of the demand arising from large Chinese cities.[35] Indeed, for some consumers, especially the well-off in cities, the levels of consumption are reaching levels of those in developed countries, for example in energy use. A major portion of China's ecological footprint is actually the country's carbon footprint, which could be reduced

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[33] J. Rockstrom et al. September 24, 2009. *A Safe Operating Space for Humanity*. Nature. 461, 472-475

[34] BSEMP Bohai Sea Environmental Management Project

[35] This year WWF China, in cooperation with CCICED, is producing an updated report on China's ecological footprint. See also the recently released WWF *2010 Living Planet Report*

through pursuit of a low carbon economy. Also, a substantial portion of the footprint is related to China's export-oriented economy. These observations raise concern about China's regional (within China) and global ecological footprint in the future. It suggests a need for a green development strategy that tries to reduce ecological demands associated with market supply chains internationally and within China. The world is already consuming more ecological resources than the planet can support, suggesting long-term decline in ecological services is taking place. The question is what can China do to ease this burden rather than add substantially to it?

2.5 Nine Key Issues

In this section nine key issues shaping the debate about ecosystems and green development are discussed. These are by no means the only major issues, but they are among the most urgent. Each is presented not as a recommendation, but as a framing of the positive action that needs to be debated in order to safeguard China's ecological future via a green development strategy.

2.5.1 China must Increase the Level of Available Ecological Services of All Types (Supporting, Regulating, Provisioning and Cultural) from Natural Ecosystems, as Well as Those Used Extensively or Intensively; and at the Same Time Stop Further Degradation of Ecosystems. This Mammoth Task has to be Undertaken Throughout the Country, Including Its Terrestrial, Aquatic and Marine Systems

The key concerns include:

(1) ***Avoiding tipping points*** where environmental impacts lead to sudden changes in the state of ecosystems and their services, for example, the green algae mats caused by excessive nutrients (eutrophication) that threatened the Olympic sailing events offshore in Qingdao.

(2) ***Identifying the characteristics of "wedges"*** that reveal the magnitude of different components to problems and the actions that can be taken to address each component. The idea of wedges, originally proposed to address complex problems such as climate change action internationally, could be valuable for ecological problems where there are several contributing factors. An example is the planning for a "living river" strategy that optimizes improvement of ecological services throughout the basin.

(3) ***Changing the relationship between provisioning services and the supporting, and regulating services in both extensively used and intensively used ecosystems.*** Theory sug-

gests that supporting and regulating services decline when natural systems are altered. Also, frequently, biodiversity declines, for example in agricultural, harvested and cultivated forests, and in aquaculture systems. In urban areas the declines may be even greater than for rural areas. China will continue to intensify uses in many types of ecosystems, but new ways must be found to permit ecological services to be maintained or increased, ecological integrity to be maintained, and biodiversity to be conserved.

(4) ***Avoiding option foreclosure*** that affects future economic and social opportunities**.** The consequence of lost ecological services can be drastic. Consider the loss of bees due to pesticide use in Sichuan pear orchards, which has required pollination of the trees by hand rather than the bees.[36] Tourism opportunities taking advantage of nature are at a premium but fall off in degraded ecosystems. Biodiversity and genetic diversity is the basis for future biotechnology opportunities. Ecological remediation is costly; prevention of loss will generally be much cheaper.

At present the value of ecological services is still poorly measured and monitored within China as in other countries. Thus it is truly difficult to know the full significance of particular services and indeed how the regulating and supporting functions can actually be improved while still continuing to increase provisioning and cultural demands from ecosystems. There is no national inventory maintained of ecological services, nor do most provinces have a full sense of their ecological service values even though many have eco-compensation schemes proposed or in place.

2.5.2 Integrated Ecological Management is Required in Order to Optimize Economic, Social and Environmental Benefits, but Efforts are still Weak and Generally not Systematically Implemented

Sectoral strategies carry the day in China (and in most other parts of the world) with the result that inter-sectoral impacts do not receive full consideration. In addition, interprovincial and regional differences lead to serious ecological problems between upstream and downstream interests. Along China's coasts, and in the ocean, there are concerns, such as migratory species, ocean currents and mixing processes that create important ecological issues for shipping, ports, and other economic development initiatives including matters such as land reclamation.

Ecologically-based planning can be of real value in reducing the transactional costs of integrated management, and to some extent this methodology is now well used in China, es-

[36] http://ileia.leisa.info/index.php?url=getblob.php&o_id=70478&a_id=211&a_seq=0

pecially in local and project development. Examples include the protection afforded the Three Rivers area of the Qinghai Plateau, and the Xiamen City coastal development planning effort.

There have been successful planning efforts at the regional level as well, such as in the Loess Plateau anti-desertification efforts. However, integrated coastal zone management (ICZM) and integrated river basin management (IRBM) have had a more difficult time. There is no national ICZM agency or approach in place. IRBM is still in its infancy in China although the level of basin planning for many aspects of hydrological engineering is very sophisticated.

While numerous institutional improvements could be made to existing Water Commissions and other models can be suggested for particular areas of the ocean such as the Bohai Sea, and these are logical to pursue, it is important to recognize that effective use of several tools can be very valuable steps towards integrated ecological planning and management.

(1) ***Redlining*** is declaring a target level of land or water area, or habitat type and ensuring that this target level is maintained or achieved. This is the case for agricultural lands in China where the target is set based on projected land area required to achieve a specific level of food self-sufficiency. Redlining could be used for setting the amount of land that might be converted in the coastal zone, for example, the maximum area of reclaimed land, or of wetlands that might be converted to other uses. Redlining is also a helpful concept for addressing nature reserves required to meet specific species or habitat requirements.

(2) ***Functional ecological zoning*** could be expanded beyond its current uses for example in delineating ecologically sensitive areas as off limits to shipping, closed fisheries and wildlife zones to permit spawning, feeding or safe passage of migratory creatures, etc.. Functional zoning can be linked to environmental characteristics and capacity of rivers and terrestrial zones. However the concept should not be used as a “triage” mechanism that assigns some areas a permanently degraded status.

(3) ***Market-based mechanisms*** have considerable potential to minimize inter-sectoral problem solving and for addressing maintenance of ecological services. This is especially the case if economic values can be assigned to formerly unrecognized elements. Carbon sequestration capacity is an example.

(4) ***Strategic environmental assessment*** is a useful addition to normal project based assessments. A strategic assessment can be used to consider the range of possible uses and cumulative impacts, so that option foreclosure can be minimized.

(5) ***Regional planning and management*** is necessary at various scales, and is being used in China for Western Regional Development in particular. Possibly it could be employed for ecologically-based integrated regional development of ocean regions such as the Yellow Sea. Regional management of lake basins and surrounding watersheds is another important need. Lake Poyang provides a good model.

This list of possible interventions through tools already available and tested in China is encouraging because there are a number of useful pilot projects and other initiatives. Unfortunately there are institutional barriers and other problems that have hindered fully functional integrated management. There is a strong need for further attention at both national and more local levels of government to create workable institutional arrangements while at the same time spreading the use of proven tools for inter-sectoral environmental problem-solving.

2.5.3 Mainstreaming Biodiversity into China's Short-and Longer-Term Development Strategy is Essential to Stem the Loss of Important Ecological Services, and Ecosystem Health

This means making biodiversity a significant element within the major planning and management functions at a national level and at other levels, including counties and municipalities. At the 16 September 2010 Executive Meeting of the State Council a decision was reached to adopt in principle a Biodiversity Protection Strategy and Action Plan of China (2011-2030). This will build on activities carried out under the existing 1994 Action Plan. As noted at the meeting[37]:

"However, influenced by excessive use of resources, climate change and other factors, some ecosystems keep on degrading, exacerbating endangerment of species and loss of genetic resources. The trend of biodiversity loss has not been effectively curbed. We must coordinate the relationship between biodiversity protection and economic development and uphold the principle that gives priority to protection, encourages sustainable utilization, public participation and benefit sharing to strengthen biodiversity protection."

"First, we will improve related policies and legal systems to incorporate biodiversity protection into national and regional plans. Second, we will launch an investigation, assessment and monitoring of biodiversity, strengthen scientific research, personnel training and capacity building in biodiversity protection. Third, we should step up in situ conservation of biodiversity and conduct ex situ conservation as appropriate. Fourth, we will promote sus-

[37] http://english.mep.gov.cn/News_service/infocus/201009/t20100926_194969.htm

tainable development and utilization of biological resources and establish access and benefit sharing system for biological resources and traditional knowledge. Fifth, we will enhance management of invasive species and safety of GMOs and build up our capacity for addressing climate change. Sixth, we will improve public participation mechanism and intensify international exchanges and cooperation."

This new Biodiversity Strategy and Action Plan (BSAP) approach will be a valuable step forward. There are various ways to ensure full value is achieved. Most important is the need to ensure that action occurs at local levels. Thus BSAPs are needed at provincial and local levels. They need to have a strong ecological focus, essentially letting nature do more of the work, focusing attention on the role of biodiversity in fostering ecosystem resilience. Governance and institutional innovation to incorporate local inputs, improved accountability from the bottom up, and promoting public awareness are essential. As well, there is a need to strengthen not only laws and regulations and their enforcement, but also to create better value-added from incentives and to improve investment models. The eco-compensation models now in use can be substantially improved.

2.5.4 Poverty Reduction and Equitable Distribution of Ecological Service Benefits Should be Addressed in All Chinese Ecological Improvement Efforts

Chinese ecological improvement efforts have contributed to poverty reduction for many years, and in general are intended to provide a steady stream of benefits to rural dwellers. Programs are designed with both social benefits and ecological improvement as objectives, especially in the forest and grassland efforts. As the China-Europe Biodiversity program has shown in its case studies of biodiversity conservation involving local communities, it is possible to improve livelihoods while conserving biodiversity.[38]

It is also possible to provide other direct benefits such as reducing the risk associated with droughts and floods, and to improve human health by paying attention to ecosystem health and by understanding the relationship of people's activities and infectious disease ecology. By shifting use of biomass as a source of energy and for organic fertilizer farmers can improve both income and family health. Many other examples could be given of how China in general is managing to stay on track to achieve its Millennium Development Goals (MDG). However, Goal 7, Environmental Sustainability, is still lagging and will require a concerted effort to improve performance.

The countryside of China is tied to the cities when it comes to ecosystem management

[38] http://www.ecbp.cn/en/projects.jsp

and ecological services. Benefits of ecological optimization flow to the cities in the form of clean water, flood prevention, and a range of cultural benefits such as recreation and spiritual uplifting. Yet countryside residents continue to earn substantially less than those living in cities, and do not enjoy the same access to high quality health and education. It is not surprising therefore that full acceptance of programs designed to achieve eco-environmental benefits for areas beyond the local environs may not be fully accepted by local inhabitants. This appears to be the case for grassland restoration in some parts of the country. Cultural differences also are important in the degree of acceptance of programs if they are not designed with a high degree of local participation. These observations come from reviews of Chinese forest and grassland restoration efforts. But they likely would apply to marine and coastal initiatives as well.

The enhancement of benefits to rural areas could occur in several ways.

(1) ***Greater involvement of local communities in the planning and management of nature reserves.*** With so many nature reserves and other protected areas, the role of local residents is vital—not only for their cooperation but also for their local knowledge. Co-management arrangements need to be explored.

(2) ***Full assessment and valuation of local ecological services, and of environmental security needs related to prevention of natural disasters and public health.*** By focusing on local flow of benefits in addition to those for beneficiaries located elsewhere, there should be greater acceptance of ecological service concepts and programs.

(3) ***Ecological extension services of high quality and reliability will increase the likelihood that new benefits will materialize.*** The emphasis of conventional extension services is generally on how to increase productivity, not on the ecological support components and biodiversity.

The full participation of rural resource users in protecting local ecosystems has national, regional and local benefits, and is the single most important way to guarantee enhanced ecological services. It is also a means for developing a green new socialist countryside and reducing the gap between rural and urban incomes. This decade will be the most important time to build on progress already made and to ensure efforts lead to the naturalization of forests, grasslands and coastal areas so that biodiversity significantly increases in ecological construction zones.

2.5.5 China Needs to Advance Its Efforts to Protect Ocean Ecological Services and Ecosystems, Including Those Related to Open Water Fisheries Production, Sensitive Habitats such as Coastal Wetlands, Estuaries and Semi-enclosed Bodies of the Sea such as Large Bays, and to Better Address Land-based Drivers of Undesirable Ecological Change in the Sea. These Issues are Important if China's Economic Dependence on the Ocean is to Continue and Grow

In 2008, the State Council published the Planning Outline of National Marine Program Development. President Hu Jintao signaled a desire for developing marine industries during his visit to Shandong in 2009 and emphasized the utilization of marine resources based on sound science and the nurturing of marine industries. It is a very complex business to actually do so while ensuring sustainable green development.

The pressures will continue to rise from land-based sources of marine pollution, including agricultural chemicals, from the continued alteration of China's coast through urban development and land reclamation and the construction of further infrastructure, including not only ports and harbours, but also new offshore energy projects. The stresses on the Bohai and Yellow Seas and areas such as the Pearl Delta will become ever more intense. Some marine fisheries and aquaculture systems are not operating in a sustainable fashion. Compared to terrestrial areas, progress on marine eco-compensation, designation of protected areas and other ecological protection measures is relatively limited.

These pressures suggest that at a national level there is a need for a comprehensive policy on sustainable ocean use. This policy would require a firm legal basis and be linked to both strategic and action-oriented initiatives. Many of the initiatives would be sectoral but there also is a need for overarching initiatives that address cross-sectoral aspects and linkages between land, rivers and the ocean. A number of other countries provide possible model policies and/or legislation, including the USA, UK, Australia and Canada. Institutional development to address cross-sectoral ocean issues is needed.

At the moment, the attention paid to some very important ocean ecological and environmental services is still limited. Those related to climate change are of particular significance. Likely, the oceans are as important as China's terrestrial areas for their value in carbon storage. The role oceans will play in mitigating climate change impacts is still poorly understood, and this is an important topic for international cooperation. China is quite vulnerable to storm damage, sea level rise, and negative effects on ocean productivity. These are topics on which more detailed understanding of oceanic changes is needed as part of strategies for future use and expectations of sustainable development of China's seas.

There are many opportunities to draw upon innovative technology, institutional and management practices in order to achieve sustainable use of China's seas, islands and coastal areas. To take advantage of the opportunities, China can make substantial investments in science and technology[39] and draw upon its own people to build workable solutions in local settings, as has occurred in Dalian, Xiamen, Hainan and elsewhere.

2.5.6 Terrestrial Ecosystems in China Provide the Greatest Range of Ecological Services, Especially Provisioning. The Pressures on These Systems Continue to Increase Both in the Intensity and Diversity of Negative Impacts. These Problems Need Urgent Attention, Especially Soil Pollution, Grassland Restoration Programs That are not Performing Well, and Reduction of Agriculture's Ecological Footprint

China's most dramatic ecosystem construction has been the spread of artificial forests, the world's largest reforestation effort, so that China now has about 1/3 of the world's planted forests. The ecological benefits are immense. However these forests are still lagging in terms of biodiversity, volume of wood and productivity. Grassland restoration initiatives have been less successful than reforestation; grassland ecological services are still quite limited and desertification significant. Soil pollution has now reached the point where it should be viewed as a major national concern, with a need for urgent and long-term action. Agro-ecosystems are the dominant user of China's water and consume some 35% of the world's fertilizers, plus other agricultural chemicals. Clearly more robust protection and programs are needed for the future. Such programs should place more emphasis on biodiversity enhancement, carbon storage, addressing non-point pollution, and should be aligned with local social, economic and environmental conditions and interests. These problems are also the subject of the next two recommendations.

2.5.7 A Third Generation of Programs for Addressing Ecosystem Protection and Improvements such as Eco-compensation and Ecological Restoration/Construction Will be Needed in Order to Comprehensively Improve China's Ecological Situation by 2020

The first generation of programs focused on reforestation and improvements to croplands and water management during the time of Chairman Mao and into the 1980s. The second generation from the 1990s up to the present time has served a broader array of inter-

[39] A comprehensive set of proposals is provided in Xiang, Jianhai (ed). 2010. *Marine Science & Technology in China: A Roadmap to 2050*. Springer. 182 pp (Original Chinese edition published by Science Press, 2009)

ests including not only reforestation but also the major initiatives in grasslands and wetlands, and, of course, the designation of nature reserves throughout China, but especially in many areas of special concern such as in the Tibet-Qinghai Plateau, Hainan, etc.. In addition, there have been many improvements to the regulatory framework via national laws and via international treaties such as the Convention on International Trade of Endangered Species (CITES), and via the Convention on Biodiversity (CBD).

The third generation of ecosystem protection programs is needed soon, perhaps starting with China's 12th Five Year Plan, the proposed National Biodiversity Strategy and Action Plan, and with the accords reached at the Nagoya Conference of the Parties to the CBD. It is timely to set in place a robust set of longer-term objectives that would guide the strengthening of ecosystem stewardship and management until 2030. Some goals have already been set, including those for national reforestation, grassland improvements and restoration of wetland functions. But the effort needs to be more comprehensive and to address systemic issues that relate to impacts cascading from one ecosystem to another, such as the effects of agricultural fertilization on inland waters and on the ocean. There is a need to ensure that new topics such as carbon sequestration, and enhancement of biodiversity are adequately incorporated into programs.

Important matters include the following needs:

(1) ***Development of differentiated objectives within programs.*** The broadband kinds of programs in place now will not necessarily meet sophisticated conservation objectives of tomorrow. As the USA found in its Conservation Reserve Programs for farmers, it took several generations of programs to achieve targeted approaches that provided wildlife habitat, improved water quality, soil conservation, etc.. What started out as "one size fits all" turned into a wide array of support programs administered using market-based instruments and with much better results.

(2) ***Incorporation of carbon sequestration and biodiversity protection objectives, likely opening new sources of income for rural areas.*** Meeting these objectives will carry valuable co-benefits for ecological services and may open new revenue streams such as international funding through climate change and biodiversity maintenance trading systems patterned along the lines of the existing Clean Development Mechanism.

(3) ***Extension of eco-compensation and ecological restoration to threatened ecosystems not currently covered.*** China's ocean and coastal waters are poorly covered in the current programs, although there is a clear need. The future quality of life for coastal residents and many economic activities depend upon healthy ocean conditions. And, at the most fundamental level, all ecosystems and the fundamental need for uncontaminated food and water

and other provisioning ecological services depend upon healthy soil ecosystems. While some forms of soil erosion and degradation have been the subject of extensive ecological improvements, soil pollution has not.

(4) ***Development of standards, normalized measures, and credible monitoring of ecological protection and improvement performance.*** This effort is needed to ensure that programs can evolve rapidly with experience, and can adapt to new circumstances. Also it is essential to know whether goals are actually being met, and that Chinese efforts can be properly compared to efforts elsewhere.

The immense investment China has made already in ecological compensation, construction and restoration provides a solid base for expansion and fine-tuning. It would be sensible to create a national system for ecological improvement, much as the recent restructuring for energy efficiency.

2.5.8 Ecological Optimization Strategies Need to be Worked Out for All of China's Regions, Taking into Account the Ecological Linkages from Mountains to Seas, and the Ecological Support Functions Provided to Urban Development by China's Vast and Diverse Countryside. This Optimization likely will Open New Opportunities for Land and Water Allocation and Increase the Potential Benefits of Green Development Initiatives. Green Development, as a Consequence, will Need to Take on Even more of an Ecological Character than at the Present Time

Currently there is no national ecological optimization modeling that would cover in a comprehensive way the type of macropolicy inputs provided by computable general equilibrium (CGE) modeling of economic performance. Thus it is difficult to determine the tradeoffs being made through investments in various types of ecological restoration, protection and utilization. Over time this type of information will be needed for the same reason that CGE models are useful—to understand limits on activities and where the greatest value-added is likely to found; and to address issues of risks, cost and benefits. The methods differ, however. In the case of ecological services and ecosystems, the emphasis is on patterns of land use, and quality and resilience of ecosystems, plus the impacts of losing or gaining biodiversity, various types of ecological services, and natural resources.

Green development at present often is based on hope—that investment will enhance value. However, the hard facts surrounding at least some of the investments are that money and effort will be expended with limited return. Or that investment will be at cross-purposes: fertilize soils but destabilize lake or coastal environmental conditions, expand urban areas but destroy natural wetlands of high ecological value.

During the 12th Five Year Plan, it would be reasonable to put in place a systematic approach to identify the most significant ecological optimization needs, including those involving land-sea linkages, forests and grasslands, and soil pollution prevention, and pilot efforts within the western regions of China and other areas with fragile ecological situations. The resulting strategies would help to shape ecologically-based green development strategies.

2.5.9 China's Role and Participation in International Regional and Global Ecological Stewardship is of Growing Significance. China's Experiences Can be Shared with the Rest of the World, as Well as the Country's Ecological Footprint and Ecological Debt Should be Considered in National Decisions Concerning Land, Water and Biodiversity Uses and Ocean Development

China depends on market supply chains that include raw and processed materials being sent to China and exported goods from China with their embedded water, energy and material components. China has sacrificed its own ecosystems and affects the ecology of other countries in these transactions. In addition, China suffers as do other nations, from those problems influencing global ecological services. In the past half decade, and for the foreseeable future, China's influence in the international circles related to environment and green development has reached unprecedented levels. Increasingly, there are opportunities where China can make a contribution that reaches well beyond meeting its own needs. This is the case in the UN Millennium Development Goals, where China can now use its own development assistance efforts to share its experience in achieving these goals domestically.

Some of the key opportunities related to improving ecology and green development might include the following:

(1) Work towards improved consideration of ecological stewardship as part of green development and via existing MEAs, global and regional trade accords;

(2) Ensure ecologically-responsible practices in Chinese market supply chains involving Chinese enterprises abroad, sourcing of imported natural resources, and in Chinese international development initiatives;

(3) Recognize the important role of Chinese financial sector in shaping ecologically-responsible practices;

(4) Expand efforts to improve performance of FDI in China on internalizing environmental costs, so that damage to ecological services is minimized or eliminated;

(5) Employ greater use of international certification programs within China;

(6) Improve cooperate on international monitoring and action to prevent movement of potentially invasive species into and out of China.

2.6 Conclusion

China has set in place many of the necessary steps to safeguard its ecosystems and the services they provide for ensuring the basic needs, quality of life, economic opportunities and other requirements of the Chinese people and for global goals such as those for climate change, poverty reduction and biodiversity conservation. The remarkable efforts of China on reforestation deserve the global praise they have received. However, some other actions to date, for example in grassland restoration, have not reached the point where they can provide guarantees about their effectiveness, and there are important gaps. Economic growth is still being carried out at a rate and in a fashion that threatens the ecological integrity and biodiversity of China's lands, freshwater and ocean areas. Based on the evidence of studies concerning China's ecological footprint and other sources, China's ecological deficit appears to be on the rise, with important immediate and longer-term consequences. To confront the outstanding issues will continue to be a major challenge, although with opportunities that also are of major significance. Based on the proactive approach of the central government and many provinces during the last decade, there should be considerable hope for the future.

It is time to shift gears. Existing programs for ecological restoration, eco-compensation and various planning and regulatory mechanisms will require revision to achieve specific ecological and conservation goals attuned much more to local circumstances. Ecosystem health and ecological services should become part of decision-making for all major developments. And much greater attention has to be given to certain major ecosystems under threat—the case for both the oceans and for the many types of soil ecosystems and their associated groundwater.

The importance of linking ecological improvement to development goals, and, more specifically, to innovative patterns of green development is a new imperative.

Green development is an extremely broad topic but it must be grounded in the reality of ecological constraints and opportunities. China prospered over many centuries because it was well-endowed in natural capital. However, given all that is now demanded of ecosystems and their services, plus environmental tipping points overshot in the past, legacy industrial pollution and other ecological damage such as that related to natural or human-caused disasters, there is now a growing set of challenges that have limited the success of ecosystem protection, restoration and ecological construction.

2.6.1 Challenges

These challenges include:

(1) Inadequacies in the formulation, application and enforcement of existing laws;

(2) Poor understanding of ecological services and their economic and social value;

(3) Underpayment for use of ecological services (fees, taxes, eco-compensation);

(4) Failure to consider fully the system-wide impacts of development (especially for non-point pollution from agriculture, impacts of dams and land reclamation on wetland and coastal ecosystems);

(5) Limited efficiency and efficacy of many existing ecological restoration initiatives including the need for higher biodiversity, productivity and ecological complexity considerations;

(6) Limitations on capacity for ecological monitoring and ecosystem management;

(7) Inadequate level of participation by local resource users and communities;

(8) Approval of ecologically-unsound development initiatives that are fail to take into account biodiversity, conflicting objectives, etc.;

(9) Difficulty of implementing cross-sectoral coordination;

(10) Significant economic losses, human health and ecological problems related to the lack of control over invasive species, natural disasters involving degraded ecosystems, and disease fostering conditions;

(11) Need for innovative investment and institutional arrangements tailored to local circumstances and ecological needs.

This list of challenges is reasonably well understood by the national government and at provincial levels as well. However, there is still an on-going tug-of-war among the many objectives for economic development both nationally and at sub-national levels. Thus, longer-term ecological considerations can slip when placed against short-term social-economic matters leading to jobs and local revenues. Although good tools such as environmental impact assessment are available, they are not always well applied, and often the information base about ecosystems is inadequate. These problems can become acute at the county or municipal level—where ecological change actually takes place.

As noted earlier in the paper in Figure 2-2, the future development demands on ecosystems and their services are likely to become even greater. Green development initiatives therefore must help to build greater resilience and adaptive capacity into those ecosystems being intensively or extensively used, and natural ecosystems must be extremely well protected so that they help to safeguard important services. New and on-going ecological degradation will have to be more or less eliminated wherever it occurs. These demanding con-

ditions need to be met at a time when climate change will add additional burdens.

2.6.2 Opportunities

Fortunately, there are significant ecological opportunities, including some that may be unique to China's situation.

First, China has been remarkably successful in setting out some of the necessary foundations in its commitment to rural development, the substantial area of Nature Reserves, its commitment to stopping biodiversity loss, its many good agricultural lands, and, particularly the array of well-financed programs to restore degraded forests, wetlands and grasslands. There is now a well-established set of experiences that can be used to enhance the quality of green development initiatives and therefore the quality of constructed and restored ecosystems. This effort should be helped by the fortunate financial situation of China, being able to invest in these longer-term efforts.

Second, China has established the scientific and planning groundwork for some of the integrated management approaches that will be needed in the coming decade, including ecological monitoring throughout the country, and improved ecological planning for major rivers and lakes. This will permit the development of ecologically sustainable agriculture and open possibilities of dealing with non-point source pollution. It also should help with the adaptive planning and management needs related climate change.

Third, the rise in both domestic and international tourist visits within China opens significant opportunities to develop relatively low impact eco-tourism. The result could be new streams of income for rural residents and the investment needed to secure ecological services. This route of green development will require great care in planning and implementation in order not to create new levels of ecological damage, but there are good models within and outside of China.

Fourth, the interest of China in Low Carbon Economy should lead to improved land use, soil conservation and, perhaps, less damaging forms of aquaculture and mariculture. These improvements will be based on carbon storage in the soil, in tree biomass, and possibly in the sea.

Fifth, the economic return associated with ecological improvement. There are numerous examples where proper treatment of brownfield sites provides developers with greenfield conditions that can be used for amenities such as the 40 km coastal walkway in the city of Qingdao, and the Shanghai Expo site which will have mixed land use opportunities after the Exhibition is over. The restoration of degraded soil systems is perhaps one of the greatest opportunities available to China—whether it is to forest in the countryside, or to residential and commercial uses within cities.

Some of these opportunities may be uniquely suited for meeting not only environmental

protection objectives but also for reducing poverty and the income gap between rural and urban dwellers. Site planning that prevents local economic option foreclosure, and environmental impact assessment of development initiatives such as mines and water resource projects needs to be routinely and carefully applied to ensure that development is indeed green and beneficial locally.

Properly carried out, green development should substantially increase the efficiency of resource use and therefore the proportion of limiting factors such as water that can be dedicated to supporting and improving ecological services and high value ecosystems such as wetlands. Eventually nature should once again be able to do its work and human intervention and engineering may be reduced.

2.6.3 Institutions and Awareness

The types of institutions required to support ecological aspects of green development will be capable of crossing sectoral boundaries, and will operate on the principle of scientific development. They will function at various levels but must reach local levels, and have adequate mechanisms for public awareness raising and stakeholder participation.

Elements of awareness raising and participation include the following:

(1) Decentralized efforts at county levels and in relation to nature reserves and other protected areas;

(2) Consumer and general public understanding of choices towards a lower ecological footprint and on preservation of ecosystems;

(3) Education of school children towards green development and ecological matters;

(4) Enhanced role for communities, including support for their surrounding ecosystems and protection of ecological functions;

(5) Ecologically-responsible practices for enterprises of all scales, including SMEs and major Chinese enterprises operating in China and abroad. This should include specific consideration of improvements in water use efficiency, biodiversity protection, and responsible sourcing of raw materials and waste disposal.

These elements are being introduced gradually; the pace needs to be accelerated in the years ahead.

2.6.4 Concluding Observations

China is at a defining moment in its efforts to improve ecosystem management, conserve biodiversity and enhance ecological services. Much of the necessary groundwork has been carried out during the past decade, and yet the challenges have become greater over

this same period, primarily as a result of very rapid economic growth and development. The path forward will not be easy since it requires fundamental transformation of China's relationship between its ecology and economy. Major emphasis should be placed on getting better value for the sizeable investments currently being made or planned, including programs for eco-compensation and ecosystem reconstruction. Over the longer-term it should be possible to depend more on natural capital and ecological services so that less needs to be spent on ecological construction and on conventional engineering solutions.

The encompassing concept of green development must be based on meeting human need while respecting ecological conditions. This ideal could eventually lead to the desired situation of an Ecological Civilization in China, but that is very much an aspirational goal at the present time. Certainly it will be essential to place much greater emphasis on improving ecological services from all types of ecosystems, including those being intensively used. It is helpful to recognize the important value of regulating and supporting ecological services in addition to those which provide more easily measured economic benefits.

There are many opportunities still available for addressing China's ecosystem sustainability and resilience. These opportunities need to be well understood and exploited using a scientific development approach that is based on adequate ecological knowledge appropriate for the different regions and ecosystems of China. Western China, and China's seas and coastal areas deserve concerted attention. Problems related to soil pollution, ecological services of rivers, lakes and wetlands and of groundwater, and grasslands are of great significance. Forests and nature reserves are the areas where China has made considerable progress since the 1990s but their quality and ecological management generally are not yet at a satisfactory level.

Incentives and an improved regulatory framework will help China to achieve green development objectives related to protection and development of its natural capital and ecological services. However, much can be accomplished within the existing laws and the rather extensive programs for ecological restoration and eco-compensation. These programs are oriented towards the land and freshwater. Marine and coastal programs need to be introduced.

China's ecological stewardship roles require consideration of both domestic and international aspects, especially regarding the nature of China's ecological footprint, and the footprint of other countries on China's ecosystems. It should be possible to reduce ecological debt within China and that goal should be embraced for the coming years.

Green development and economic approaches are essential components of China's New Path for Environmental Protection. Ecosystem health is the foundation. The starting point should be the 12th Five Year Plan.

Chapter 3 Ecosystem Service and Management Strategy in China

3.1 Introduction

In order to develop a moderately prosperous ecological civilization and promote harmony between people and nature in China, the China Council for International Cooperation on Environment and Development (CCICED) established the Task Force on Ecosystem Service and Ecosystem Management. It was co-sponsored by CCICED and EU-China Biodiversity Program (ECBP) and commenced work in December 2008. The Task Force was asked to:

(1) Assess the economic and social benefits of sustainable ecosystems management based on an ecosystem service approach;

(2) Identify better practices in ecosystem management from Chinese and international experiences;

(3) Recommend how to better integrate ecosystem services into development decision-making in China.

CCICED asked the Task to focus on forests, grasslands and wetlands, and their respective services (as the marine and urban biomes are the focus of separate CCICED work).

The ESMS Task Force was co-chaired by Prof. Chen Yiyu, Standing Committee Member of the National People's Congress and President of National Natural Science Foundation of China, and Prof. Beate Jessel, President of Federal Agency for Nature Conservation, Germany. The Task Force comprised ten members and two invited consultants from government departments, international organizations and research institutes (see Section 8). More than twenty supporting experts contributed to the Task Force's work. The Task Force held two international workshops, four workshops and four field trips, supplemented by inter-sessional working groups for case studies and also scenario analysis. Consultation meetings with key ministries in China were held to better understand relevant national policies

and benefit from their experience.

This Executive Report presents the main findings and policy recommendations of the Task Force for improving China's ecosystem services and ecosystem management. In Section 2, ecosystem services and ecosystem management are defined. The current status and trends of major ecosystems in China, the institutions for ecosystem management and the progress of key ecological programs are assessed in Section 3. Three scenarios examining potential land cover and ecosystem services changes were prepared: Current Trends, Planned Development (socio-economic development targets adopted 2020, 2030 and 2050), and Optimized Development. The policy implications are summarized in Section 4. In Section 5, Chinese experiences in sustainable ecosystem management from the Loess Plateau, Poyang Lake, Chinese Ecosystem Research Network (CERN) and Baoxing County are summarized. Lessons are also drawn from international experiences of ecosystem management relevant to China. The Task Force's findings are discussed in Section 6 leading to recommendations in Section 7.

The methodology applied by the Task Force is shown in Figure 3-1, illustrating how the lessons from case studies, scenario analysis and consultation with key organizations contributed to the findings and recommendations.

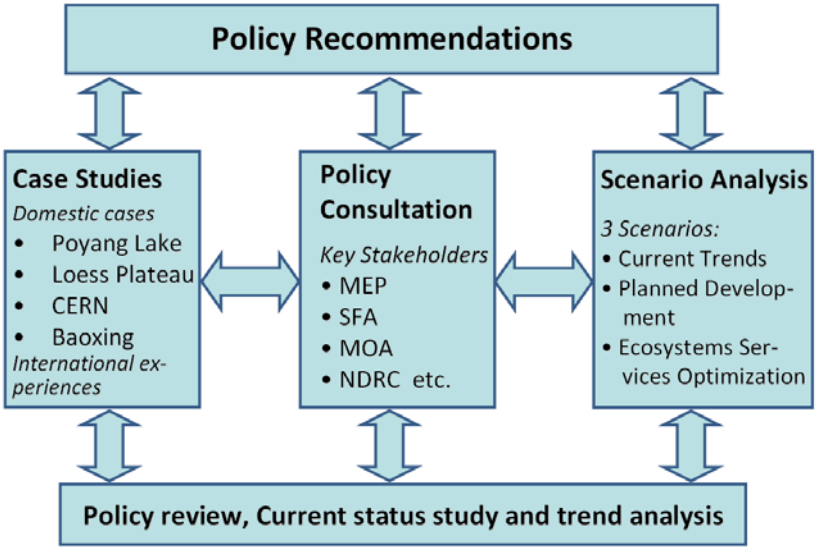

Figure 3-1 Methodology of the Task Force on Ecosystem Service and Ecosystem Management Strategy

A series of consultation meetings with key ministries on ecosystem management, including the Ministry of Agriculture, State Forestry Administration, National Development and Reform Commission, and Ministry of Environmental Protection – among others-enabled the Task Force to benefit from their experience and test and refine draft policy recommendations. This report presents the concepts of ecosystem services and ecosystem management, the status of major ecosystems and ecosystem management in China, key results and implications from Chinese and international cases studies, and the scenario analysis. The major findings and policy recommendations for China's sustainable ecosystem management are then detailed for consideration by decision makers.

This work was only possible thanks to core funding from CCICED and the EU-China Biodiversity Conservation Program for Task Force activities.

3.2 Concept of Ecosystem Services and Ecosystem Management

3.2.1 Definition and Importance of Ecosystem Services

The Millennium Ecosystem Assessment (MEA) defines ecosystem services as the benefits people obtain from ecosystems.[1] These include provisioning, regulating, cultural and supporting services. Provisioning services are the products people get from nature, such as food, fiber and fresh water. Regulating services are the benefits people obtain from ecological processes, such as flood mitigation, climate regulation, and water purification. Cultural services are nonmaterial benefits like knowledge, recreation, spiritual and aesthetic values. Supporting services are those necessary for the production of all other ecosystem services, such as production of biomass and oxygen, soil formation and retention, nutrient cycling, water cycling, and the provision of habitats for plants and animals. Biodiversity is not defined as a single service, but it underpins the generation of all ecosystem services. The relationship of biodiversity to ecosystem services and human well-being is shown in Figure 3-2.

[1] Millennium Ecosystem Assessment, 2005. *Ecosystems and human well-being: synthesis.* Island Press, Washington D.C.

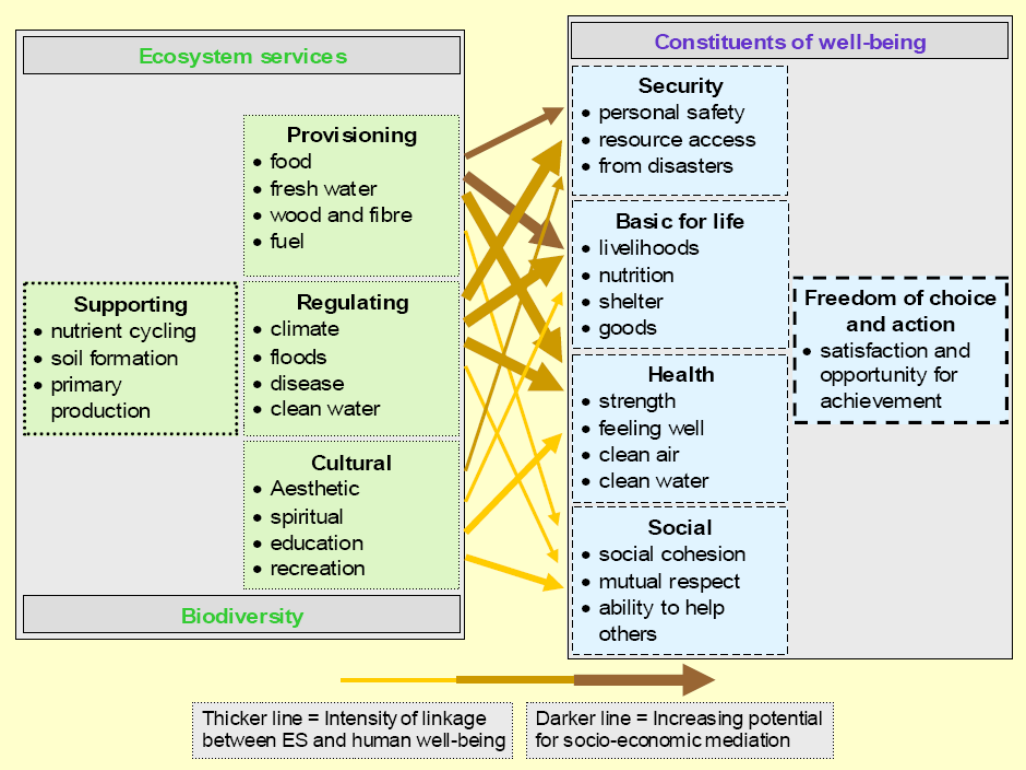

Figure 3-2 Biodiversity Underpins the Generation of All Ecosystem Services, and These Services are of Fundamental Importance for Human Well-Being[2]

Different ecosystem services are closely interrelated. There are trade-offs in increasing the supply of one ecosystem service with generation of other ecosystem services (Figure 3-3). In particular there is a tension between provisioning and regulating services: increasing provisioning services such as food production might lead to the declining of regulating services, such as flood mitigation. Therefore decisions related to a single ecosystem service should consider the implications for linked ecosystem services. For example, expanding agriculture polders on floodplains may reduce the area of land available to store and safely release flood peaks (Figure 3-3, MU1 to MU4). This highlights the problem when decision-making in one sector (e.g., agriculture, water, or forests) does not consider all the implications for other sectors.

[2] Millennium Ecosystem Assessment, 2005. *Ecosystems and human well-being: synthesis.* Island Press, Washington D.C.

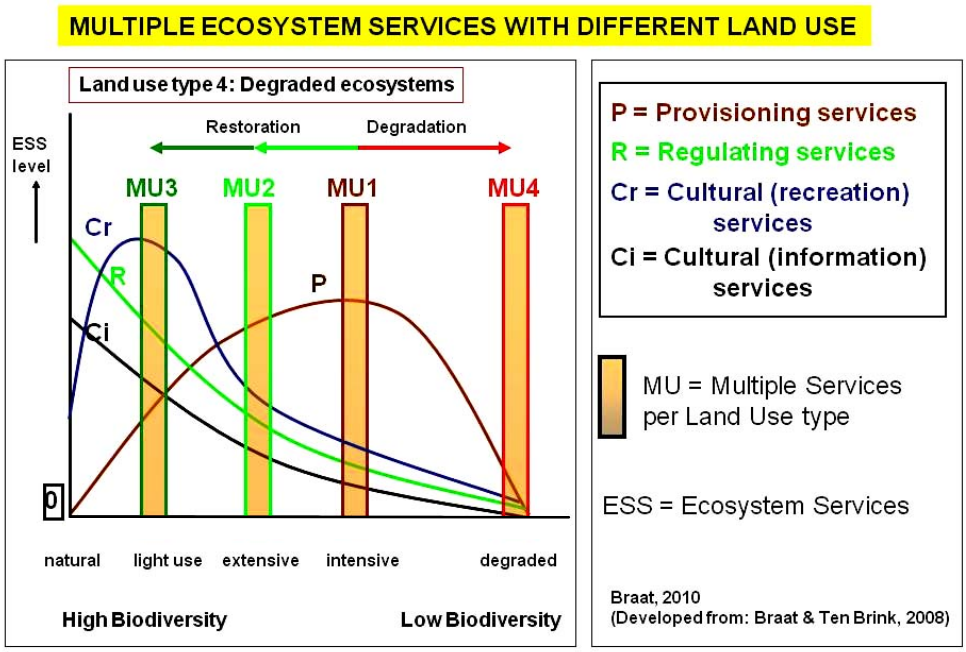

Figure 3-3 Restoration Steps or Degradation Use of Intensive Lands Leads to Different Levels of the Mix of Ecosystem Services in Other Land Use Types

This report considers two ways in which generation of ecosystem services could be increased. In Figure 3-3, starting at intensive land use (e.g., agriculture on steep slopes) there are restoration steps (MU1 to MU2 and MU3; e.g., afforesting steep slopes), leading to generation of a more diverse mix and greater total provision of ecosystem services. In Figure 3-4 increased yield of ecosystem services is achieved per hectare with an extra energy input (e.g., labor, fertilizer), but this risks soil changes (e.g., excess nitrogen levels, degradation of micro-biota), so that regulating services may decrease.

Generation of ecosystem services is affected by various factors, such as changes in demographic, economic, social, political, scientific and technological, cultural and religious, physical, biological and chemical conditions. Any natural, semi-natural and managed ecosystem can provide some combination of ecosystem services and contribute to social development. However, with the fast growth of society, the gap between the capacity of ecosystems to supply services and human needs is steadily widening. In the last 50 years, 60% of the ecosystem services worldwide have been degraded due to the increase in global popula-

tion and economic growth.[3] In China, the degradation of ecosystem services (Section 3.3.1) has constrained sustainable socio-economic development in recent decades. For example, the current demand for freshwater use in northern China exceeds available supplies with negative socio-economic consequences: better ecosystem management can make more efficient use, and improve the quality and quantity of available water. Similarly, China now imports a large portion of its timber requirements: in future, better management of forests may increase local wood production. As a result, maximizing sustainable generation of ecosystem services by improving ecosystem management is urgent if China is to meet the needs of its citizens for a moderately prosperous ecological civilization.

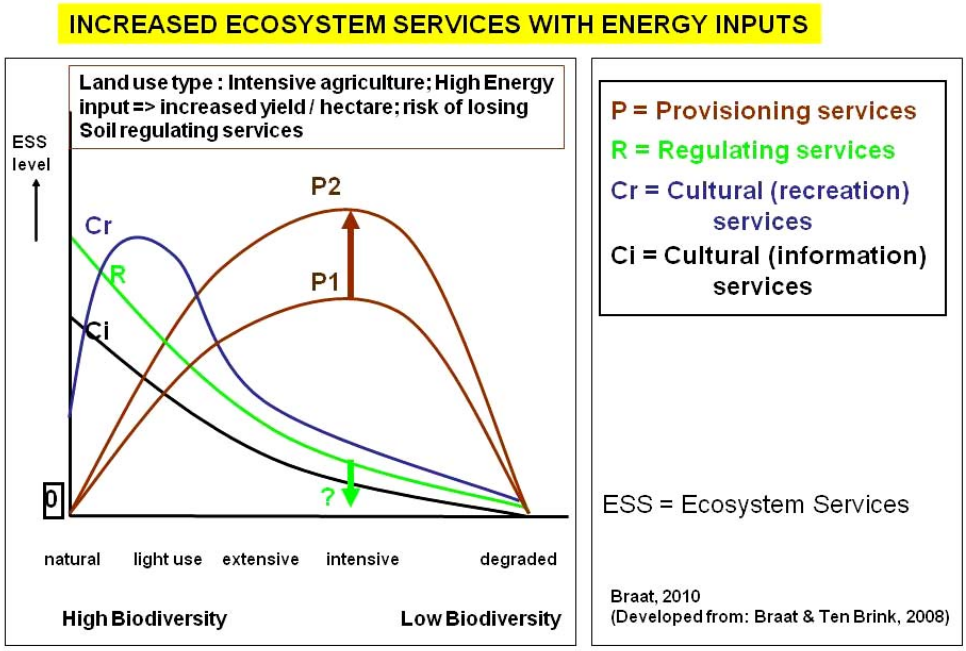

Figure 3-4 Increased Yield of Ecosystem Services per Hectare (P1 to P2) Requires Some Kind of Extra Energy Input but Risks of Degradation of Regulating Services

3.2.2 Definition and Importance of Ecosystem Management

The current concept of ecosystem management emerged in the 1980s with environmental reforms in some developed countries, such as in North America, and Western Eu-

[3] Millennium Ecosystem Assessment, 2005. *Ecosystems and human well-being: synthesis.* Island Press, Washington D.C.

rope. New approaches and tools for ecosystem management, and their extensive application, has played a significant role in helping to improve ecosystem management, enhanced the capacities of their ecosystems to generate services, and created better living conditions in these countries.

There are a range of different definitions for ecosystem management. These vary due to the different background of the proponent organizations and scientists, and their targets and operational objectives. To date, no single definition has been widely accepted. In the Chinese context, the Task Force has defined ecosystem management as: "the combination of management activities and all the laws, regulations, other institutions, education and public behavior that contribute to sustainable provision of ecosystem services." Good practice in ecosystem management includes the following components:

(1) Developing management goals Clearly-defined management goals provide the basis for implementing ecosystem management. To develop science-based goals it is necessary to understand the structure, function and dynamic features of the ecosystem, the local site conditions, as well as the ecological, social and economic needs of the policy-makers and the general public. For example, if a goal is to maximize provision of clean water from a catchment to a city, then provision of conflicting ecosystem services may need to be curtailed, such as restricting agricultural or timber production.

(2) Defining the temporal and spatial scales Ecosystem management occurs at specific temporal and spatial scales. Changing the temporal and spatial scales often leads to alternative management actions. Ecosystem management goals provide the basis for defining appropriate temporal and spatial scales. For example, a goal of maximizing wild fish catches may require the seasonal opening of sluice gates between the Yangtze River and adjacent lakes to enable fish to breed and thrive, whereas maximizing crop production on lands around such lakes may require water levels to remain constant.

(3) Selecting the appropriate ecosystem structure Ecosystem structure has horizontal and vertical components depending on the species to be selected, their habitat needs, and the spatial interaction between/among these species. Knowledge of the biological and ecological features of the target species and ecosystems is needed to inform decisions on appropriate management actions. For example, populations of giant pandas are culturally significant and support a large tourism industry in China. To conserve them in the wild in most years only a small area of forest may be required, but in the years when bamboo dies back, very large areas of habitat must be available for their populations to survive.

(4) Balancing different ecosystem services To meet human needs different man-

agement approaches are applied to natural and man-made ecosystems. Usually, natural ecosystems (including the near natural forest) are managed for regulating and cultural services, such as soil erosion control in forested catchments and flood retention of wetlands. Man-made ecosystems are used to provide provisioning services, such as intensive timber production from planted forest and grazing of grasslands, maximizing the supply of some services at the expense of others. For example conversion of coastal wetlands to aquaculture ponds has increased supply of shrimps, but at the expense of services such as wild-caught fisheries and shell fish, plant products, storm surge buffer zones and biodiversity. By understanding these trade-offs between ecosystems services, multi-purpose management strategies can be applied to maximize the provision of a range of services to better meet to human needs.

(5) Monitoring and assessing the performance of management actions Ecosystem management is a long-term and dynamic process. Ecosystems will respond to different management interventions in a positive or negative manner. For example, the re-vegetation of the Loess Plateau in China is one of the world's greatest examples of ecological restoration, and it has achieved its primary aims of reducing soil erosion and improving the livelihoods of local people. However two unanticipated perverse outcomes have now been detected: reduced water inflows into streams as the re-growth forest consumes more water, and use of an exotic tree species has reduced the opportunity to better conserve Chinese species. It is only long-term monitoring that has enabled these unanticipated negative impacts to be identified for corrective actions. Hence, it is necessary to monitor and assess the performance of management activities to enable ecosystem managers to make necessary adjustments to achieve better outcomes for people and nature.

(6) Public participation in ecosystem management The concept of ecosystem services recognizes that people are intimately linked with ecosystems and that successful ecosystem management is only possible with public participation. Public engagement is critical to draw on local knowledge to improve management interventions, gain additional resources, and engender the support needed from local residents to sustain such reforms. Therefore, while particular government authorities may play the leading role, it is necessary to fully engage other government agencies, non-governmental organizations, businesses and the general public in ecosystem management by means of legislation, consultation, education and public awareness campaigns.

Having defined and elaborated on the principles of ecosystem services and ecosystem management, we now look at the status and trends of ecosystems in China as the basis of the Task Force's assessment.

3.3 Status of Major Ecosystems and Ecosystem Management

3.3.1 Status and Trends of Major Ecosystems and Services

The major ecosystems considered by the Task Force are forests, grasslands, and wetlands. These three biomes cover about 63.8% of China's landmass. By one estimate, the value of their ecosystem services is between 74.4% and 81.5% of the total value of terrestrial ecosystem services in China.[4,5] We now outline the current status and trends for each of these ecosystems in largely qualitative terms (further quantitative data is summarized in the main report).

3.3.1.1 Forest ecosystems

Over the past 300 years, the area of forests in China declined up to 1960 and since then the area of forests has expanded mainly due to the regeneration of woodland, shrub and man-made forests since 1980. Man-made forests contribute about 90% of the increased forest coverage whereas the old growth natural forests are declining: the average annual reduction of mature forest is 610 000 hm^2. Comparing forest resources in the periods 1950-1962 to 1999-2003, the percentages of man-made forest areas and timber stocks have increased substantially, while those of natural forest areas and stocks have declined.[6] The seventh national forest resources inventory (2004-2008) reports that 20.36% of China has forest coverage. In spite of this afforestation, in recent decades, the volume of timber grown in China is insufficient to meet national demand, with a small forest area per capita (0.128 hm^2 per capita), uneven distribution, and poor generation of ecosystem services.[7] The value of ecosystem services per unit area decreased from 1977 to1998 and was then restored by 1999-2003 to the same level as 1977-1981.[8] From the perspective of the contribution of different ecosystem service types, provisioning services of forest ecosystems account for only small part of

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[4] Hao He, Yaozhong Pan, Wenquan Zhu, Xulong Liu, Qing Zhang, Xiufang Zhu. Measurement of terrestrial ecosystem service value in China. *Chinese Journal of Applied Ecology*, 2005, 16 (6): 1122-1127

[5] Wenquan Zhu, Jinshui Zhang, Yaozhong Pan, Xiaoqiong Yang, Bin Jia. Measurement and dynamic analysis of ecological capital of terrestrial ecosystem in China. *Chinese Journal of Applied Ecology*, 2007, 18 (3): 586-594

[6] Junkai Gao. Research on principal disturbances of forest health in China. *Forest Inventory and Planning*, 2008, 33 (6): 34-38

[7] Shidong Li, Xinliang Chen, Fanqiang Ma, Tielong Cheng. *China ecological status report 2009: ecological succession in China 1949-2009*. Beijing: Science Press

[8] Bin Wang, Xiaosheng Yang, Biao Zhang, Moucheng Liu. Dynamics of ecosystem services in China during 1973-2003. *Journal of Zhejiang Forestry College*, 2009, 26 (5): 714-721

the evaluated forest ecosystem services so far.[9]

Since 1999, the forestry development strategy has changed from one that focused on wood production to one that highlights both ecological and social benefits. Forest ecosystem degradation and resource depletion in China has been contained thanks to a series of new policies, increased investment, as well as expanded education and an awareness campaign. In particular, the implementation of six national forestry ecological programs (e.g., natural forest conversation, returning farmland to forest and grassland) has seen China's total forest area expand to 195 million hm^2, with a forest coverage rate of 20.4% and a forest stock of 13.721 billion m^3.

The lack of forests managed for conservation (rather than production), which play a key role in regulating, supporting, and cultural services, will pose a serious challenge for future forestry management in China. As a consequence, innovation to improve forest management, for integrated provision of ecosystem services is a priority for forest management in China.

3.3.1.2 Grassland ecosystems

Grasslands in China cover an area of about 41.7% of the total land area[10] with 84.4% of grasslands occurring in western China. Grassland ecosystem services account for approximately 17.9% of the terrestrial ecosystem services value in China.[11] The most valuable grassland areas are found in eastern and northeastern Inner Mongolia, Qinghai, Tibet, as well as in northern Xinjiang.[12] The value of grassland products (provisioning services) accounts for 22.3% of the total grassland ecosystem service values.[13] The share of national production from grasslands is limited, in terms of beef (14%), mutton (33%) and milk (33%).[14] Despite this low level of production, the natural grasslands have been heavily used and degraded. Remote sensing assessment shows a net loss of net of 11 860 km^2 of grassland ecosystems in China: three-quarters of this decline was in Northwest China and North China. The ecological status of grasslands in Southwest China and Central and South China improved slightly after the implementation of the Program of Returning Farmland to Grassland.

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[9] Fang Jin, Shaowei Lu, Xinxiao Yu, Liangyi Rao, Jianzhi Niu, Yuanyuan Xie, Zhenming Zhang. Forest ecosystem service and its evaluation in China. *Chinese Journal of Applied Ecology*, 2005, 16 (8): 1531-1536

[10] National Bureau of Statistics of China (2009). *China Statistical Yearbook 2008.* China Statistics Press, Beijing.

[11] Hao He, Yaozhong Pan, Wenquan Zhu, Xulong Liu, Qing Zhang, Xiufang Zhu. Measurement of terrestrial ecosystem service value in China. *Chinese Journal of Applied Ecology*, 2005, 16 (6): 1122-1127

[12] Lipeng Jiang, Zhihao Qin, Wen Xie, Ruijie Wang, Bing Xu, Qi Lu. Estimation of grassland ecosystem services value of China using remote sensing data. *Journal of Nature Resources*, 2007, 22 (2): 161-170

[13] Gaodi Xie, Yili Zhang, Chunxia Lu, Du Zheng, Shengkui Cheng. Study on valuation of rangeland ecosystem services of China. *Journal of Nature Resources*, 2001, 16 (1): 47-53

[14] Chunxia Lu, Gaodi Xie, Shengkui Cheng, Beibei Ma, Yue Feng. Rangeland resources utilization of China: Conflict and coordination between product function and ecological function. *Journal of Natural Resources*, 2009, 24 (10): 1685-1696

In contrast, agricultural reclamation continues to damage the ecosystems in the northeastern, northwestern, northern and eastern grasslands of China.

Since the 1950s, nearly 20 million hectares of high quality grasslands in China have been cultivated: 18.2% of the existing farmland across the country was converted from grasslands. Only 330 million hectares of grassland in patches of more than 25 hectares remain, and the productivity of grasslands has been reduced by 30%-50% since the 1950s[15] and national economic losses due to grassland degradation amount to US$ 6.66 billion during 2003-2005.[16]

3.3.1.3 Wetland ecosystems

China has more than 2 700 natural lakes with an area of over 1 km^2. Wetlands cover an area of 38.48 million hectares (excluding paddy fields) and 94.07% are natural. Research from various regions reports isolated examples of expansion of wetlands in some locations but an overall loss of wetlands is evident (and this is detailed with examples in the main report). The human factors responsible for degradation of wetland ecosystems include: agricultural cultivation and conversion (30.3%), pollution (26.1%), over-exploitation of biological resources (24.2%), to water and soil loss and siltation (8%), and unwise use of water resources (6.6%).[17]

The provisioning service values account for only a small part of the total ecosystem service values of wetland ecosystems. As a result of long-term development the extensive loss of natural wetlands in China has reduced the provision of ecosystem services, posing a serious risk to fishery production, water supply and biodiversity conservation. For example, ecosystem service values of wetlands on the Ruoergai Plateau decreased by 37% during 1975-2006, with a slight increase of the provisioning service values (about 300 million *yuan*) at the cost of 24 times (approximately 7.2 billion *yuan*) decrease in regulating (air regulation and water conservation) ecosystem service values.[18] Therefore, the key to sustainable use and protection of wetland resources lies in restoring and maintaining wetland areas.

This summary shows that there are many and complex mechanisms driving change of forest, grassland and wetland ecosystems. Population growth, livelihood needs and economic growth are often regarded as the most important direct drivers of ecosystem change. National and local economic and social policies can strengthen or weaken the intensity of hu-

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[15] Zongli Wang. Strategical thinking of protecting grassland ecology in China. *Grassland of China*, 2005, 27 (4): 1-9

[16] Ruijie Wang, Zhihao Qin, Lipeng Jiang, Ye Ke. Lost value of Chinese grassland ecosystem due to degradation: An estimate based on remote sensing. *Chinese Journal of Ecology*, 2007, 26 (5): 657-661

[17] Kun Lei, Mingxiang Zhang. The wetland resources in China and the conservation advices. *Wetland Scie*nce. 2005, 3 (2): 81-86

[18] Xiaoyun Zhang, Xianguo Lv, Songping Shen. Dynamic changes of Ruoergai Plateau wetland ecosystem service value. *Chinese Journal of Applied Ecology*, 2009, 20 (5): 1147-1152

man development and utilization of ecosystems. The tendency to focus on increasing the supply of provisioning services results in over-exploitation and impairs the capacity of ecosystems to generate regulating, supporting and cultural services as the environment is degraded. To positively regulate ecosystem processes at large temporal and spatial scales a set of combined legal, organizational, administrative, planning, financial and educational measures has to be taken into consideration. To maximize benefits for people, these interventions should promote sustainable management of ecosystems by balancing production of provisioning, regulating, supporting and cultural services of ecosystems.

3.3.2 Institutional System of National Ecosystem Management

3.3.2.1 Management system and cooperation mechanism

At the national level in China, government agencies that are closely associated with ecosystem management can be divided into: a) legislative and supervisory agencies (National People's Congress (NPC) and its Environmental and Resources Protection Committee), and b) administrative authorities, with the latter consisting of industry management departments (e.g., State Forestry Administration (SFA)), unified regulators (e.g., Ministry of Environmental Protection (MEP)) and integrated management departments (e.g., National Development and Reform Commission (NDRC)).

Due to the complexity of ecosystems, and ecological conservation and development, cooperation and coordination between sectoral institutions is particularly important. For example, the responsibility for developing and restoring forest, wetland and grassland ecosystems often rests with the separate sectoral authorities. Wetland ecosystems are under the jurisdiction of forestry sector in China. However, the water that is vital to sustaining wetland ecosystems is managed by the water resources sector, while the environmental protection sector is responsible for the management of water quality. The complexity and integrity of ecosystems requires exemplary administrative integration and coordination to maximize benefits for people and nature. However, the overlapping mandates of different institutions encourage competing measures if benefits are involved while encouraging 'passing the buck' in face of costs.

3.3.2.2 Analysis of the legal system of ecosystem management

The State Council recently emphasize[19] that resource conservation and environmental protection is a national priority, and that the legal system for environmental and resources protection should be reinforced. A basic legal system is in place for utilization, protection and management of forest, grassland, wetland ecosystems. Most of the laws and regulations

[19] *China's Efforts and Achievements in Promoting the Rule of Law*, published by the Information Office of the State Council on February 28, 2008

(including the *Environmental Protection Law*) have extensive provisions and principal rules with a broad scope but lack specific and operational regulations, and consequently they are too general to be easily implemented. Lack of mechanisms for broader public participation in ecosystem protection and accountability of government authorities is another major problem. The main laws related to forest, grassland and wetland management have the following challenges:

(1) The public tenure of these ecosystems, in terms of land and other resources means that they are owned by the nation or by local collectives. The lack of clarity as to the specific owner leads to a 'tragedy of the commons' situation, where it is in the interests of many people to exploit resources but no-one has a clear incentive or mandate to conserve them. Uncertainty as to the ownership can contribute to conflicts between the interests of the central, local governments and collective organizations, contributing to waste and damage.

(2) The complex legal framework for resources and environment management lacks clarity in assigning responsibilities, powers and rights for management of these ecosystems between various sectors, and the central and local governments in utilizing. In turn, this has contributed to the overlap of institutional functions and conflicts between their interests, which has diminished the effectiveness of these laws (Box 3-1).

Box 3-1 Examples of Legal Conflicts between Different Laws

In Law on Agriculture, Article 2 defines forestry as part of agriculture, and thus explicitly overlaps with the Law on Forest. The definition of fishery areas in the Law on the Prevention and Control of Water Pollution differs from fishery waters as stipulated in the Law on Fishery, making it difficult to decide whether the fishery department or the environmental protection department should be responsible for fisheries law enforcement.[20] Legal conflicts are also evident[21] in other areas, for instance the Law on Protection of Wildlife requires a license for hunting in steppe regions, otherwise hunting is considered illegal, but the Law on Grassland has no such requirement. Further, the exploitation of the same resource is regulated under some laws but not others. For example, the Law on the Conservation of Water and Top Soil regulates tree cutting, whereas the Law on Forest does not have corresponding requirements. The same action is illegal under some laws but not others. For example, conflicting uses can be authorized under different laws, such as livestock grazing and fisheries production in a wetland nature reserve, under laws in the forest (wetland) and agriculture sectors (grassland and fishery).

[20] Liping Song. The problems in the environmental legal system and recommendations. *Security, Health and Environment*, 2007, 7 (11): 2-3

[21] Canfa Wang. The limitation of the natural resource laws on nature conservation in China and the relationship between natural resource laws and nature conservation laws. *Environmental Protection*, 1996, (1): 43-45

(3) While the government is the regulator of resources and the environment, it lacks a legal obligation to promote conservation. Limited mechanisms for public participation, among others, have constrained the authority, practicality and accountability of environmental and natural resources laws. The government's failure to fulfill its environmental responsibilities is the major reason behind China's persistent environmental problems. Because of incomplete accountability systems in governments for conservation measures, the governments can easily make poor environmental decisions with negative impacts on the entire society.[22]

As a result, there is a need to develop the legal system to provide better guidance and supervision sustainable ecosystem management.

3.3.3 Outputs of National Ecological Programs

China has invested over 700 billion *yuan* (about 100 billion USD) and covered extensive areas in implementing its ecological conservation and restoration programs. There have been some positive results from key programs for better forest, grassland and wetland ecosystem management. In terms of forest ecosystems, the SFA reports that from 2001-2007 the total area in China that has been reforested is 42.6 million hm^2. The Chinese central government has invested 191.8 billion *yuan* in forest management.[23] Under the 'Grain to Green' program, 26.867 million hm^2 of land was reforested during 1999-2008. In the regions where the Program has been implemented the average forest coverage rate has increased by over 3%. For biodiversity conservation, by the end of 2008 China had established 2 538 nature reserves covering a land area of 15.5%, including 49.6% of natural wetlands, and many habitats and threatened species are under special state protection. The area in which the grazing is prohibited, suspended or rotated now amounts to 98.67 million hm^2.

Nevertheless, in the course of implementing these programs, some common problems have emerged including: a) poor preliminary verification and planning; b) difficulties in consolidating the ecological results, establishing follow-up industries, and securing ongoing financial support for implementation; c) lack of long-term supervision, monitoring and assessment mechanisms.

Besides the procedural problems in running ecological conservation and rehabilitation programs, another important constraint is insufficient consideration of the service provision from the restored or established ecosystems. For example, during the implementation of

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[22] Shuimiao Qian. Governments Environmental Responsibility and the Modification of the Environmental Protection Law. *Journal of China University of Geosciences* (Social Sciences Edition), 2008, 8 (2): 50-54

[23] Yucai Li. Great practice of the construction of ecological civilization: the 10th anniversary of the project of returning the grain fields to forest. *Forestry construction*, 2009 (5): 3-13

Grain for Green program, the criteria for performance evaluation were: a) the areas that had been reforested, b) the survival rate of tree seedlings. However, the health and long-term suitability of the rehabilitated forest ecosystems, and their socio-economic functions, which determine the sustainability of the reforested ecosystems have not been well managed. For these reasons it is critical to develop a scientific decision-making, integrated assessment and monitoring system for national key ecological programs into ensure the effectiveness of both procedures and provision of ecosystem services. In addition, there are problems with the ecological resettlement policy due to poor supervision and inadequate audit mechanisms in resettlement planning and construction most of the immigration planning. For instance, establishing new villages on lands incapable of the agricultural production required. In particular, immigration village sites and their construction have not been based on long-term, scientific planning, resulting in problems for the immigrants in sustaining their livelihoods.

3.4 Scenario Analysis

3.4.1 Introduction

Given the crucial role of land use and ecosystem policies in ecosystem service management, the Task Force conducted a *Scenario Study* to improve the understanding of the actual and potential contribution of ecosystems services from different land uses in China to national economic development. The objectives of the scenario analysis were:

(1) Assess the current status of and trends in ecosystems services in a “Business as usual” (BAU) scenario, focusing on forests, wetland and grasslands.

(2) Examine the potential contribution of ecosystems services management to the sustainable development of China in two alternative scenarios, the “Planned Scenario” and an “Optimized Development” scenario.

(3) Recommend a set of ecosystem service management strategies, policies and actions for the management of forests, wetlands and grasslands at different geographical scales that will maximize benefits for people and nature.

The research was conducted in a sequence of four analyses (Figure 3-5). A land use change model feeds an ecosystem service assessment, which then is the basis of an economic valuation. The results of these analyses form the basis for identification of policy options and informed the policy recommendations of the Task Force.

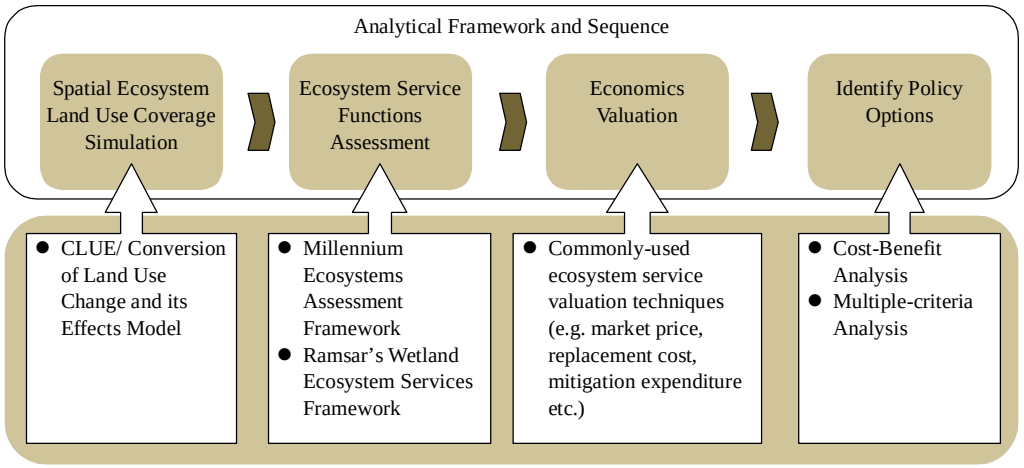

Figure 3-5 Analytical Framework and Sequence

The three scenarios were used for analysis:

(1) The BAU Scenario is based on extrapolation of the land use change from 1995 to 2000, right before the national ecological restoration program just started.[24] The scenario provided data to assess how would the landscapes change in the next 50 years up to 2050 if the same land use pattern is practiced and thus represents a kind of trend analysis. It enabled consideration of the effects on forest, grassland and wetland ecosystems, and how ecosystem services would be affected.

(2) The Planned Scenario is projected based on the targets for forests, grasslands and wetlands adopted by the sector administrations of the Chinese government plus the three rivers conservation zone in Qinghai Province, to intervene the BAU practice. The Planned Scenario is compared with BAU to assess the impacts of land use on ecosystem services.

(3) The Optimum Scenario integrates the results of the BAU and the Planned Scenarios, the results of the policy consultations which examined the gaps between the development targets and outcomes, as well as the inconsistencies between the sector-based development plans. This scenario included a complementary strategy to the sector-based ecosystem development plans. The spatial and temporal features of the ecosystem services which would prevent further possible ecosystem degradation in deciding investment in ecological rehabil-

[24] In January 2000, the Central Committee of the Communist Party issued No.2 Document, and in March the State Council approved a joint report by the State Forestry Administration, Ministry of Finance and the National Development and Reform Commission to start the Pilot Program of Returning Farmlands to Forests and Grasslands at upper stream of the Yangtze River and upper-middle reaches of the Yellow River, marking the beginning of a national ecological restoration program

itation at the national level were prioritized. This resulted in ecosystem development targets for greater sustainability, and which are closer to reality and more cost-effective (Section 3.4.2.5).

3.4.2 Assessment Methodology

3.4.2.1 Land use change assessment

CLUE[25] is a spatial model used to analyze land use change and its effects, giving multi-scale, quantitative descriptions through identification and quantification of the most important bio-geophysical and human drivers of land use change based on the actual land use structure. In this study is land use is analyzed in each of eight ecological zones.

3.4.2.2 Ecosystem service assessment

We drew on assessments of the relative capacity of different land use classes to deliver provisioning, regulating and cultural, including recreational, ecosystem services.[26,27] For each combination of land use and service type a relative score was generated, based on the capacity of the land use to deliver the service compared to the other land uses. This approach is based on literature review, expert knowledge, and a hypothetical framework as shown in Figure 3-3 and Figure 3-4 that shows how supply of different ecosystem services changes with land use intensity. The index values for each of the land use types in the CLUE models are based on the remaining biodiversity values from "natural" to "degraded" from the GLOBIO model.[28] Biodiversity is expressed with the indicator Mean Species Abundance (MSA), as detailed in the main report.

3.4.2.3 Future demands-supplies and economics

Due to data limitation, the biodiversity matrix was only used to estimate broad scale generation of provisioning ecosystem services, namely livestock stocking density on grasslands, timber production from forests, and a cultural function – forest tourism. Social, economic and demographic factors are identified as the drivers of ecosystem service consumption change. GDP growth and income change crossing geographic locations and/or in form of rural-urban convergence or divergence, population dynamics coupled by urbanization

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[25] Verburg, P. H., Overmars, K. P., Koomen, E., Stillwell, J., Bakema, A., & Scholten, H. J. (2007). Dynamic simulation of land-use change trajectories with the CLUEs Model. In *Modelling Land-Use Change-Progress and applications* (pp. 321-335). Dordrecht, The Netherlands: Springer

[26] Millennium Ecosystem Assessment, 2005. *Ecosystems and human well-being: synthesis.* Island Press, Washington D.C.

[27] Braat, L., & Ten Brink, B. (2008). *The cost of policy inaction, The case of not meeting the 2010 biodiversity target.* Wageningen, the Netherlands: Alterra, Wageningen UR

[28] Alkemade, J. R. M., van Oorschot, M., Miles, L., Nellemann, C., Bakkenes, M., & Ten Brink, B. (2009). GLOBIO3: A framework to investigate options for reducing global terrestrial biodiversity loss. *Ecosystems*, 12 (3): 374-390

momentum, and interactions amongst these social, economic and demographic factors are considered in estimating the future demands and supplies. Further details of the methodology are in the main report.

3.4.3 Major Results

Scenario analysis answers the questions of what the changes of the three studied ecosystem would be, the magnitudes of the changes, and where the changes would likely take place in three different scenarios.

3.4.3.1 Future scenarios: BAU vs. Planned

Remote sensing data of land covers (1995 and 2000) provided a land use trend and a baseline status of forests, grasslands and wetlands in China for the BAU Scenario. Forest as a whole was decreasing (–1.4%), due to decrease of *low-mid density forests* (–5.6%) coupled with a minor increase of *high-density forests* (1.0%). Wetland was decreasing slightly (–0.4%), composed of drop of *swamps and peatlands* (–1.6%) and marginal increase of *water bodies*. For grassland, *low-density grassland* declined by 35.9% while *high-density* went up by 16.6%, making the total area relatively stable (0.5%). As for other land use types, *built-up* area increased by 2.8% and *arable* land by 3.0%. *Unused* land areas decreased by 5.2% while *unusable* land increased by 1.4% in five years focused in the Northwest.

For the *Planned Scenario* (2000-2050), the land use requirements are the development targets set by the sector administrations of the Chinese government. The relevant policy restrictions on land use included (1) stabilizing the total *arable* land after 2005,[29] and (2) having the *built-up* area grow at the same pace to meet national social and economic development targets. Comparing the results of the BAU and the Planned Scenarios:

(1) In the BAU scenario all the three studied ecosystems decline, particularly high density grasslands in the dry Northwest Zone. An exception is *high-density forest* which experiences an increase of 10% from the baseline but the overall forest coverage drops by 42.5%. *Waterbodies* remain the same.

(2) The Planned Scenario sees all three ecosystems growing in area and quality. Total forest coverage reaches more than 3 million km^2 by 2050, with an increase of 30% from the baseline made up of an 80% increase of *high-density forest* and 50% decrease of *low-density forests*. Although the total grassland coverage remains unchanged, low-density grassland declines by 12.4% coupled with a 5.5% growth of high-density grassland by 2050. *Waterbodies* and *swamp* lands are better conserved with respective increases of 7%

[29] National Land Resources Bulletin.

and 16%.

(3) In BAU the *built-up areas* and *arable* lands increase by 22% and 31% respectively by 2050. In the Planned Scenario the *arable* lands remain constant and the growth of the built-up area is faster at 28.5%. *Unused* land is reduced sharply in the Planned Scenario. The *unusable* area remains unchanged in both Scenarios.

Given spatial and temporal variation in ecosystem services values it is important to understand where the ecosystem alteration happens and to what degrees. The results of this assessment by region are detailed in the main report.

3.4.3.2 Ecosystem services optimization – the Optimum Scenario

The Optimum Scenario was developed on the basis of policy consultations and by integrating the CLUE results with the case studies, and seeks to enhance generation of ecosystem services. Three major conditions differentiate the Optimum Scenario from the two previous ones: a) there is no more conversion from natural to artificial (planted) systems to maximize ecosystem quality; b) land conversion for forests and grasslands is only from low-density to high-density ecosystems; and c) forest coverage is limited to 28% by 2050 to leave land for other uses.

Four key issues arose in this scenario. Firstly, data quality limits the CLUE simulation, which in turn affects the results. The resolution of the remote sensing data is 2km × 2km. Further, there are gaps between the remote sensing data and statistical data (see main report). Given the highly temporally and spatially specific nature of the ecosystem services remote sensing data is the rational choice for analysis. This has policy implications because the development plans defining the Planned Scenario are based on the statistical data. Secondly, planning inconsistencies identified between the sector-based development plans have affected the simulation process. Double accounting, overlapping or insufficient statistical systems, and insufficient communications between the sector administrations in planning are the likely reasons. Thirdly, the BAU and Planned Scenarios highlighted that the Northwest and the Qinghai-Tibet Plateau have the highest probability for grassland and forest degradation if no policy interventions take place. Ecological restoration in these places would be more difficult once the ecosystems are damaged. Therefore prevention from degradation is equally or more important as restoration in the ecosystem development and management programs. Under the national ecosystem restoration programs the areas of planted forests and grasslands have increased but the value of ecosystem services generated by natural ecosystems is higher. Consequently, the Optimum Scenario focuses on improving ecosystem quality and preventing further ecosystem degradation.

At the national level, greater ecosystem services are generated by the Optimum com-

pared to the BAU scenarios (Figure 3-6). The major differences between the Planned and Optimum scenarios are with forests, where by 2050 the low density forest of the Optimum is 24% higher and the high-density forest is 20% lower. There is little difference with grasslands and wetlands.

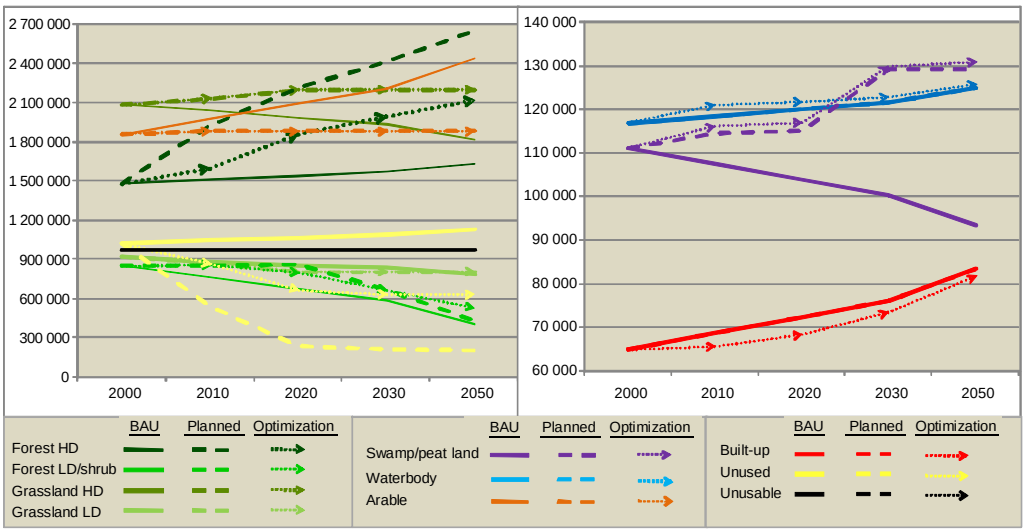

Figure 3-6 Land Use Change in the BAU, Planned and Optimum Scenarios

(Note: Y-axes are area, unit: km^2)

Further, in the Optimum Scenario 44% of the *unused* land from BAU will be converted to other types by 2050, compared to 80% in the Planned Scenario. The *built up* area in the Optimum is 2% lower than the Planned and the *arable* land is not changed. The land use trends in the scenarios are displayed in Figures 3-8.

3.4.3.3 Ecosystem service assessment (ESS), demands and valuation

ESS was assessed for each scenario through multiplying the area of grid cells with a certain land use change by the relative capacity of the new land-use types to deliver the different types of ESS, and is detailed in the main report.

Future demand for ecosystems services was inferred from the development projections of population and economic variables. Population is expected to peak between 2030 and 2040, with continued urbanization. This, together with the decrease of the GDP growth rate in the next few decades imply a slowing of the rate of increase of demand for ecosystem services, which may allow for better planning and matching demand with supply. Further, the likely shift of the growth to the tertiary sector may imply increase demand for higher quality food and water, together with higher environmental quality and more opportunities

for outdoor recreational activity.

As an illustration of the potential of the ecosystem services valuation to inform decision making, data from a case study in Shenzhen, China[30] were adjusted to be comparable at a global scale (Alkemade* et al., *2009)[31] and summarized in Table 3-1. For temperate forest, grassland and wetlands ecosystems, the economic values of a range of ecosystem services have been calculated. The total economic value (TEV) of the services considered illustrates that wetlands represent almost three times the value per hectare of forest, which is about three times higher than for grassland. However food values of grassland are more than three times higher than forest values, which illustrates the necessity to develop a varied landscape of ecosystems to maximize the supply of ecosystem services across a landscape (as compared to a particular hectare).

Table 3-1 China Ecosystem Services Values

Category of ecosystem services and land-use		Temperate forest	Grassland	Wetland
Ecosystem service name	Land-use name	GDP-adjusted usable values (EUR/hm^2)		
1. food	natural areas	45	134	134
1. raw material	natural areas	1 166	22	31
1. water supply	natural areas	1 435	359	6 949
2. biodiversity protection	natural areas	1 462	489	1 121
2. climate regulation	natural areas	1 210	403	7 666
2. gas regulation	natural areas	1 569	359	807
2. waste treatment	natural areas	587	587	8 150
3. recreation and culture	natural areas	574	18	2 488
4. soil formation and retention	natural areas	1 748	874	767
TEV (sum of valued services)	**natural areas**	**9 796**	**3 246**	**28 114**

1. = provisioning services; 2. = regulating services; 3. = cultural / recreation services; 4= supporting services. Source: Li, 2008; Chinese data adapted by Alkemade et al. (2009)[32]. The selection was made for this scenario study.

Climate regulation is very important in all ecosystems, particularly in wetlands. The carbon sequestration value of wetlands is very high, in the same order of magnitude as water supply and waste treatment, which are all essential features of an advanced society with sustainable quality of life as a prime objective.

The potential domestic supplies of specific ecosystem provisioning services (grassland

[30] Li Tianhong, Li Wenkai, Qian Zhenghan (2008) Variations in ecosystem service value in response to land use changes in Shenzhen. *Ecological Economics*, 2008

[31] Alkemade, J. R. M., M. v. Oorschot, et al. (2009). "GLOBIO3: a framework to investigate options for reducing global terrestrial biodiversity loss." *Ecosystems*, 12 (3): 374-390

[32] Li Tianhong, Li Wenkai, Qian Zhenghan (2008) Variations in ecosystem service value in response to land use changes in Shenzhen. *Ecological Economics*, 2008

carrying capacity and forest increment) and of a recreational service (forest tourism) were compared to their estimated demands in Figures 3-7~3-9). Unsurprisingly, as China is a rapidly growing country, domestic supply as a share of services declines between 2000 and 2050. Particularly striking is the decline in the supply of domestic forest products relative to demand, due to a rapid expansion of new construction and rising demand for paper. In interpreting these results, it is important to reiterate that domestic demand does not have to be met from domestic resources: livestock can be fed from grains, timber and pulp can be (and is) imported from abroad, and Chinese citizens can travel abroad or to non-forested areas for recreation. What the results suggest is that in the near future China will increasingly rely on imports or intensification of production of some commodities.

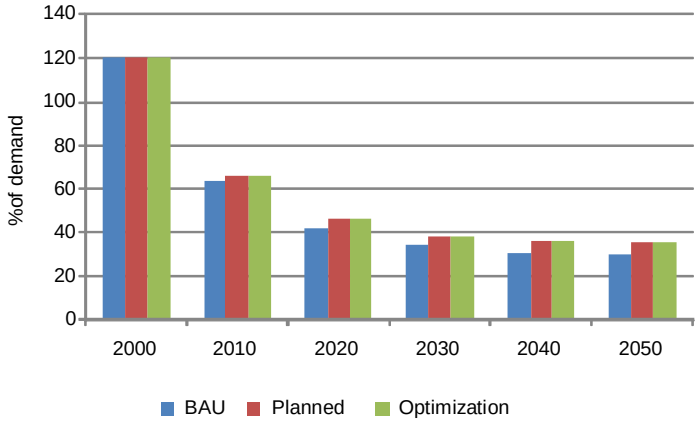

Figure 3-7 Grassland Carrying Capacity Provision, as Share of Demand

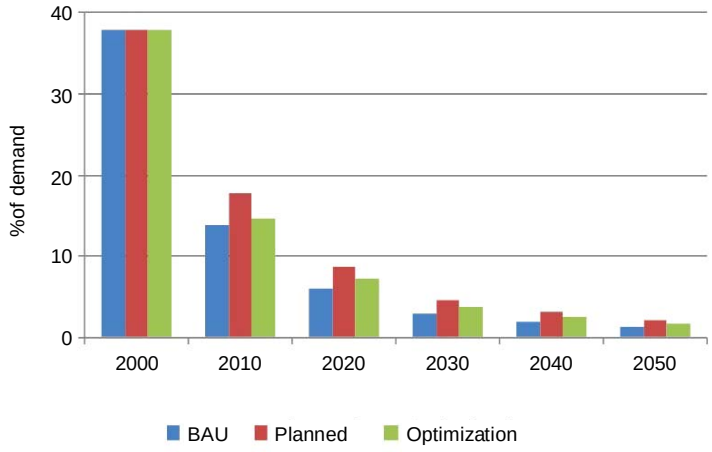

Figure 3-8 Forest Product Increment Provision as Share of Demand

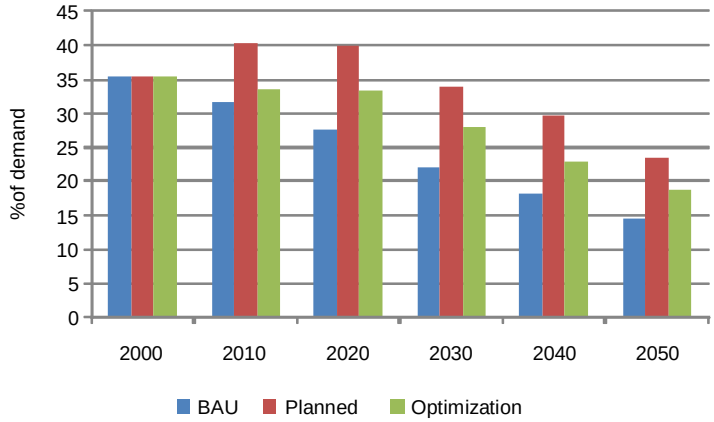

Figure 3-9 Forest Tourism Services as Share of Domestic Demand

Each of the assessed provisioning and recreational services (Figures 3-7~3-9) are estimated to be higher in the Optimization Scenario than under BAU, highlighting that better land use planning can generate more ecosystem services relative to China's historical trajectory. In general the Planned Scenario outperforms the Optimum Scenario in generating ecosystem services, but this is an artifact of statistical data that classifies the lands suitable for forest growing into the category of wood-covered land, and the limited economic data on the value of non-timber products. Therefore, the most revealing comparison is between the BAU and the Optimum Scenario, where the forest coverage target is set as 28% without including the forest suitable lands.

3.4.4 Summary

The following conclusions are drawn from the scenario analysis. BAU is likely to lead to lower ecosystem services. The Planned Scenario is more promising to achieve long-term economic welfare. However, the sector-based targets defining the Planned Scenario are inconsistent due to the gaps in data on which plans are or are not based. The optimum scenario, which restricts degradation and has less ambitious forest development targets, gives improved land use structure. This is expected to enhance the ecosystem service functions of forests, wetlands and grasslands. The improved land use structure in the Optimum Scenario does not generate improved MSA. The reason is the magnitude of the improvement in terms of areas of specific ecosystems is too small, which is overwhelmed by the major "loss" of forest coverage set for this scenario. However, the improvement in ecosystem quality should show better MSA values in the long term.

The Northwest is identified as an ecologically fragile zone, and would suffer the most serious degradation of forests, grasslands and wetlands without policy interventions. With the policy support further degradation would be halted and recovery of forests, grasslands and wetlands is possible. The BAU and the Planned Scenario highlight the necessity of zoning ecosystem service development and management, prioritizing prevention of degradation in the Northwest and the Qinghai-Tibet Plateau where the ecosystems are more fragile and more difficult to restore if they are damaged.

The substantial inconsistency identified between remote sensing and statistical data is not only a technical problem: it has substantial policy implications. Planning has long been based on the statistical data however remote sensing, as a high-tech based information instrument that better captures the spatial and temporal features of ecosystems, and should now be used in the policy making arena to improve decisions and outcomes.

3.5 Chinese Case Studies and International Experiences

3.5.1 Selection of Chinese Case Studies

The biggest challenge for ecosystem management in China is how to control ecological degradation and how to maximize various ecosystem services with ecological conservation and restoration. The Task Force focused on four issues in considering the domestic and international case studies namely, how to: a) balance the inter-relations among various ecosystem services so as not to emphasize one ecosystem service while neglecting others, considering that people focus on different ecosystem services in different areas and development stages; b) better coordinate the participation of different stakeholders; c) effectively leverage and enhance scientific support; and d) expand the experiences and best practices of identified in case studies to propose more effective models, policies and guidelines.

The Task Force under took Chinese case studies to examine the on-ground issues associated with ecosystem services and management, and to explore the perspectives of the key stakeholders. The four case studies were selected to draw on evidence from the county to national scales, covering a range of ecosystem services, and exploring key policies. They are: Poyang Lake and watershed, Loess Plateau, CERN (Chinese Ecosystem Research Network), and Baoxing County (Table 3-2) The case studies cover the three ecosystems that are the focus of the Task Force’s work,

Table 3-2 Overview of the Case Studies Assessed in This Study

Case study	Poyang Lake	Loess Plateau	CERN	Baoxing
Spatial scale				
National			√	
Eco-regional scale	√	√		
Provincial scale	√			
Local level		√		√
Predominant ecosystem services examined				
Provisioning services	√	√		√
Regulating services	√	√	√	√
Supporting services	√			√
Cultural services	√	√		√
Key findings and supported policy recommendations				
National planning			√	
Ecosystem approaches	√	√		√
Coordination and participation	√	√		√
Eco-compensation and investment	√	√		
Monitoring, assessment and education	√	√	√	

In particular: the case of Poyang Lake and its watershed focuses on the wetland ecosystems of the largest freshwater lake in China, with nearly 30 years of reforestation and restoration of the watershed under umbrella of Mountain-River-Lake Program of Jiangxi Province; the case of Loess Plateau focuses on the serious degraded ecosystems with 10 years restoration of *Grain for Green* Project after the heavy floods in 1998; CERN showcases the experiences of ecosystem monitoring, research and best practices of ecosystem management at national level; whereas the case of Boxing County, Sichuan Province examines the establishment of a cross-sector coordination mechanism for better ecosystem management at the local level.

3.5.2 Case Study of Poyang Lake

3.5.2.1 Lessons learned in ecosystem management

(1) Integrating wetlands in flood management. The flood retention capacity of Poyang Lake has declined due to wetland reclamation raising the question of how to manage the growing flooding risk. Since 1950 “hard” engineering solutions were applied with dykes and sluices, yet the flood risk grew every year. After the disastrous 1998 flood a “soft” river basin

management was adopted with the Central Government's "32-character policy". This included water and soil conservation through upstream reforestation and wetland restoration downstream.

(2) Engaging local community in wetland conservation. Over the past 27 years, Poyang Lake Nature Reserves and other 18 nature reserves with different conservation goals have been established. The management of these reserves has evolved from restricting access for local communities and outsiders at first to embrace co-management with local communities as well as extensive cooperation with international organizations, national research institutions and local NGOs.

(3) Coordinating different sectors at the provincial level. In order to coordinate the efforts of different government departments and local governments in ecosystem management, the Mountain-River-Lake Development Committee was established with the leadership of the Provincial Governor. It made a comprehensive plan for ecosystem restoration, which was implemented by different government agencies. After nearly 30 years the status of ecosystems and services has improved.

(4) Reviewing ecosystem conservation and restoration projects. The ecosystem management practices in Poyang Lake and its watershed were reviewed against the 12 principles of ecosystem approaches adopted by Convention on Biological Diversity[33] and found that governments at all levels did not meet all the principles, including planning, design, implementation, monitoring and evaluation.

3.5.2.2 Policy implications

(1) Strengthen wetland conservation and restoration. The ecosystem services of Poyang Lake have decline over the past 50 years despite a series of wetland conservation and restoration programs. Wetlands only cover 3.77% of China. Further restoration of wetland ecosystems and ongoing investment in ecological construction is required.

(2) Establish more effective ecosystem management mechanisms at the provincial or river basin level. More effective ecosystem management requires better sectoral coordination, the active participation of stakeholders to control the drivers of ecological degradation, ecological compensation mechanisms and substitute industries.

3.5.3 Case Study of Loess Plateau

3.5.3.1 Lessons learned in ecosystem management

(1) Long-term investment and commitment to adequately understand and address the complex array of natural and socio-economic factors impacting a particular site is the basis

[33] UNEP/CBD/SBSTTA/12/2, In-depth review of the application of the ecosystem approaches. 30 March 2007

for successful ecosystem management. Lessons learned from the 50-year ecosystem conservation program of Gaoxi Gully in Mizhi County, Shaanxi Province, as well as the 30-plus-year water and soil conservation efforts in Zhifang Gully, Ansai County, Shaanxi Province show the benefits of long-term investment and a stable policy framework for ecosystem management.

(2) Project implementation offers important opportunities for improving ecosystem management frameworks and processes, as exemplified by the project for restoring cropland to forest (or grassland) and the World Bank financed water and soil conservation project in Loess Plateau.

(3) Institutional innovation is the key to ensuring successful ecosystem management. In the Loess Plateau cooperation and integration between different levels of government and other stakeholders to capitalized on synergies between institutions and was important in maximizing the outcomes. Additionally, some local governments have an accountability system which incorporates ecological management outcomes, which is used to assess the performance of relevant officials and sectors in local governments. In terms of investment, funds for ecological management were sought from 'big contract owners'[34], and sustainable agriculture was developed. Project selection and design is increasingly based on feasibility studies and demonstration projects. Planning is being undertaken in an adaptive management framework, informed by monitoring and evaluation.

3.5.3.2 Policy implications

(1) Develop a scientific decision-making mechanism for ecological restoration and rehabilitation projects. Decision-making processes at every stage of a project should be formally structured and informed by the best available science, and tailored to regional conditions. Policies and regulations should be developed based on lessons learned from project work. Demonstration projects and feasibility studies should be undertaken before project selection, and project planning should be undertaken in an adaptive management framework, including ongoing monitoring and evaluation, and post-project evaluation to optimize project benefits.

(2) Evaluate administrative performance and cross-sectoral cooperation on ecological projects. The official cooperation system used in the water and soil conservation and restoring cropland to forest (grassland) programs, should be used to reform implementation of programs at the county level. Ecological protection and restoration needs to become a key indicator in evaluating the performance of local government.

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[34] Farmers or private companies who buy the land use right of cropland, forest or grassland from other individual farmers or villages with contracts to define the benefit sharing and time frame during the period of land release.

(3) Develop a diversified funding mechanism for ecological development projects, foster the ecological development industry and market, and promote the sustainability of ecosystem management. A range of investment models have emerged in the ecological projects in the Loess Plateau, including 'big contractors to improve environment', 'industry-fostered agriculture', 'industry investing in ecological development', and 'international aid and loans'. These models proved that diversified financing of environmental protection and ecological development is possible and practicable. Diversified investment models can help leverage funds from the private sector in order to ease funding pressure on governments, better engage the private sector in environmental protection and ecological development, and facilitate international cooperation. There is a need to formalize policies for diversified investment and create favorable conditions to encourage investment. In this way, ecological protection and sustainable development in China can become more integrated into mainstream social and economic frameworks.

3.5.4 Case Study of CERN

3.5.4.1 Experiences and lessons learned from CERN

(1) Conducting monitoring, research and demonstration projects, in line with the central government's needs, underpins effective ecosystem management. CERN has developed a suite of ecosystem management models, customized to local conditions, by utilizing data collected over several decades linked to its demonstration projects. Unlike traditional research, CERN's activities have shifted from static, short-term surveys to long-term, dynamic monitoring, with study sites encompassing both natural and managed ecosystems. In this way, the research aims to not only reveal patterns of ecosystem change, but also to develop evidence-based, optimized approaches to ecosystem management that provide social, economic and ecological benefits.

(2) Strategic planning, network-based implementation and ecological data management are essential to long-term ecosystem monitoring and research. In 1988 and 2007, CERN conducted development planning to address key issues, including its organizational structure, scientific objectives, core research areas, capacity building and policy development. Over the last two decades, CERN has established monitoring protocols, and procured and upgraded field equipment to ensure the quality of its data.

(3) Building effective relationships with domestic and international organizations can maximise ecosystem management outcomes. CERN cooperates and exchanges information with other ecological site managers (including national agencies) to enhance long-term monitoring, network-based research, effective data management and data sharing. CERN has

strengthened international cooperation with other networks, such as ILTER, US-LTER, ECN and LTER-Europe, to learn about the latest concepts, technologies and tools for long-term monitoring and experimentation.

3.5.4.2 Policy implications

(1) Carry out long-term research and demonstration on ecological restoration and sustainable management in fragile ecosystems. With significant ecological changes occurring at global and regional scales due to the combined effects of human activities and climate change, we suggest that an assessment of the structural and functional changes of major ecosystems in China is required. This would allow the study of degradation processes and restorative mechanisms of various fragile ecosystems in central and western China. It would also facilitate the development of technologies and demonstration models, an action plan, and an integrated suite of tools to restore degraded ecosystems and assess the benefits of key ecological programs and projects.

(2) Build the capacity of national ecosystem monitoring and assessment project managers to provide scientific support to decision-makers for sustainable ecosystem management, including a more effective early-warning system; and a monitoring and assessment system that can be measurable, verifiable and reportable on ecosystems nationally, particularly those in key areas.

(3) Share the CERN experiences and lessons learned with other developing countries. The joint initiative of United Nations Environment Programme (UNEP) and Chinese Academy of Sciences (CAS) establishing the international ecosystem management partnership (IEMP) needs to promote ecosystem services, management and health in developing countries, especially in Africa, South and East Asia.

3.5.5 Case Study in Baoxing County

3.5.5.1 Lessons learned for ecosystem management

(1) As the county is the smallest governmental unit in China, the application of ecosystem management-including policy development, project planning and management-can only be possible from this level up.

(2) Developing the knowledge–base and shifting the priorities of policy-makers is a prerequisite for the effective implementation of ecosystem management. While the Baoxing County government recognizes the importance of conserving the local environment, there is a lack of deep understanding about sustainability, such as the interactions between ecosystem services and development. The County Government has developed an ‘Ecology-based Baoxing’ strategy, however, with policy continuing to be heavily influenced by traditional

land management models, the strategy is not resulting in significant outcomes for the local environment and the services. The focus of activities under this strategy – such as increasing forest coverage and the development of eco-tourism projects – has been on maximizing economic benefits.

(3) Public education and training are keys to implementing ecosystem management. As a systematic program, ecosystem management is quite different to the traditional sectoral management model. As a result, it is necessary to conduct public awareness campaigns and training activities to enable policy-makers, resource managers and other stakeholders to have a better understanding of ecosystem management.

(4) Establishing an integrated management institution and coordination mechanism is crucial to implementing ecosystem management. In the short term it is very difficult to change sectoral management. For this reason and without changing the existing administrative system, it is necessary to adjust the function and scope of some sectors, develop a cross-sectoral coordination and decision-making mechanism, and establish a dedicated integrated management institution. The Baoxing Integrated Ecosystem Management Committee acts as a decision-making and coordination platform at the county level, and comprises officials of the county government and its agencies, experts and community representatives. Its major function is to make decisions about the plans and development projects proposed by various agencies of the county government, and coordinate the activities of agencies in order to implement the county government's directives for sustainability and integrated ecosystem conservation, and meet the needs of various stakeholders.

3.5.5.2 Policy implications

(1) A special ecosystem management committee and office should be established at the national level and in provincial, municipal and county jurisdictions which have important ecological assets. The committee would be the platform for cross-sectoral coordination and decision-making for natural resource management, planning, and development.

(2) To guide ecosystem management different levels of sustainability planning should be developed, based on the classification of eco-regions and major ecological functions.

3.5.6 Lessons Learned from International Experience

The international experiences in implementing ecosystem services and ecosystem management, drawn from developed and developing countries are rich and diverse. As a whole they suggest that any move towards managing for ecosystem services requires extensive ecological knowledge, a long time frame for implementation, the support of coordinated multi-disciplinary research, and extensive stakeholder engagement. The Millennium Eco-

system Assessment (MA)[35] provides a strong basis for understanding the consequences of ecosystem change for human well-being, and the broad actions needed ensure the sustainable use of ecosystems and their services.

International experience has identified many general strategies for more effective implementation of policies related to ecosystem services and ecosystem management. A study on The Economics of Ecosystems and Biodiversity (TEEB) undertaken by several European Union countries and the United Nations Environment Programme detailed need to develop national plans for ecosystem services that include: [36]

(1) Rewarding suppliers of ecosystem services through payments and markets;

(2) Reforming subsidies that harm ecosystems;

(3) Responding to losses of ecosystem services through regulation and pricing;

(4) Adding value through expanding protected areas;

(5) Investing in ecological infrastructure;

(6) Ensuring equity and the institutional arrangements are in place for equitable access and use of ecosystem services across the different groups of users.

Additionally a synthesis of lessons learned from international case studies[37] suggests the following prerequisites for the successful management of ecosystem services:

(1) There must be measurable time bound objectives, and ecosystem services should be made specific and quantifiable.

(2) Management should recognize the full spectrum of human impacts, and consider actions ranging from preserving intact ecosystems, restoring damaged ecosystems and allowing appropriate use of less threatened ecosystems.

(3) The stakeholders for setting management goals and insuring enforcement include local communities, national or regional governments, industry, and scientific institutions.

(4) An agreed framework is required to mediate conflicts among stakeholders, using tradeoffs in ecosystems services as a negotiating platform.

(5) Instituting ecosystem service based management requires investments in the form of payments, or restoration, or monitoring, and stakeholders who benefit most from the ecosystem services being managed pay for these investments.

(6) Allocation of payments or funds for ecosystem service management should be dictated by the underlying ecology, and the performance of the management activities being undertaken. Regions that supply more ecosystem services and particularly successful

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[35] Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being. Synthesis*. Washington, D.C., Island Press

[36] The Economics of Ecosystems and Biodiversity (2009)

[37] Natural Capital Project

projects should receive more funds.

(7) Demonstration of benefits to people (clean water, flood protection, hydropower, fish to eat, irrigation for crops, jobs, etc.) is important in the early stages of innovation and promotion of ecosystem services and ecosystem management.

(8) Management strategies should be dictated by the ecology and geology.

(9) Funding to promote ecosystem services and ecosystem management should be commensurate with the scale of the problem. Under-investment can fail to protect ecosystems, whereas over-investment could retard economic growth.

Satisfying the majority of these criteria will greatly aid ecosystems services and ecosystem management. In general, experience demonstrates that good science linking management practices to ecosystem services outcomes, clear identification of beneficiaries, government-developed regulatory policy, clear stakeholder responsibility buy-in and participation, and the existence of mechanisms for sustainable funding are key factors associated with successful implementation of ecosystem services management. There is a strong need to enhance coordination between and amongst governments at various levels, and the contribution of community and private sector organizations towards ecosystem services conservation, restoration and management.

Policy and program innovations in China can also benefit from international experience in market-based instruments for enhancing ecosystem services and management. There are a growing number of programs that are increasingly utilizing payments for ecosystem services (PES), known as eco-compensation schemes. These consist of negotiated contractual arrangements involving direct payments between those who can provide, and those who benefit from ecosystem services. It should be noted that policy frameworks for the development of PES and other market-based instruments in China are rapidly taking shape.[38] Internationally, direct payment schemes have begun to flourish and have expanded beyond government-funded initiatives to real market transactions between beneficiaries and providers of services.

In 2007 the market for ecosystem services at the international level was estimated to be approximately USD$77 billion worldwide. Total payments are expected to increase to approximately USD$300 billion by 2020.[39] Internationally, biodiversity and certified

[38] Bennett, M.T. 2009 Markets for Ecosystem Services in China: An Exploration of China's "Eco-compensation" and Other Market-Based Environmental Policies. *A report from Phase I Work on an Inventory of Initiatives for Payments and Markets for Ecosystem Services in China Forest Trends*

[39] Carroll, N. and Jenkins, M. 2008. *Payments for Ecosystem Services (PES) Markets: The PES Matrix* Chart. Washington, D.C.: Ecosystem Marketplace. Accessed at: http://ecosystemmarketplace.com, 2010

eco-labeling markets are the most active. In China, markets for carbon and certified agricultural products are expected to account for a significant proportion of the growth in markets for ecosystem services in the near future. The World Bank study of markets for ecosystem services in China concluded that a clearer and more comprehensive picture of the status of markets for ecosystem services in China, including the key actors and the distribution of activities across ecosystem services and regions, can provide valuable insights for policy-makers in terms of where cross-collaboration across government ministries could be most beneficial.

The experience generated by TEEB[40] provides valuable guidance on practical policy responses to the impacts of losses of biodiversity and ecosystem services, and highlights the inextricable link between ecosystem services and poverty. The study also concludes that the achievement of several Millennium Development Goals (MDG) was at risk due to the neglect and deterioration of ecosystem services and biodiversity. TEEB demonstrates that analyzing the value of biodiversity and ecosystem services enhances the case for strong international action to curb greenhouse gas emissions. It also highlights the inherent value for money in investing in natural capital to help both climate change mitigation and adaptation. Although there is significant international experience to inform policy choices, many gaps still remain. According to the TEEB study, the lack of market prices for ecosystem services and biodiversity means that the benefits derived from these goods are neglected or undervalued in decision-making. This leads to actions that result in biodiversity loss, unsustainable development, and adverse impacts on human well-being. These issues are likely to be growing global concerns in years to come. Clearly, the legislative protection of areas critical to the sustainability of ecosystem services needs to be strengthened and effectively enforced.

China can learn much from international experience in ecosystem services and ecosystem management, and avoid the pitfalls of inadequate policy coherence and lack of coordinated implementation by developing a firm national strategy for the use of ecosystem services and ecosystem management as the basis for decision-making. Unanticipated collateral benefits are also likely with ecosystem-based policy and decision-making. Departure from previously fragmented management initiatives can contribute substantially to sustainability, and innovative management can reduce the likelihood of the need for trade-offs when making policy and management choices. Stronger support must be provided to scientific and technological research towards ecosystem services and ecosystem management.

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[40] TEEB – The Economics of Ecosystems and Biodiversity for National and International Policy Makers – Summary: Responding to the Value of Nature, 2009

3.6 Major Findings

Progress has been made in conserving and restoring ecosystems in China, in the context of rapid development and globalization. Nevertheless, sustainable ecosystem management faces serious challenges from the huge demand for socioeconomic development drawing upon finite ecological resources. The mission of the Taskforce is to provide advice on how best to manage these challenges. We found:

3.6.1 Some Advances have been Made in Ecosystem Conservation and Restoration, However the Capacity of China's Ecosystems to Generate Multiple Services is too Low

Since 1998 the Chinese Government has increased its support for ecological conservation and restoration of forest, grassland and wetland ecosystems. More than 700 billion *yuan* (about 103 billion USD) was invested in key programs, including returning cropland to forest (or grassland), natural forest conservation, returning cropland to lake, and returning grazing land to grassland. Forest ecosystems have been protected, or improved with afforestation, and forest cover has increased to 20.4% of China's land area[41]. The rate of deterioration of grassland and wetland has also slowed, but related processes are still going on. So far 2 538 nature reserves have been established, covering 15.5% of China's land area.

Scenario modeling showed that business as usual would have led to lower generation of ecosystem services in China. However, even with the planned restoration and conservation of these ecosystems, there has often been a one-sided focus on certain provisions likes food-production, water retention or prevention of erosion, neglecting other services such as biodiversity or carbon storage. A low level of generation of ecosystem service of forests, grasslands, and wetlands are indicated by:

a) Forest stand density per unit area that is well below the world average, there is an ongoing decline of the last few spots of natural and semi-natural forests;

b) Meat production capacity from grasslands that is only a third of the world average;

c) The ongoing decline in wetland ecosystems.

There is an opportunity to reverse this low level of ecosystem service provision and generate more services for China by improving ecosystem management.

[41] State Forest Administration, Results of seventh comprehensive survey of forest resources, 2009

3.6.2 Low Awareness of Ecosystem Services and Poor Ecosystem Management Remain as Great Challenges

Ecosystem services are the benefits people obtain from ecosystems. However, these benefits from ecosystems are not fully recognized and appreciated at present in China. Insufficient understanding of the complex and dynamic characteristics of ecosystems has led to overuse or misuse of ecosystem services, inducing environmental degradation and shortages of some ecosystem services in meeting societal demands. For example, overuse of natural forests for timber production resulted in the loss of forests and serious degradation before 1980s, and the logging ban reduced timber supply from the 2000s. More than 40% of China's demand for wood products is now met from imports. Although investment in ecosystem restoration has increased, the cost-effectiveness, ecological efficiency, and the sustainability of ecological restoration programs has not yet proven in a long run.

Moreover, key regional development plans have not fully recognized the value of natural grassland and wetland ecosystems. For instance, both the Poyang Lake and Jiangsu Coast wetlands are threatened by regional development plans approved by the State Council. Conflicts between different laws, regulation, policies, plans, and inadequate enforcement, are evidence of a poor understanding of the importance of ecosystem services and ecosystem management in China.

3.6.3 Less Land is Left in China for the Expansion of Forests, Grasslands and Wetlands, so China Now Needs to Enhance the Quality of Ecosystems and Their Capacity to Generate a Range of Services

The total area of forest, grassland and wetland occupy 55.6% of China's lands. The remaining 44.4% is farmland, built-up and unused land. There is no doubt that the built-up area will increase with rapid urbanization. To ensure food security, China has adopted a strict policy to protect farmland. As for the unused area, almost half is unusable, including alpine desert in the Tibet Plateau, arid Gobi Desert in the West Inner Mongolia Plateau, Taklimakan and other deserts in northwest China, and glaciers. Only 11% of unused land has potential for conversion to new uses, but only with large investments and often on account of related services such as biodiversity and regulating ones.

Chinese Government committed to increasing the forest area by 40 million hectares by 2020, and national sector-based plans for ecological conservation and restoration include targets for increasing the forest coverage rate substantially and maintaining the natural wet-

land area. Considering land use in China, it is difficult to expand one ecosystem without reducing the areas of other ecosystems. There are extensive and growing threats to grassland and wetlands, and ongoing reclamation of high value grasslands for croplands and urban development. Consequently, the management targets of forest, grassland and wetland ecosystem should be changed from expanding areas to enhancing the capacity to generate multiple ecosystem services per unit area.

3.6.4 Cross-sectoral Coordination and Public Participation Mechanisms are Crucial for Improving Ecosystem Management

Lessons from international experience are that successful ecosystem management depends on:

a) Planning and cross-sectoral coordination mechanisms focused on a multidimensional enhancement of ecosystem services;

b) Clearly-defined targets, comprehensive and objective monitoring and reporting systems;

c) Effective mechanisms for equitable sharing of costs and benefits;

d) Mechanisms for solving conflicts.

Lessons and experiences from Chinese case studies show that improved legislation, institutions and policy at the national, provincial and local levels can greatly improve ecosystem management, for examples:

a) Better cross-sector coordination at landscape (or regional) scale can best be achieved through planning and implementing of ecosystem restoration programs, which is vital to improve the real world effectiveness of ecosystem management (Loess Plateau case study).

b) Better coordination institutions at the provincial or river basin level are needed for effective ecosystem management. The Mountain-River-Lake Development Committee and Program of Jiangxi Province is a good example (Poyang Lake case study).

c) Effective local level ecosystem management systems can be achieved at the county scale with economic, social and economic benefits through better stakeholder involvement (Baoxing County case study).

Further, full participation of non-governmental organizations, enterprises and communities is important for determining and implementing locally adjusted and effective ecosystem conservation and restoration measures.

3.6.5 Scientific Support and Capacity Building Needs to be Strengthened for Better Ecosystem Management

The experience of CERN (Chinese Ecosystem Research Network) and the Loess Plateau case studies show that integrating monitoring, long-term research and demonstration projects provide essential technical support for better ecosystem management. Lack of adequate technical support is a barrier to adequate science-based policy-making and implementation of best practice ecosystem management in other parts of China. In particular there is:

a) Insufficient monitoring of the status of major ecosystems in terms of basic, real-time and reliable data, that is openly available to inform public participation, scientific research, and policy-making.

b) Lack of effective channels for science to inform policy, decision-making and practice. Consequently many scientific outputs are in a form that cannot be applied in practice, and many policies and plans for ecological conservation, restoration and rehabilitation are less effective than they could be.

c) A needs to focus on emerging global environmental issues-such as excessive reactive nitrogen and phosphorous in the environment[42] – that will impact on China. This uncertainty and risk needs to be managed with the knowledge generated by strategic monitoring and research.

d) Broader technical support of long-term ecosystem monitoring, assessment, and demonstration is needed to as a basis for better science education, public participation and policy-making, leading to the achievement of an ecological civilization in China.

3.7 Policy Recommendations

China is facing great challenges in meeting increasing economic and social demands with limited natural resources and limited generation of ecosystem services. In China, 7% of the world's arable land, 4% of forests, 14% of grasslands and 10% of wetland ecosystems support 1.3 billion people-22% of the world's population. The ecosystems provide necessary services, which range from food and timber to water, climate regulation, carbon storage and biodiversity. During the process of industrialization and urbanization, GDP per capita is forecasted to increase four-fold from 2000 to 2020[43], more than half the population will live in

[42] Rockström, J., Steffen, W., Noone, K., Persson, A., et al., 2009. A safe operating space for humanity, *Nature, 461* (24 September 2009): 472-475

[43] Central Government Bulletin, 2007

urban areas, and the demand for ecosystem services will increase sharply. To meet the gap between the supply and demand of ecosystem services, ecosystems should be managed in a more sustainable way. The Task Force recommends that the Chinese Government develops a national strategy on sustainable ecosystem management of equivalent stature as the national strategies on family planning, environment protection and resource saving. Important elements of this national strategy should include: adoption of a new national plan on ecosystem conservation and development; enhancement of the capacity of ecosystems to generate multiple services to meet increasing demand; support for sustainable development through better planning, cross-sectoral coordination, legislation, additional funding; and increasing long-term research and technology capacity. Specifically, the Task Force recommends that the Chinese Government.

3.7.1 Adopt a New *National Plan on Ecological Conservation and Development* to Guide and Integrate Sectoral and Regional Measures

To provide a mandate and guide consistent ecosystem management across China, a new *National Plan on Ecological Conservation and Development* is needed, based on the *National Plan on Eco-environmental Development* and the *National Guideline on Ecological Conservation.* This new plan should establish a comprehensive assessment mechanism for the maintenance and multidimensional optimization of ecosystem services that should be applied within the national planning system and to all programs and projects. This would provide a comprehensive basis for ecological development planning across sectors, regions and key river basins. Consequently, renewed efforts should be made to:

(1) Adopt the ecosystem approach to guide all planning, to implement the twelve principles of the approach of the *Convention on Biological Diversity*. The CBD's principles should be adapted to the Chinese context. The guidance principles are applicable to all relevant plans, programs and projects, and they address sustaining productivity and biodiversity, equity, poverty alleviation, and monitoring and assessment.

(2) The overall objective of the plan would be to build healthy ecosystems in China. The plan should increase generation of multiple ecosystem services through fine scale land use zoning, to reduce excessive exploitation of provisioning services over broad areas, while increasing output from smaller areas of highly productive lands. Efforts are now required to better conserve natural forests, grasslands and wetlands. These should focus on enhancing the regulatory services and biodiversity conservation so that the ecosystems can continue to provide multiple services. Conservation of remaining grasslands and natural forests and expansion of wetlands should take precedence.

(3) Set new targets and adopt measures to conserve natural forest, grassland and wetland ecosystems. China promulgated the *National Eco-environmental Development Plan* and the *National Guideline on Ecological Conservation* in 1998-1999 and has achieved its ecological objectives for 1998-2010. China now needs to further define its objectives and tasks for national ecological conservation and development in 2011-2020, based on the national major functions zoning program. In addition, particular regional targets and tasks for conserving key areas and river basins should be developed to enhance ecosystem services, such as carbon storage, water and soil conservation, and disaster prevention and mitigation-starting with Northwest China.

(4) Prioritize regions for ecosystem conservation and development according to the importance of ecosystems, population and economic pressure and threats. Within each priority region, the technical, engineering, biological and management approaches should be assessed. Sector-based projects and policies for forest, grassland, wetland, water and soil conservation need to be integrated at the regional scale to optimize investment.

(5) Establish supporting institutions and policies for formulation and implementation of the national strategy. It is recommended that the State Council establish a leadership group chaired by the Premier to take the lead, supported by an expert panel, following the models of the *National Science and Technology Development Plan*, and the *National Education Reform and Development Plan*.

(6) Additional, innovative institutional and policy reforms should be introduced in the national strategy, including: institutional reform (i.e. forest entitlement reform), market-based tools (i.e. decrease the disparity between transfer payments between different sector-based projects), centralization and decentralization (i.e. delegate more responsibilities and budget to provincial or even lower levels).

3.7.2 Improve Generation of Ecosystem Services from Forests, Grasslands and Wetland Through Sustainable Management in Priority Regions

Diverse measures are required to improve generation of ecosystem services according to different ecosystem types, and in different social and economic contexts. It is very important to balance supply of different ecosystem services and public interests, in particular, balancing generation of provisioning and regulating services so that decisions taken for social or financial benefits do not unacceptably compromise the long-term health of ecosystems. Consequently, more efforts should be made to:

(1) Enhance the management of forest ecosystems to improve their productivity without neglecting other services, such as regulating, cultural and supporting services. To this

end, forest ecosystem management in China should look beyond increased forest coverage to also improve forest quality. The Task Force recommends the following priority actions:

a) Intensive management of non-commercial planted forests for multiple purposes. In the fragile regions in the Loess Plateau, karst, hilly red soil areas the primary purpose of the forest should be providing regulating services, such as soil erosion control, water storage, flood retention capacity and carbon sequestration, while allowing reasonable use of timber.

b) Improve secondary forests to near-natural forests with more production of timber and other forest products, if management for biodiversity and soil conservation allows.

c) Strict protection for natural forests. They are important areas for biodiversity conservation, for carbon sequestration, and for studying adaptation to climate change. They should be strictly protected from conversion into other types of land uses.

The priority regions for intensive forest management for multiple purposes are: the temperate and sub-tropical reforestation region; the Loess Plateau water and soil conservation region; and the Southwest China karst stony desertification control region. Priority regions for natural forest protection are the Northeast and Southwest China natural forest regions.

(2) Restore degraded grassland ecosystems to control wind erosion and dust storms. Due to limited investment and poor management grassland ecosystems are still subject to reclamation for crop land and urban development, overgrazing, and overuse of other biological resources. The resulting grassland degradation causes severe wind-erosion and dust storms affecting the wide areas in Northern China. To reverse grassland degradation and safeguard the people from the dust storms, the Task Force recommends the following priority actions:

a) Increase investment in pastoral regions. Investment infrastructure, training and technical support is critical to sustain ecosystem services, including by improving grassland grazing systems and restoring degraded grasslands to ensure sustainable productivity for livestock.

b) Reduce the grazing pressure on grassland. Banning grazing, resting pastures, and supplementary feeding of livestock are key measures to reduce over-grazing and increase vegetation cover.

c) Support local people to enhance pasture management and alleviate poverty to combat desertification.

d) Respect the nomadic customs and traditional cultures of the ethnic minority groups, which have managed the pastoral regions sustainably in the past. Promote recreation services and eco-tourism to improve incomes and alleviate poverty for local people.

The priority areas for grassland restoration are in the semi-moist and semi-dry area in Northern China, semi-dry and dry area in Northwest China and Tibet-Qinghai Plateau.

(3) Protect natural wetland ecosystems to improve their biodiversity and regulating services. The significance of wetland conservation and wise use to counter increased environmental pressure and threats cannot be over emphasized in China. Besides the provisioning services of fish, freshwater, and aquatic plants, the wetlands also provide biodiversity and regulating services. The Task Force recommends the following priority actions:

a) Extend fishing bans in large rivers and lakes to manage overfishing and restore provisioning services such as aquaculture and wild fisheries.

b) Maintain and improve connectivity and environmental flows of the rivers, lakes and wetland to ensure their health and to increase the regulating services of water storage and flood retention.

c) Conserve and restore degraded wetlands as habitats for water birds, fish species and aquatic animals.

d) Encourage the establishment of national wetland parks to provide cultural and recreational services to communities.

e) Improve national policies and regulations for the preservation of different wetland types. Most urgent is the inclusion of wetlands as a land use type in the national land use inventory, and promulgation of the Regulations of the State Council on Wetland Conservation to provide a legal basis for wetland conservation and restoration.

The priority regions for wetland conservation and restorations are Northeast China wetlands, Central and Lower Yangtze River and lakes, coastal and delta wetlands in Eastern China and inland waters in Northwest China.

(4) Improve the ecosystem services and biodiversity of conservation reserves, especially national nature reserves. Nature reserves play critical roles not only in conserving biodiversity but also in providing a diversity of ecosystem services. The Task Force recommends the following priority actions:

a) Increase the area of biosphere reserves to create model regions of sustainable use and development that enhance the livelihoods of surrounding residents, including by sustainable use of provisioning services.

b) Generation of regulatory services should be enhanced by management of conservation reserves that should be changed from species-based approaches to ecosystem-based approaches, and a more comprehensive strategy is needed to establish on protected area networks and corridors at landscape or river basin scale (with reference to the Natura 2000 program in the EU and the wetland conservation network in Yangtze River basin).

c) Greater efforts to promote cultural and recreational services of nature reserves are needed (as these are currently focused on national parks and world heritage areas) and more grassland nature reserves need to be established.

d) The legislative process of Standing Committee of National People's Congress on nature reserve management should be accelerated (in consultation with the related government agencies and the public) as the current State Council Regulation on Natural Reserve is out of date.

3.7.3 Establish Effective Coordination Institutions for Sustainable Ecosystem Management at Central, Provincial and County Levels, and Increase Public Participation

Governments at different levels (i.e. central, provincial and county levels) are all involved in governance of ecosystem management, while the social groups (enterprises, communities and NGOs) play a critical role for implementing ecosystem management. As a result, the success of ecosystem management largely depends on enhancing coordination mechanisms within and between different levels of government, and fully leveraging the role of social groups in ecosystem management.

(1) Promote cross-sectoral and cross-regional coordination at the central level. The existing sector-based laws and regulations on environmental protection and natural resources should be reviewed to identify inconsistencies and conflicts between various clauses, and adopt amendments for forest, grassland and wetland ecosystem management. Ecosystem management should be mainstreamed in the agricultural, industrial, forest, environmental protection, water resources, and fishery sectors. Institutions for better coordination and cooperation should be established and improved nationally to solve the conflicts between different sectors and between upstream and downstream jurisdiction.

(2) Make the provincial governments 'overall accountable' for ecosystem management. Establish provincial coordination agencies to lead policy-making for ecological development, planning and management, facilitate cross-sectoral coordination and cooperation. The priorities are central and western provinces, municipalities and autonomous regions which face severe challenges in ecological development. The Mountain-River-Lake Development Commission of Jiangxi Province is a good example.

(3) Conduct pilot ecosystem management projects in selected counties in strategic central and western regions, based on the model of Baoxing County, Sichuan Province.

(4) Raise the awareness of enterprises, local communities and the general public of the importance of ecosystem management to fully engage them in this mission. Promoting corporate social responsibility (CSR) is an important component of ecosystem management.

Enterprises can benefit from regulating their production and operation activities and reducing their ecological footprint. Communities are the direct beneficiaries, as well as the people who monitor and maintain ecosystem services. The capacity of communities should be enhanced to better engage in ecosystem management, including through public and school education. Based on the international experiences of the Task Force team in Thailand and Europe, we note that NGOs serve as a bridge between the governments, enterprises and the general public; therefore, the government should provide legal and financial support for development of environment-based NGOs.

3.7.4 Promote the Establishment of Eco-Compensation Mechanisms and Long-Term Investment in Ecosystem Conservation and Management

Over the last decade, government investments and financial compensation for land managers has played a decisive role in the restoration of forest, grassland and wetland areas. As it takes decades to improve the condition and management of ecosystems, long-term investment is required to build on the initial work. Ecological conservation and restoration programs need to be expanded, in particular, in the ecologically fragile areas in central and western China with a focus on the river source areas, areas that suffer from severe water or wind erosion, key source areas for drinking water, grasslands and nature reserves. A new Regulation of the State Council on Eco-compensation is needed to guide such investments and thus to realize rural area's values and contributions to national welfare. Specifically, efforts should be made to:

(1) Extend funding and policy of subsidies to farmers for the existing national ecological development programs, including those restoring cropland to forest (or grassland), natural forest conservation, sandstorm source control in Beijing and Tianjin, restoring grazing land to grassland, and wetland and watershed conservation. There is a need to include forested lands derived from cropland into the scheme for state compensation for non-commercial forests. China has completed reforms that define the right for the long-term use of forested land and grassland. After 2016 when the extended compensation for restoring cropland to forest (and grassland) expires, the forested land should then be compensated according to the standard for non-commercial forest. To maintain the continuity and consistency of the policies, the compensation rate for non-commercial forest should be raised gradually to ensure the sustainability of the outcomes for the ecological programs, including that of restoring cropland to forest.

(2) Design and implement new ecological conservation and restoration programs in the ecologically fragile areas in central and western China, which should be closely integrated

with the new rural development and poverty reduction programs. These schemes should be planned at national level and implemented in different provinces, municipalities and autonomous regions in central and western China. Mechanisms such as financial transfer payments from the central government, investment in ecological development programs, and payment of ecosystem services should be employed to provide ongoing financial support.

(3) Establish financial incentives for rural areas providing ecosystem services. The rural areas as the providers of the diverse ecosystem services do not equally share the benefits from ecosystem conservation and social economic development. To achieve greater equity between poorer rural areas supplying services and urban consumers, payments and compensation should be established for generation of services that are not yet market based, such as water and climate regulation, carbon storage, disaster prevention and cultural values. This will allow those who provide these services to gain some financial benefits as an incentive for the maintenance of the source ecosystems from those who benefit from these services, and thus help to achieve “win-win” outcomes of conservation, provision of services and poverty alleviation.

(4) Define and revise the eco-compensation policies and implement eco-compensation pilot projects to expand the ecosystem services funded by their beneficiaries. Whenever beneficiaries can be clearly defined (i.e. for provisioning and cultural services), the principle of ‘whoever uses the services should pay the costs’ should be adopted. Where beneficiaries cannot be clearly defined (i.e. regulating and supporting services e.g., flood regulation), a non-commercial compensation fund for the people maintaining relevant forests, grasslands and wetlands should be established. Further, the Central Government should allocate a reasonable budget for national nature reserves within the eco-compensation scheme.

(5) Diversify investment and financing mechanism for ecological development, and foster the ecological development industry and market. There is much to be learnt from the diverse investment and financing models that emerged in the process of conducting the programs of restoring cropland to forest (or grassland), and water and soil conservation. Pilot projects for investment and financing system and preferential policies should be implemented and developed in selected areas in central and western China to leverage private sector funds.

3.7.5 Strengthen Ecosystem Monitoring, Long-Term Research and Training for Better Knowledge-Based Support of Ecosystem Management

Projects like reforestation of large parts of the Loess Plateau have shown how science and long-term research contributes to successful ecosystem management. However major

new challenges and risks are emerging that affect China's national interests and development in a long run. Examples include the impacts of climate change and the opportunities to sequester carbon in the landscape, and the emerging debate over excess emissions of reactive nitrogen into the environment from agriculture and fossil fuel combustion. These challenges and risks can best be managed by drawing on sound, long-term research and monitoring. A more effective ecosystem monitoring and assessment platform is required, specifically:

(1) Facilitate the development of nation-wide research networks with representative sites, such as the China National Ecosystem Observation and Research Network (CNERN). CNERN should be enhanced by increasing the capacity and regional distribution of their sites and providing long-term financial support so as to generate key data, demonstration models and technologies for more sustainable ecosystem management. Their work can be directed to emerging issues for China's national interests, such as carbon sequestration, climate change adaptation and excess reactive nitrogen.

(2) Conduct a national ecosystem inventory and assessment on a regular basis. The problem of reduced stream flows following afforestation of the Loess Plateau is the type of change that such an assessment could help identify so as to prompt solutions. The *in situ* ecological monitoring, remote sensing and ecosystem modeling can be applied to produce a national ecosystem inventory, which would underpin the development of the National Five Year Plan with relevant scientific information for priority setting.

(3) Climate change and ecosystem adaptation. Priorities include collection of scientific data on: ecosystem responses to climate change in the past; ecosystem adaptation to long-term climate changes; and short-term extreme events (such as floods, drought, and snow storms). Demonstration projects (or sites) are needed to pilot techniques for ecosystem adaptation to climate change.

(4) Promote education and training on ecosystem management: include ecosystem management into the text books for formal education and routine training of leaders at national, provincial and local levels (especially the Party School).

Chapter 4 Ecosystem Issues and Policy Options Addressing Sustainable Development of China's Ocean and Coast

4.1 The Importance of Sustainable Development for China's Ocean and Coasts

The next 10-20 years will be a key phase for China's strategic development and a critical period of rapid industrialization and urbanization. It also offers a chance to modify and perfect the country's development patterns. The international and domestic situations that China now faces are profoundly different than those of just a few years ago. Now, not only does China have to respond to the global challenges of financial crises and climate change, it also has to resolve increasingly serious domestic resource shortages and environmental issues in order to regain a pattern of sustainable development. Furthermore, faced with a depletion of land-based resources, the knowledgeable development of the ocean and coasts becomes an essential step on the path toward the sustainable development of the Chinese economy.

4.1.1 Oceans-The Basis for China's Sustainable Development

China is an important coastal country with a continental coastline of more than 18 000 km. It possesses 6 900 islands[1] having an area of more than 500 m^2. China has a claimed jurisdictional sea area [2,3,4,5] of 3.0 million km^2 including 380 000 km^2 of territorial seas. The ocean, coasts, and offshore marine environments are therefore an important piece of the

[1] The National People's Congress Standing Committee legislation working team, Explanation of Sea Island Protection Law of China. 2010, China Law Press, p.165, 182.

[2] Data source: National Statistics Administration. Chinese Statistical Year Book-2008. Beijing: Chinese Statistics Press.

[3] China Institute for Marine Affairs (CIMA). Chinese Ocean Development Report-2010. Beijing: Chinese Ocean Press.

[4] For comparison, China's land area is 9.6 million km^2.

[5] Yang Jinsen, Collection of China Marine Strategy Papers. 2006, Ocean Press, p.271.

challenge for the sustainable development of China. The wealth of natural marine resources and the enormous value of marine ecosystem services are — and must continue to be an important contributor to the nation's socio-economic development.

Box 4-1 Marine Biological Diversity

China's marine jurisdiction includes: temperate, subtropical and tropical climatic zones crossing 38 degrees of latitude. There are 20 000 species residing in these zones including 14% of the world's fish species, 43% of the mangrove species, 14% of the cephalopods, and 33% of the Indo-west Pacific region's coral reef species. For example: there are 1 140 species in the Yellow Sea and Bohai Sea; 4 167 in the East China Sea; and 5 613 in the South China Sea.

China's offshore and coastal environment provides an array of resources for peoples' livelihoods, including biological resources, minerals, pathways for transportation, locations for port development, and tourism assets. It is estimated that the ocean supplies more than 20% of the nation's animal sources of protein; 23% of its oil and 29% of its natural gas reserves[6]; as well as providing pleasing locations for recreation. Apart from direct economic values, China's ocean and coastal environments offer countless habitats that contain a wealth of biological and genetic diversity, along with providing ecosystem services such as nutrient recycling, detoxification and shoreline protection. Further, the ocean also plays a key role in carbon sequestration, regulating the water cycle and climate, and is a major source of oxygen. These services are vital for human survival and development.

Box 4-2 Ecosystem Services and Functions

Scientists recognize four categories of ecosystem services: provisioning services such as food and water; regulating services such as the regulation of climate, floods, coastal erosion, drought and disease; cultural services such as recreational, spiritual, and religious benefits; and supporting services such as nutrient cycling and photosynthesis. Some key benefits provided by the ecosystem services of functioning marine systems include healthy seafood, clean beaches, stable fisheries, abundant wildlife, and vibrant coastal communities.

[6] See Footnote 5.

4.1.2 Marine Economy as a Driving Force for China's Socio-Economic Development

Since the 1990s, China has included the development of marine resources as an important theme within the nation's development strategy and has used the development of the marine economy as a major vehicle to help revive China's economy. China is placing increasing importance on marine resources, environmental protection, marine management, and marine industries – allowing marine development to become one of the fastest growing sectors of the Chinese economy.

In the 21st century, the contribution of the marine sector to regional economic development has grown increasingly prominent. In 2008, total marine revenue[7] reached 2.97 trillion *yuan*, accounting for 9.87% of the national GDP and 15.8% of the coastal provinces GDP[8].

This rapid development of the marine economy has promoted employment in coastal areas. The workforce in marine-related industries has expanded from 21.1 million people in 2001 to 32.2 million people in 2008, accounting for 4.15% of the total national workforce and 10.3% of the coastal workforce in 2008[9].

Box 4-3 Marine Economy

Since 2001 there has been a 15% annual growth rate in marine revenues and marine industries. In 2008, the total marine revenue reached 2.97 trillion *yuan*, accounting for 9.87% of the national GDP and 15.8% of the coastal GDP. The main (principal) marine industries' 2008 revenues were 1.74 trillion *yuan*, accounting for 5.7% of the national GDP. By 2020, these main marine industries are projected to have revenues of 5.34 trillion *yuan*, accounting for 7.03% of the national GDP.

More importantly, the Chinese economy is currently highly dependent on an open global marine economy as China houses five of the world's 10 largest container ports. Nineteen percent of the world's bulk goods are shipped to China and 22% of the world's containers transporting exports come from China. China's merchant vessels are found in more than 1 200 ports internationally, and together they form an import-export economic structure that is utterly dependent on the world's oceans.

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[7] Total Marine Revenue includes: marine tertiary industries; marine secondary industries; and marine primary industries. Ref. Statistical Bulletin of China's Marine Economy in 2008; SOA.

[8] Statistical Bulletin of China's Marine Economy (2001-2009); SOA.

[9] See Footnote 5.

In the past 30 years of Chinese economic reform, the structure of marine industries has undergone profound changes. Where marine salt and fisheries were once the leading industries, now the five most important (main) players are: marine transportation; marine tourism; fisheries; offshore oil and gas; and shipbuilding. Other industry sector players including marine energy, seawater resources, marine engineering, biopharmaceuticals, and marine science and education are now also playing an important supporting role. The five main marine industries contributed about 91% of the marine primary industry revenues in 2008[10].

Table 4-1 National Marine Primary Industry Revenue and its Ratio to National GDP [11]

[Trillions *yuan*]

	Rate of Increase [Year]	2008	2011	2012	2013	2014	2015	2016	2018	2020
Total National Marine Industry Revenue	10%	1.735 1	2.262 7	2.489 0	2.737 9	3.011 7	3.312 8	3.644 1	4.409 4	5.335 3
GDP	8%	30.067	37.875 8	40.905 8	44.178 3	47.712 6	51.529 6	55.651 9	64.912 4	75.713 8
GDP% Ratio		5.7	5.97	6.08	6.19	6.31	6.42	6.55	6.79	7.05

Projections show that by 2020, the revenue generated by the Chinese marine primary industries will reach 5.34 trillion *yuan* accounting for 7% of the projected national GDP. One should note that this represents an expected 100% growth in the sector during the next decade.

4.1.3 Sustainable Development of the Ocean and Coasts: Pillars to Support and Secure Coastal Development

In the 30 years following the Chinese economic reform, China's opening-up policy has evolved from establishing special economic zones — including some southeastern coastal cities — to a multi-dimensional approach that includes many regions. Yet due to their advantageous locations, rich marine resources and policy strategies, China's coastal areas are seeing an increasing concentration of industrial and broader economic activity. Currently, China has formed a coastal ribbon of high economic development, which has brought with it population density and urbanization.

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[10] See Footnote 5.

[11] China Institute for Marine Affairs (CIMA). Chinese Ocean Development Report-2010. Beijing: Chinese Ocean Press. Page 226. Note: Predicted values are for marine primary industries only.

From 2001 to 2008, the total GDP of the 11 coastal administrations increased by an annual rate of 10% reaching 19.47 trillion *yuan* or 57% of the total national GDP. The coastal population is currently 554 million. Though China's coastal area constitutes only 13% of its total landmass, more than 40% of the Chinese population now lives in this area. The region is responsible for 90% of China's imports and exports[12].

Coastal areas are now also heading into a new stage of industrialization. Local governments of coastal administrations are introducing a full range of supporting policies and measures, creating an upsurge of marine-related development. At the same time, in response to the global financial crisis, the Central Government has introduced a series of important policies some of which aim to satisfy domestic land demand and to ensure economic growth and the adjustment of infrastructure to suit future development expectations.

In 2009, China introduced several key industrial revitalization plans for steel production, shipbuilding, automobile and equipment manufacturing, and the result has been significant restructuring. Looking at long-term development, there will continue to be large-scale relocation of petrochemical, steel, shipbuilding, and thermal and nuclear power industries into coastal areas, making the continuing industrialization and urbanization of these regions inevitable. In the new industrial development of coastal areas, the five main industries will be: heavy industries, ports and logistics, shipbuilding and marine engineering, modernized fisheries, and marine tourism – all of which are expected to undergo rapid change. These major developments are obviously linked with the ocean and coasts and will require ongoing access to marine areas and resources to fuel their progress.

Projections suggest that by the year 2020, the GDP from coastal areas will experience a 2.5 fold increase from 2008 figures and will reach 47 trillion *yuan*, goals that have been set in order to achieve a moderately well off society. According to Chinese demographic research, the national population will reach 1.45 billion people by the mid-2020s and 1.5 billion by 2030. In 2020 and 2030[13], the coastal areas' population will grow to 700 million and then 840 million people. At the same time, the industrialization of these coastal areas will require new adjustments and the redistribution of marine spatial resources. Total shoreline occupied by harbours may increase from 600 km to more than 1 000 km; coastal industries and urban development may require sea reclamation of more than 5 000 km^2; port construction, ship building and marine tourism industries will all need to expand their marine space; and modernized fisheries industries will need to develop seaward towards deeper waters. Marine space is one of the main elements in supporting sustainable economic development

[12] See Footnote 5.

[13] Jiang, Z.H., Xu, K.D. and Song, J. 2006. Research Report on National Population Development Strategy, Beijing.

in the future, and therefore ecosystem functions must be considered when analyzing the capacity of marine spatial resources to accommodate projected development needs.

Box 4-4 Coastal Population
By 2020 China's coastal population is expected to grow to 700 million; and, by 2030 it is expected to be 840 million. It is currently 554 million.

4.2 Historical Background of China's Sustainable Development Policy

In 1996, sustainable development officially became one of China's basic development strategies. It evolved from originally being a scientific consensus into being an important element of Government policy and operational programming. China's Ocean Agenda 21 proposed the background, aims, and priority areas for the sustainable development of marine areas. Since the implementation of Agenda 21, the sustainable development of China's ocean and coasts has seen an almost 15-year history, which coincides with the period of transition in China's economic and social development. The terms 'a moderately well-off society', 'harmonious society', 'environmentally friendly' and 'resource-saving society', and 'ecological civilization' are now all continuously employed at the highest levels of government, shaping progress and defining China's sustainable development. Also China is signing and joining many environmental treaties and conventions such as the GPA etc.. The process by which China is sustainably developing its marine areas is seeing continuous improvement, and there is a growing capacity for truly sustainable development of the ocean and coasts.

Box 4-5 GPA – Marine
The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities is a long-standing UNEP led initiative to assist States to protect their marine environment from land-based sources of pollutants. It addresses pollutants such as sewage, heavy metals, hydrocarbons, radioactive waste, litter, nutrient over-enrichment, and the physical alteration and destruction of critical habitats.

4.2.1 Strategy and Planning for the Sustainable Development of the Ocean and Coasts

In 1996 and 1998 respectively, the China Ocean Agenda 21 and the White Paper. 'The Development of China's Marine Programs' were published, together forming the foundation for a sustainable development strategy for China's ocean and coasts and for a national marine policy. With the arrival of the 21st century, the government has shifted even more of its focus onto marine development.

China's program outline of the 10th Five Year Plan of the National Economy and Social Development, passed in 2001, was the first high-level national development strategy to mention the ocean and coasts. It did so in the following statement: 'Strengthen research on marine resources, development, protection and management, improve research on the utilization of marine resources and develop marine industries; and increase the usage of marine areas and protect national maritime interests'. The State Council released the National Marine Economic Development Plan in 2003, proposing key tasks such as developing the marine economy and protecting marine ecological habitats.

In 2006, the 11th Five Year Plan of the National Economy and Social Development of China was endorsed during the Fourth Session of the 10th National People's Congress. This marks the first time an individual chapter was dedicated to the ocean. It proposed strengthening marine awareness, protecting national maritime interests, protecting marine habitats, developing marine resources, implementing marine integrated management and promoting the development of the marine economy. It also outlined the rational use, protection and development of marine resources. The ocean being listed and placed in an important chapter in the national development strategy plan was a significant step towards the promotion of the sustainable development of China's marine industries. In January 2008, the State Council published the 'Planning Outline of National Marine Program Development,' which now lays out specific requirements regarding the aims and goals of protecting marine ecological habitats.

In 2002, the endorsed report of the 16th National Congress of the Communist Party of China proposed: 'The Implementation of Marine Development.' This marks the first appearance of the term 'ocean' in a National Congress report. In 2007, the 17th National Congress of the Communist Party of China clearly indicated 'Development of Marine Industries.' General Secretary Hu Jintao particularly emphasized the nation's intention to develop marine industries during his visit to Shandong, and he placed emphasis on the utilization of marine resources based on sound science and the nurturing of marine industries. The 12th Five Year Plan, which is being prepared currently by the State Council, is expected to place

ocean activities and marine resources at the same level as energy strategies, emphasizing the importance of the ocean and coasts in current national planning strategies.

As a conclusion, against a backdrop of socio-economic development and a determination to further implement proper scientific concepts, China's policies, laws and legislation regarding the sustainable development of the ocean and coasts are continuously improving. Though various phases of action plans allow sustainable development principles to be incorporated into marine industry plans and government-related policies, the emphasis on both the development of marine resources and the protection of ecological habitats means that marine environmental management and land-based pollution control need to be clearly integrated. The main focus must be on the protection of offshore marine environmental resources and further expanding development opportunities towards the open ocean by finding and creating new resources in deeper waters. On the other hand, marine management has evolved from single departmental administrative controls into an integrated management approach considering a combination of legal, economic, technical and the necessary administrative responsibilities. Various regions are now increasingly practicing ocean and coastal management using ecological systems as the basis for decision-making.

4.2.2 China's Actions on Ocean and Coastal Management

China's ocean and coasts are among the most intensely used marine areas on the planet and have made an extraordinary contribution to the nation's dramatic economic development during the past half-century. They have helped to transform China into a truly global marine transportation nation complete with modern shipbuilding industries and competitive harbours and ports. Those same waters support fisheries and innovative mariculture industries that lead the world.

This report generally focuses on the deteriorating environmental conditions of China's ocean and coasts and offers insights into why changes have occurred and what needs to be done to improve the situation. One should not, however, mistakenly conclude that China is currently standing still and not attempting to correct matters. The truth is that China has already achieved much in ocean management and is well positioned to achieve sustainable development of its ocean and coasts.

For example, it has only been in the last couple of years that leading ocean management nations have adopted marine spatial planning as a key tool in their arsenal for implementing marine area-based management, but China has been working with the idea for nearly two decades and implemented their own initial marine functional zoning scheme in 2002.

Fisheries nations recognize that seasonal closures are an important tool for the conser-

vation of fisheries resources and the consequential sustainability of their fishing industries. Many nations successfully implement these closure strategies across single species and selective areas but China has been boldly implementing full summer closures across all species at sub-national regional levels since 1995[14,15].

To aid decision making, some advanced ocean management nations have been undertaking statistical surveys of their marine-related activities for the last decade or so on various time scales. But here again China is a leading nation and has been producing a detailed statistical analysis of the economic value of their marine related activities annually.

Integrated coastal zone management (ICZM) is being implemented currently in many nations at the local level. The southern city of Xiamen initiated China's first ICZM programme in 1997[16]. Xiamen has created an ICZM model characterized by 'legislation first, centralized coordination, scientific support, integrated legal enforcement, funding guarantee, and public participation'[17]. This successful model is regarded as an ICZM demonstration site not only for East Asian countries but also for countries around the world. There are more than 20 local ICZM initiatives in China at present.

Box 4-6 ICZM

Integrated Coastal Zone Management is intended to bring together the management of the river basin to coastal sea linkages and the larger coastal and marine ecosystems, thereby putting the concept of ecosystem-based management into practice. An effective ICZM program will minimize multiple use conflicts; protect lives and properties from natural and man-made disasters; protect and conserve habitats and biodiversity; ensure the sustainable use of freshwater resources; and ensure food security for the coastal population. There are more than 20 local ICZM initiatives in China at present.

There are many other examples that can be added to this list of accomplishments China has successfully implemented ahead of other nations. However, these aforementioned (and other) examples have not been without their challenges and problems along the way. Often, China has moved ahead too quickly without a full understanding of the scientific conse-

[14] A reference of summer closures: Sherman K. & Tang Q. et al. 2005. A global movement toward an ecosystem approach to management of marine resources. Marine Ecology Progress Series, 300: 275-279.

[15] A decade of summer ban fishing in China, edited by Bureau of Fisheries, Ministry of Agriculture, China.

[16] Chua Thia-Eng; Dynamics of ICM: Practical Applications in Sustainable Coastal Development in East Asia. Manila: PEMSEA. 2008.

[17] The Third Ocean Institute and Xiamen University. The Strategic Action Plan of Ecosystem Based Jiulong River Watershed and Xiamen Bay Management. 2009.

quences and without a sufficient appreciation of the longer-term environmental transactional costs. One of the aims of this report is to suggest how China can improve its environmental management of these important activities.

China's legal system for the sustainable development of the ocean and coasts.

Since the Marine Environment Protection Law was passed in 1982, the Chinese government has implemented a series of additional pieces of legislation to promote the sustainable development of the ocean and coasts as well as the conservation of marine habitats. By the beginning of the 21st century, the Chinese government had already set up a relatively complete marine legal system and supporting legislation and regulations. The set-up and implementation of these laws and regulations has sped up the progress of the protection of the marine environment, marine management, and has also accelerated ecological restoration within China, effectively promoting the sustainable development of the ocean and coasts. However, challenges remain for the implementation of such legislation, and for the engagement of authorities and the full uptake of a wide range of responsibilities, including, for example, the necessary regulations and enforcement.

A number of crucial pieces of legislation now guide activity and provide a context for future policy decisions:

(1) The Marine Environmental Protection Law of the People's Republic of China (formulated in 1982, revised in 1999) is China's fundamental law for the protection of the marine environment and establishes the basic principles of protecting marine resources, preventing pollution, maintaining ecological balance, securing human health, and promoting sustainable socio-economic development. Within the Chinese legal system of marine environmental protection, the first category is generic and it is applicable to all marine environmental protection-related activities, which include: monitoring and management, pollution control, marine spatial planning, emergency response to major marine pollution incidents, marine protected areas, and the damage liability system. The second category is for the management of specific cases, namely supporting legislation for the implementation of the 'Marine Environment Protection Law', including: pollution prevention from shipping, offshore oil and gas exploration, marine dumping, prevention of pollution from ship dismantling, the building of coastal infrastructure and marine engineering works, and the prevention of land-based pollution.

(2) The Law on the Administration of the Use of Sea Areas. Before the 1980s, although various marine activities were restricted to certain marine areas, in principal, there was no corresponding legislation on the use of sea areas. In May 1993, the Ministry of Finance and the State Oceanic Administration jointly published the Law on the Administration of the Use of Sea Areas. The legislation, which received the endorsement of the State Council, clearly pro-

poses the establishment of 'maritime licensing' and payment for the use of sea areas, contributing to the initial establishment of the administration of the use of sea areas. The Law on the Administration of the Use of Sea Areas was passed in 2001 and officially put into force in 2002, marking the formal establishment of the management system for the use of sea areas. The basic sea area management regime includes a functional zoning system, and a sea area use payment system and property use rights system. China has completed the development of a national, provincial, municipal and county-level zoning scheme for coastal waters and a usage charge standard that is the basis of sea area management. Of some concern, however, is the fact that the current zoning scheme gives priority to social development over ecosystem protection needs.

(3) The Law for Island Protection. Under vigorous promotion by the National People's Congress, 'The Law of the People's Republic of China for Island Protection' was adopted during the 12th session of the 11th National People's Congress Standing Committee in 2009. The Island Protection Law consists of five key elements including: an island conservation plan; the protection of island ecological habitats; ownership of uninhabited islands; the protection of special islands; and the monitoring and control of island use. The legislation explicitly indicates the duties of all levels of government administrations for marine management regarding the protection and development of islands. Its introduction symbolizes the legalization of China's management, protection and development of islands.

(4) The Fisheries Law of the People's Republic of China covers all fisheries-related activities including marine fisheries. This law was adopted in 1986, and revised twice – in 2000 and 2004. In 1987, the Ministry of Agriculture released the Fisheries Law implementation guidelines which outline rights and management processes regarding the exploitation of fisheries resources. They also set specific rules regarding aquaculture, fisheries, and the enhancement and protection of fishery resources. The law established a system of harvesting permits and seed stock permits for aquaculture; determined allowable catch and a licensing system for the fisheries industry. The law also provided for permits for high seas fishing and fishing in waters under the juridisdictions of other countries; limited fishing areas, times, fishing methods and tools; the enhancement of fishery resources and conservation systems (fishery resources protection fee system, fishing ban, and restriction measures), and determined closed areas and seasons for fishing. State and Local authorities within the purview of the legislation also issued a number of supporting regulations and implementation measures.

4.2.3 The Status and Problems of Marine Management

4.2.3.1 The current status of marine management

Since the 1950s, China's marine management system has gone through significant

development and change. It has evolved from the management of individual industries to the combined management of industries and the marine environment, and finally, after decades of progress, China is gradually shaping an integrated ocean management system. In 2008, the State Council gave the State Oceanic Administration (SOA) the new task of focusing their work more on strategic marine research and the coordination of marine affairs, on top of their responsibility for marine management and administration. There are about ten other departments that are involved in marine-related affairs, including the Ministry of Environmental Protection, Ministry of Agriculture (Fisheries), Ministry of Land and Resources, Ministry of Communications (Transport), Ministry of Water Resources and the State Forestry Administration as well as provincial, state, county, and local government agencies.

Marine-related State administrations are obliged to implement management controls on marine-related activities under their jurisdiction according to the current legal system, which includes the 'Environmental Protection Law' and the 'Marine Environment Protection Law' and other supporting legislation. The SOA and other marine-related administrations have developed a series of provincial and national plans for the conservation of marine biological diversity and ecological habitats. The enlisting of marine habitats into national socio-economic development plans has increased the effectiveness of the overall management of the marine environment. With regard to marine spatial use, three systems related to marine spatial planning are in effect: marine tenure, rights to resources, and the paid usage of the sea. Each is implemented according to the 'Law on the Administration of the Use of Sea Areas.' Management of Islands – the planning and protection of island ecological habitats, ownership of uninhabited islands and the protection and monitoring of special islands – is conducted according to the 'Island Protection Law'. The Ministry of Agriculture and several levels of local governments carry out the management of fisheries and marine biological resources under the 'Fisheries Law' and other marine biological resources legislation.

It is in the nature of environmental issues that they do not respect administrative boundaries, therefore various government administrations are exploring new co-management arrangements for land, estuarine, coastal, and sea area activities to better address marine environmental issues. For example, on the 2nd March 2010, the Ministry of Environmental Protection and the SOA signed an agreement that signifies China's formation of a new environmental protection system for coastal land and seas. According to the agreement, both parties will strengthen communication and collaboration in nine areas, including monitoring nitrogen, phosphorus, petroleum and heavy metal pollution in key sea areas. The Ministry of Environmental Protection has already initiated environmental impact assessments for key strategic developments in the areas around the Bohai Sea, the economic zone on the western

coast of the Taiwan Straits and in the Beibu Gulf economic rim.

4.2.3.2 The problems of marine management

Even though the legal system in China dealing with marine resource management is already relatively comprehensive, the planning system is steadily improving and, among other things has established four levels of enforcement at national, provincial, local and municipal levels, thus shaping the capacity to manage marine habitats within territorial waters. However, several structural flaws remain at the governmental and industry-focused marine management levels, some of which are described below.

Firstly, marine management systems are not effectively marine-focused and need better internal coordination. China's marine management is, for the most part, handled by departments primarily responsible for land-based resource management, therefore China's administrative decision making is greatly influenced by the natural resources and industry development sectors. This fragmented system of development-minded management has resulted in the serious loss of marine resources and ecosystem functions and services, and is not conducive to the integrated management needed specifically to secure the protection of marine ecosystems as a whole. Accordingly, the management of marine resources and the implementation of environmental management continues being carried out through a stove-pipe management approach, where departments responsible for such things as ocean space, transportation, agriculture, oil & gas, and tourism manage both the land and marine functions and where there is a lack of coordination within agencies and between agencies on such important matters as joint law enforcement. This lack of coordination extends even between different governments (national, provincial, local) and different departments at the State level, and is an obstacle to the implementation of integrated marine management. There is currently no coordinated whole-of-government approach to marine management in China.

Box 4-7 Conflicting Marine Environmental Governance

The responsibility for China's marine and coastal environmental protection is scattered across different administrations of the Central government and coastal local governments. There is no single agency providing a whole-of-government coordinated approach for the sustainable development of China's marine territory. The responsibilities of the various departments are governed by different uncoordinated legislation, therefore causing many overlaps and conflicts of functions. There is an urgent need to create a high-level administration to oversee and coordinate the sustainable development of China's ocean and coastal activities.

Secondly, even though China has an adequate suite of marine legislation, the overall system lacks comprehensiveness, particularly when it comes to a coordinated approach to marine environmental protection. The existing series of marine-related laws and legislation are aimed at supporting development, industry protection, and the management of specific individual marine resources. They overlook other resources and industries, and there is a clear lack of a coordinated National Marine Strategy to provide guidance to policy makers. On the other hand, while the content and structure of many pieces of legislation emphasize shared high level marine protection issues, they lack *specific* solutions to the range of different regional problems that arise. The existing legislation cannot adapt to the needs of a modern integrated marine management system, especially with regard to region-specific marine environmental management challenges.

For example, China has joined the International Convention on Civil Liability for Oil Pollution Damage (1992), but due to the lack of domestic oil spill-related legislation on the criteria of assessing ecological impacts and compensation standards and claims, even though many oil spill incidents have caused serious damage to the environment and ecological habitats, they cannot be legally compensated for. In particular, vessels that carry less than 2000 tonnes of oil are not included in this convention, and there are no laws within China that regulate these vessels. Many oil spill incidents are caused by small-scale oil tankers, and they inflict serious damage on marine ecosystems. Another similar cause of the continued degradation of marine environments in China is the lack of policy to control non-point sources of marine pollution from agricultural activities.

At the same time, many marine environmental protection laws in China are concerned with the general *principles* of marine protection and lack specific necessary legal mechanisms and procedures; they provide inadequate basis for supervision, monitoring, reporting, assessment, and corresponding punitive measures. The result is poor implementation of environmental laws.

Thirdly, there is a lack of policy guidance coupling integrated marine management with river basin management. Currently, China has set up many pollution prevention and control projects within national, local and basin-wide areas; examples include the Huai River Water Pollution Control and Planning, and the Bohai Sea Blue Sky and Clear Water Projects. These sorts of projects are mainly 5-year water environmental management plans. However, for technical, economic and policy reasons, if these plans do not allow the connection between resource management and land use planning, they cannot be integrated within the nation’s socio-economic development plans, making it difficult to achieve water environment goals and standards. Even after more than 10 years of com-

prehensive integrated treatment and the significant investment of financial resources, the water quality in the Huai River basin, Bohai Sea, Taihu Lake, and the Dianchi Lake is still not improved.

At the time of the development and implementation of integrated watershed management projects, many integrated marine and coastal management projects were also being developed at the national and provincial levels. An important issue is whether or not the linkage between river basins and adjacent marine waters was even considered. It is difficult to link various marine management initiatives at the scale of ocean, coasts, estuaries, and watersheds, with land-based management that is normally under the jurisdiction of local administrations. Fragmented area management models lead to problems in coordinating resource and environmental management systems. Hence, there is a lack of integrated river-basin-to-marine-management strategic planning.

There is as well the vital need for a coordination mechanism between marine management and the Chinese economy. For example, local governments responsible for managing coastal areas have developed their own individual economic development plans and there is a clear trend toward the rapid development of heavy industries all along the coasts. Even though there are environmental impact assessment requirements, these only give consideration to single projects and do not currently consider the cumulative impacts of numerous projects in a single area. There is a lack of integration between policies on the protection of the marine environment and localised economic development.

Finally, there is a lack of information-sharing mechanisms. On one hand, the nation's monitoring and data systems cannot satisfy the full needs for environmental protection because the monitoring standards are inadequate and enforcement is poor. On the other hand, there are many departments who monitor the environmental parameters of marine, river basin, and coastal pathways, including for environmental protection, marine quality, water quantity, fisheries stock assessments, and marine works. However, different departments use different monitoring standards and therefore generate different statistics. In some cases, conflicting situations arise, and therefore monitoring results are not readily shared among departments. Conflicting data pose a great threat to the development of an adequate marine management system. Overlapping work between monitoring agencies, and the lack of transparency of the data, cause a waste of resources and clearly contribute to poor decision making at the end of the day.

Box 4-8 Agricultural Pollution

Pollution from agriculture is one of the main environmental problems in China. The current river basin management practiced by China mainly focuses on point-source pollution with non-point source emissions being neglected. Even the new 2008 PRC Law on the Prevention and Control of Water Pollution does not include any specific regulations, standards or monitoring criteria for agricultural non-point source emissions. The highest discharged pollutants are from agricultural sources (44%), domestic sources (37%), and industrial sources (19%). These include: chemical oxygen demand, ammonia nitrogen, total nitrogen, total phosphorus, petroleum products, volatile phenols, and heavy metals.

4.3 The Ecological Challenges of the Sustainable Development of China's Ocean and Coasts

China's marine ecological habitats have distinctive regional characteristics and localized endemic species. Ecological health is highly dependent on coastal habitats, and ecosystems and biological diversity are particularly vulnerable. Due to the rapid development of marine industries and the coastal economy during the past three decades, coastal ecosystems and their habitats have been under significant threat and have deteriorated. Even though the Chinese government has given marine conservation high priority — including with measures to *prevent* the deterioration of marine environments — existing marine legislation remains much weaker than similar terrestrial environmental conservation legislation. Since the end of the 1970s, the health of coastal environments in China has weakened and ecosystems have suffered, which is a serious threat to the sustainable development of China's ocean and coasts. Moreover, as rapid development in coastal areas continues, the effort to ensure the sustainable development of the ocean and coasts will encounter many new risks and threats.

4.3.1 The Current Status of Chinese Coastal Environments

Since the beginning of the 1980s, profound changes have taken place in the type, scale, structure and nature of marine environmental problems. The four major issues are: the environment, the ecology, marine hazards, and shortage of natural resources. And though these four categories are conceptually quite straightforward, in reality they intertwine in ways that are unique to the Chinese situation, and they exert a compounded effect that is unlike common marine environmental issues familiar to most developed countries.

4.3.1.1 Serious pollution of coastal marine environments

In recent years, the degree of pollution within China's offshore waters remains high, with the area of polluted coastal waters increasing. In 2009 for example, polluted offshore waters covered approximately 147 000 km^2 [18], which accounts for over half of China's total coastal marine areas[19]. Polluted areas are mainly concentrated in large estuaries and bays, including Liaodong Bay, Bohai Bay, Laizhou Bay, Jiaozhou Bay, Xiangshan Harbour, Changjiang Delta, Hangzhou Bay and the Zhujiang River Estuary. Limited waste treatment has placed great pressure on the marine environment. The previously mentioned areas are largely the most developed coastal areas within China, and the developmental strategy of 'treatment after pollution' is one of the main reasons for the serious environmental problems.

Currently, the major marine pollutants include inorganic nitrogen, phosphate, and oil – where the main pathways are from land-based sources. Wastewater contains many persistent organic pollutants (POPs) such as polycyclic aromatic hydrocarbons, organochlorine pesticides, polychlorinated biphenyls and heavy metals that are occasionally detected. These POPs all pose a major threat to food safety and human health.

4.3.1.2 Damage to the health of marine ecosystems

Pollution, large-scale reclamation, and the invasion of exotic aquatic species have caused significant damage in coastal wetlands and the decline of biological diversity resulting in the degradation of coastal marine habitats. Monitoring results from 2009 show that China's healthy, sub-healthy and unhealthy coastal systems constitute 24%, 52% and 24% of total coastal waters respectively[20]. According to preliminary analysis, China has lost 57% of its coastal wetlands, 73% of its mangroves, and 80% of its coral reefs since the 1950s. Two-thirds of the coasts are under the threat of coastal erosion and the reduction of marine biological diversity. Moreover, populations of endangered species are facing serious declines.

Box 4-9 Ecological Disasters

Since the 1990s, ecological disasters caused by red tides, green tides and jellyfish blooms have been frequently recorded in China's seas, which provide an alarm on the overall health of marine ecosystems. The frequency and scale of red tides significantly increased since the late 1990s. The area of a single red tide can reach thousands of km^2. A large-scale green tide occurred

[18] SOA. Bulletin of China Ocean Environmental Quality (2001-2009).

[19] The coastal marine area is measured from the high water mark seaward to the ten-metre depth contour. This area quoted also includes internal waters (Bohai Sea for example).

[20] See Footnote 21.

for the first time in 2007, and has reappeared every year thereafter. The affected area of a green tide has reached tens of thousands of km^2. Since 2000, the biomass of giant jellyfish has been increasing and since these ingest large amounts of zooplankton, they rob fish of their food supply.

4.3.1.3 Increasing prevalence of marine hazards

The main environmental problems experienced in Chinese coastal waters include eutrophication, harmful algal blooms (HAB), coastal erosion, salt-water intrusion, and oil spills. Compared to the 1990s, the problem of HABs has become more serious both in terms of frequency and the size of the areas affected. From 2001-2009, the average occurrence of HABs was 79 annually, with the area affected reaching 16 300 km^2. The recorded HAB events and accumulated areas affected by HAB are now 3.4 times more than during the 1990s[21]. From historical statistics, there is a trend for HAB occurrence to be spreading from local to regional waters. Large-scale green tides occurred in consecutive years — 2008 and 2009 — causing direct economic losses of near 2 billion *yuan*. An HAB in the Yellow Sea raised global concerns due to its threatening of the Olympic sailing competitions in 2008.

As China moves from being an oil-exporting country to an oil-importing country, there is a corresponding increase in the volume of oil imports. Currently, China's volume of offshore oil shipments places it third globally after the USA and Japan. The annual growth rate of domestic oil output is 10 million tonnes. With the increase of oil transportation volume and the number of vessels involved, the risk of ship accidents has also increased and China's seas could become more prone to oil spill accidents. According to statistics provided by the Ministry of Communications, there were a total of 2 635 oil spill incidents from 1973-2006[22]. At the same time, the increase in offshore oil and gas exploitation has further increased the risk of oil spill incidents. The pipeline burst and resulting large volumes of oil spilled into the sea in Dalian in 2010 caused great ecological damage[23].

4.3.1.4 Decline of inshore marine fishery resources

Historically under-utilized, China's inshore marine fishery resources are now being over-exploited. Since the 1960s, the number and horsepower of fishing vessels has steadily increased, and fishing technologies have modernized and grown ever more efficient. In the mid-1970s, fishery catches reached three million tonnes. The harvest of traditional targeted species such as large and small yellow croaker dramatically decreased, while catches of lower quality fish species increased. Through the mid-1980s, catches rose an

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[21] See Footnote 21.

[22] http://finance.qq.com/a/20070706/000458.htm

[23] http://www.cnr.cn/china/newszh/yaowen/201007/t20100719_506752529.html

average of 20% each year, and the main targeted species shifted to small sized pelagic fishes such as anchovies, mackerels, and scads which eventually constituted more than 60% of the total catch[24,25]. The accelerating harvest and a lack of systematic fisheries management then also combined with a loss of fishery habitats and the destruction of nursery and breeding grounds to create a decline in the offshore fishery resources evident today.

Box 4-10 Aquaculture

China has been the world's top producer of aquatic products since 1990, and is the only country where aquaculture production is greater than its wild capture fishing yield. In 2009, aquatic production was slightly more than 51 million tonnes, with more than half coming from aquaculture among which the dominant products were: fish, crustaceans, mollusks, seaweeds, and echinoderms.

4.3.2 Marine Ecological and Environmental Problems – An Increasingly Urgent Threat

4.3.2.1 Serious land-based pollution and the continuing deterioration of the marine environment

Land-based pollutants that are produced by human activities and then released into the marine environment through direct emissions such as river runoff and atmospheric deposition significantly impact marine environmental quality. Therefore, the control of land-based pollutants is of utmost importance to protection of the marine environment and the sustainable development of the oceans and coasts around the world. Since the establishment of the Global Program of Action by UNEP in 1995, the protection of marine environments from land-based pollution has been a common goal of more than 160 countries.

Land-based pollution is a key factor in the decline of conditions in China's ocean and coasts. For the past 10 years, the volume of pollutants carried by river discharge has steadily increased. River monitoring results for the period 2002-2007, show that pollutants carried to the sea by the major rivers (Changjiang River, Zhujiang River, Huanghe River, Minjiang River, Qiantang River and others) increased by 121.3% and reached up to 13.67 million

[24] Tang Q, 1993. The effect of long—term physical and biological perturbations of the Yellow Sea ecosystem. In *Large Marine Ecosystem: Stress Mitigation, and Sustainability*, pp.79-93. Ed. by K. Sherman, L. M. Alexander and B. O. Gold. AAAS Press, Washington, DC. USA.

[25] Jin X.S., Zhao X.Y., Meng T.X. 2005. The marine resources and habitat in the Yellow Sea and Bohai Sea. Beijing: Science Press.

tonnes in 2009. The Changjiang River and Zhujiang River contribute about 70% of China's total pollution run off into the sea[26].

In recent years, as efforts to control the point source pollution carried by rivers achieved some success, agricultural non-point source pollution was found to be a key contributor to increasing levels. The first national pollution census[27] shows that the chemical oxygen demand (COD) emitted from agricultural non-point source pollution reached about 13 million tonnes, which is 2.3 times the amount produced by industrial sources — indeed, in some watersheds, agricultural sources can outweigh industrial sources by as much as 5 times[28]. Pollutants transferred by rivers from agricultural and village sources affect the downstream coastal water quality and marine environment. Therefore, agricultural pollutants have become one of the more pronounced problems for the control of China's terrestrial and marine water pollution and this and other environmental problems in drainage areas should be addressed as soon as possible.

The nation's marine sewage discharge has declined from 13.63 million tonnes in 2005 to 8.36 million tonnes in 2008, a relatively dramatic decrease yet a total that still exceeds environmental quality standards[29]. The four major sea regions — the Bohai Sea, Yellow Sea, East China Sea, and South China Sea — all have high marine pollution discharge rates, on average exceeding the Integrated Wastewater Discharge Standard (GB 8978-1996) rate by 75%, with the highest being measured in the East China Sea where standards were surpassed by 92% in 2008. Looking at different oceanic regions, the Bohai Sea has a pronounced increasing trend in pollutant discharges; these are exerting great pressure on the marine environment.

Atmospheric deposition has become another of the most significant pathways for nutrient and heavy metal pollution entering the ocean, and densely populated coastal areas are particularly important sources of the nutrient loading (especially nitrogen). Excess nutrients have significant impacts on marine phytoplankton growth and development and in some serious cases cause HABs. According to a study, land-based soluble inorganic nitrogen is transferred to the western Yellow Sea mainly through atmospheric deposition, and the amount of ammonium nitrate has surpassed the amount deposited by streams[30,31]. Currently,

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[26] See Footnote 21.

[27] The First National Pollution Census was done during October 2006 – July 2009. Ministry of Environmental Protection website

[28] The Bulletin of the First National Pollution Census. Ministry of Environmental Protection website

[29] See Footnote 21.

[30] Zhang J, Chen SZ, Yu ZG, Wang CS, Wu QM. Factors influencing changes in rain water composition from urban versus remote regions of the Yellow Sea. Journal of Geophysical Research, 1999, 104, 1631-1644

[31] Chung CS, Hong GH, Kim SH. Shore based observations on wet deposition of inorganic nutrients in the Korean Yellow Sea Coast. The Yellow Sea, 1998 (4): 30-39

China's monitoring of aerosols and rainfall is focused in specific cities and regions, but atmospheric deposition on marine environments is still at an early stage of research, lacking data from long-term and large-scale monitoring. Hence, there needs to be more in-depth research and monitoring work on the impacts of atmospheric deposition on oceans.

More than 70% of nutrients discharged into the sea are from land-based origins[32], and these and other sources of pollution being leached into the marine environment have led directly to a decline in marine water, sediment and biological quality. Beyond the obvious direct link to marine water quality, the volume of pollutants discharged into the sea has a direct connection to huge economic costs tied to marine fisheries, marine tourism, and human health and safety. Taking fisheries as an example, the average revenue loss caused by pollution reached 2.3% of total fisheries GDP[33,34]. Marine pollution also causes environmental degradation, the decline in biological diversity, and the loss of ecosystem services, each of which may be difficult to account for in monetary terms but is significant nonetheless.

It is expected that in reaching 2020, China's GDP will quadruple compared to 2000. Consequently, it is further expected that the amount of industrial and domestic wastewater and pollutants will reach double the 2003 figures as a baseline, and that the livestock industry will generate pollution nearing three times the 2003 levels. Coastal water pollution is predicted to grow much higher than the national average level (2-3 times)[35], placing tremendous pressure on offshore coastal environments.

4.3.2.2 Increased eutrophication of inshore waters, leading to significant ecological disasters

Eutrophication refers to 'a process of changing nutrient concentration and profile in seawater resulting from the enrichment of nutrients caused by anthropogenic activities, leading to further changes of the structure and function of marine ecosystems, and the degradation of their services and values'. As coastal population and production patterns and standards of living change, the amount of nutrient material discharged to the ocean also increases. Nutrient pollution caused by the large amount of nutrients deposited into the sea has become a global environmental problem. According to the recently published American and European coastal eutrophication evaluation results, 28% and 65% of the EU and USA seas

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[32] Nengwang Chen, Huasheng Hong, Luoping Zhang, Wenzhi Cao. Nitrogen sources and exports in an agricultural watershed in southeast China. Biogeochemistry, 2008 (87): 169-179.

[33] Ministry of Agriculture-State Environmental Protection Administration. Bulletin of China's Fishery Ecological Environment, 2000-2008.

[34] Value of Fisheries GDP in 2009 was 594 billion *yuan*. China Fisheries News – May 2010.

[35] Cao Dong. Economy and Environment: China in 2020. Beijing: Chinese Environmental Science Press. 2009.

respectively experience varying degrees of coastal eutrophication[36,37].

Coastal eutrophication is an increasingly serious problem within Chinese waters, with the following key concerns: 1) The extent of sea area with eutrophication. Since 2000, more than 130 000 km^2 (nearly half of China's offshore coastal waters) have been found not to meet water quality standards. The source of the trouble is nitrogen (N) and phosphorus (P) overloading of coastal waters. 2) There exists a serious nutrient pollution problem within estuaries and bays. These include areas such as the Bohai Sea's Liaodong Bay, Bohai Bay and Laizhou Bay, the East China Sea's Changjiang River Estuary and Hangzhou Bay, as well as the South China Sea's Zhujiang River Estuary. 3) The nitrogen pollution in coastal waters is prominent. The average concentration of DIN in seawater exceeds the Grade-I level in most coastal provinces. In Shanghai and the Zhejiang province, the DIN concentration has exceeded the Grade-IV level for many years[38].

Box 4-11 Hypoxia

Coastal hypoxia is a low oxygen condition of inshore waters that occurs when oxygen levels fall below normal. It occurs when excess chemical nutrients run in from the land, e.g., from agriculture and sewage. Desirable marine and estuarine species, especially those in fisheries and aquaculture, are severely affected by hypoxia.

The trend for coastal nutrient pollution problems is upward, both in area affected and seriousness of the problem. From 2004-2009, sea areas with moderate eutrophication increased by 6%, those with severe eutrophication increased by 66%[39]. In turn, studies confirm that eutrophication is one of the main reasons for the increasing incidence of HABs globally.

Since the 1970s, there has been an increase in the frequency of HABs within Chinese waters, with a three-fold increase in the rate of occurrence every decade[40]. Algal blooms

[36] OSPAR Commission. 2003. OSPAR Integrated Report 2003 on the Eutrophication Status. London, U.K.: OSPAR.

[37] Bricker S., Longstaff B., Dennison W., Jones A., Boicourt K., Wicks C., Woerner J., 2007. Effects of nutrient enrichment in the nation's estuaries: A decade of change. NOAA Coastal Ocean Program Decision Analysis Series No. 26. Silver Spring, MD: National Center for Coastal Ocean Science. Online at: http://ccma.nos.noaa.gov/publications/eutroupdate/.

[38] See Footnote 21.

[39] Report on China's Environmental Quality. Ministry of Environmental Protection. Beijing: Chinese Environmental Science Press. 2009.

[40] Zhou M.J., Zhu M.Y., Zhang J., 2001, Status of Harmful Algal Blooms and Related Research Activities in China. Chinese Bulletin of Life Sciences, 13 (2): 54-59.

composed of Alexandrium, Karenia, Gymnodinium, Prorocentrum and other toxic and harmful dinoflagellates blooms continue to emerge[41]. The distribution and extent of harmful dinoflagellates blooms and the damage caused by them are all increasingly seriously. In 1999, the Bohai Sea area experienced a 6 000 km^2 HAB. Between the years 2000 and 2010, the East China Sea has experienced 10 000 km^2 large scale HABs every year. In 2005, Karenia blooms caused the death of large numbers of caged fishes in the coastal areas of Zhejiang Province, resulting in more than 10 million *yuan* in economic losses. In 2008, a large scale HAB affected the Yellow Sea, affecting 30 000 km^2 of sea and damaging a million tonnes of biological resources, causing a direct economic loss of 1.3 billion *yuan*. At the same time, the growing number of HABs exacerbates paralytic shellfish poisoning, posing a significant threat to human health and safety.

Hypoxia is another environmental problem closely related to eutrophication. Out of 415 sea areas that are affected by eutrophication, 163 areas are also experiencing hypoxia[42]. This serious lack of oxygen leads to the collapse of marine ecological systems and fisheries resources, resulting in the formation of dead zones. In recent years, bottom water hypoxia is increasingly evident in the areas surrounding the Changjiang River Estuary. From 1990 onwards, the probability of the occurrence of hypoxia in summer has increased by 90% and a wide extent of hypoxic zones has been observed[43, 44].

In addition to HAB and hypoxia, eutrophication also plays an important part in the proliferation of jellyfish and the decline of fisheries resources.

Under the driving force of coastal eutrophication, China's offshore coastal ecosystems are at a critical period of evolution. Given China's rapid economic development, increasing urbanization and energy consumption patterns, the problem of coastal eutrophication is certain to worsen in the future and will be one of the key challenges to China's marine environment. HABs and hypoxia will be more pronounced and will become a major threat to the health and sustainable development of the marine ecosystems within China.

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[41] Wang B. D., 2006. Cultural Eutrophication in the Changjiang River Plume: History and Perspective. Estuarine Coastal and Shelf Science. 69(3-4): 471-477.

[42] Selman M., Greenhalgh S., Diaz R., Sugg Z., 2008. Eutrophication and Hypoxia in Coastal Areas: A Global Assessment of the State of Knowledge. WRI Police Note, Water Quality: Eutrophication and Hypoxia, No. 1.

[43] Science of China (D) 32(8)：686-694。Wei, H., He, Y., Li, Q., Liu, Z., Wang, H., 2007. Summer Hypoxia Adjacent to the Changjiang Estuary. Journal of Marine Systems. 69, 292-303.

[44] Wang B. D., 2009. Hydromorphological Mechanisms Leading to Hypoxia off the Changjiang Estuary. Marine Environmental Research, 67: 53-58.

4.3.2.3 Out of control large-scale sea enclosing and reclamation – weakening marine ecosystem services

The coastal areas of China have undergone four major sea enclosing and reclamation phases since the founding of the Peoples Republic of China, including the last two decades, which have seen huge demand for the construction of cities, ports and industrial infrastructure. From 1990 to 2008, the total area of reclaimed land has increased from 8 241 km^2 to 13 380 km^2, an average increase of 285 km^2 annually[45]. According to incomplete statistics, as the new coastal development strategy unfurls, there will be a demand for a further 5 780 km^2 of sea to be reclaimed by the year 2020, which undoubtedly will create severe environmental impacts on coastal ecological environments.

The current sea enclosing and reclamation projects in China have the following characteristics: ① A change of the use of the land reclaimed from the sea. The reasons for the reclamation of land has changed from sea salt, agriculture, and aquaculture production into major developments of ports, harbours, coastal industries, and the development of cities. Therefore the economic gain from sea reclamation is dramatically increasing. ② The scale of sea enclosing and reclamation is increasing at a much faster pace of development. From 1990 to 2008, there was average sea reclamation of 285 km^2 annually, whereas it will be more than 500 km^2 per year from 2009 to 2020. These figures clearly illustrate an expansion in the scale and rate of reclamation activities. ③ Reclamation activities are mainly concentrated along the bays and estuaries of large coastal cities, and have enormous impact on the environment. ④ Most project design and evaluation is usually lacking; the approval period is short; the implementation of the reclamation is fast. ⑤ It is difficult to manage and monitor reclamation activities. Before the establishment of the Law on the Administration of the Use of Sea Areas in 2002, there was no regulation or monitoring or compensation involved in reclamation activities. Since the passing of that Law in January 2002, the management of sea reclamation activities has steadily improved, but the actual management and enforcement still faces many issues and problems.

Large-scale sea enclosing and reclamation has inflicted great damage on the Chinese marine ecological environment as a result of:

(1) The loss of coastal wetlands and ecological services. Coastal wetlands provide important and valuable ecosystem services such as the purification of water sources, detoxification, nutrient recycling, habitats crucial to biodiversity, regulation of atmospheric composition, and protection of the shoreline. Moreover, marine ecosystems, especially coastal wet-

[45] Fu, Y.B., Cao, K., Wang, F. and Zhang, F.S. 2010. Preliminary study of the methods used to evaluate the potential impacts of sea reclamation. *Ocean Development and Management* 27 (1): 27-30.

lands, are important natural barriers against marine hazards such as flooding. The activities related to sea reclamation on coastal areas lead to a decline in coastal wetlands and a large-scale loss of those essential ecosystem services, and a diminished capacity of coastlines to protect against marine hazards.

(2) The weakening of the carbon sequestration functions of the ocean and coastal wetlands influences. Oceans and coastal wetlands play an important role in the global carbon cycle. Sea reclamation affects large areas of the coasts and seas. The conversion of coastal wetlands into agricultural lands, urban areas and industrial lands will lead to the loss of areas for carbon sequestration and transform these places into carbon sources instead.

(3) The loss of habitats and feeding areas for birds. Since 1988, the reclamation activities in Shenzhen have destroyed large areas of mangrove forests, including 1.47 km^2 of mangroves in the Futian nature reserve, with a resulting decrease in the number of bird species from 87 (1992) to 47 (1998), a decline of 46%[46]. From 1956 to 1998, Shanghai Chongming Dongtan has experienced many phases of reclamation resulting in a total of 552 km^2 of reclaimed land. The reclamation activities have shrunk coastal wetlands and destroyed salt marshes. The living habitats of wetland birds have been destroyed and food sources have been removed. The winter populations of Eastern Curlew, Spotted Redshank and Mongolian Plover shrank between 1990 and 2001. From the winter of 1986 to the winter of 1989, the population of Tundra swans remained at a level of 3 000-3 500 but has steadily decreased in recent years. Only 51 were found during the winter of 2000/2001 in Dongtan[47].

(4) Decrease in the biological diversity of benthic species. Sea enclosing and reclamation work such as dredging and land filling causes dramatic changes to the marine environment, including the decline in benthic and community structural change. The development of the deepwater channel in the Changjiang River Estuary in 1998 caused a species diversity decrease of 87%, biomass decrease of 76% and a drop of 66% in average density, when monitoring results in May-June 2002 were compared with the baseline surveys from 1982-1983. In 2002-2004, 15 tonnes of benthic organisms were returned to the Changjiang River Estuary in restoration experiments after the construction of the north-south dike, although the diversity and biomass were raised, the community structure changed from crustacean to mollusks-dominated[48]. Sea enclosing and reclamation have also impacted Jiaozhou

[46] Xu, Y.G. and Li, S. 2002. The impact of urban construction and protective measures on the mangrove ecology and resources in Futian, Shenzhen. *Resources Industries* 3: 32-35.

[47] Ma ZJ, Jing K, Tang SM, Chen JK, Shorebirds in the Eastern Intertidal Areas of Chongming Island During the 2001 Northward Migration [J]. The Stilt. 2002 (41): 6-10.

[48] Zhen, X.Q., Chen, Y.J., Luo, M.B. and Wang, Y.L. 2006. Preliminary study on the restoration of benthos in the Yangtze River Estuary. *Journal of Agro-Environment Science* 2: 373-376.

Bay, and intertidal species diversity has dropped from 154 in the 1960s to only 17 in the 1980s, leaving only 1 of the original 14 dominant species close to extinction[49].

(5) Coastal landscape diversity damaged. After sea enclosing and reclamation is completed, artificial landscapes replace natural landscapes and valuable coastal and island landscape scenery and resources are damaged during the process. Currently, studies in Liaoning Province, Laizhou Bay in Shandong Province and other areas have gathered evidence of coastal wetland shrinkage, loss of wetland patches, decrease in wetland scenic diversity and evenness, and high rates of fragmentation and human disturbance. The loss of coastal landscape diversity has led to an increase in the vulnerability of ecological environments[50].

(6) Damage of fish habitats leads to unsustainable fishery resources. Most breeding and feeding habitats of fishes are in offshore shallow seas or estuaries, where most of China's sea enclosing and reclamation takes place. During large-scale sea enclosing and reclamation projects, the high concentration of suspended particles causes damage to fish eggs and juveniles. The destruction of breeding habitats causes difficulties in recruitment, which leads to negative impacts on the sustainable development of fishery resources. Reclamation projects also lead to a change in hydrological characteristics, affecting the migration of fishes, damaging the habitats of fishery populations, and causing a decline in fishery resources. For example, Fujian Mindong's Sandou Ao, Guangjing Yang, Minnan's Wuzhou Island, Green Island, and Tseung Kwan O are spawning areas of the large yellow croaker; Min and Jiulong Rivers are important areas for the juveniles and also for migrating adult ayu fish. Xinghua Bay, Meizhou Bay, Guanjing Yang and Xiamen Harbour are the main spawning areas of Japanese Spanish Mackerel. The various embankments for sea enclosures have transformed harbours and beaches into land and changed the coastal hydrology and sea bottom, all of which damages spawning, fishing and nursery areas and leads to a decline of fishery resources[51].

(7) Decline in water purification services, exacerbating coastal pollution. Large-scale sea enclosing and reclamation projects directly cause marine pollution through industrial wastes. The modification of coastlines and changes in the coastal hydrodynamic system weaken the resilience of the marine environment. In recent years, the increase in the occurrence of HABs in the western harbour of Xiamen can be correlated with the large-scale

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[49] Liu, H.B. and Sun, L. 2008. Game analysis on the reclamation actions in Jiaozhou Bay and the protection countermeasures. *Ocean Development and Management* 25 (6): 80-87.

[50] Han, Z.H., Li, J.D., Yan, H., Shen, T.Y.J. and Xu, C. 2010. Ecological safety analysis of the wetland of Liao River Delta based on landscape patterns. *Ecology and Environment* 19 (3): 701-705.

[51] Zhou, Y.H. 2004. Study on Fujian's tidal flatland reclamation using RS and GIS. Master Thesis, Fujian Normal University.

reclamation work around Xiamen Island. The reclamation activities around Hong Kong's Victoria harbour caused the accumulation of pollutants, exacerbating marine environmental pollution.

(8) Increased risk of marine disaster. Sea enclosing and land reclamation increases the risk of coastal land subsidence and coastal erosion, and weakens the ability of protection services for marine hazards.

4.3.2.4 Overexploitation of fisheries causing a decrease in the reproduction of resource population

The Fishery industry has contributed significantly to food safety and to the economic development of China. However, since bottom trawl is the principal fishing method and since exploitation of fisheries has surpassed stock-recovery ability, not only has the biomass of the fishery resource decreased dramatically, but so also have habitats been destroyed, resulting in the extinction of some commercially important species.

Overfishing has also caused biomass reduction of high-valued species and a decrease in body size (e.g., the average length of small yellow croaker decreased from 20cm in the 1970s to 10cm today). As well, scientists are concerned by observations of early maturation, and lowered trophic level. The catch of juveniles has increased, and the quality of catches decreased[52]. Also species extinction has meant that naturally dominant species are gone, biodiversity has decreased, and there has been a change of ecosystem structure and function that poses great difficulties for the restoration and sustainable development of marine fisheries [53, 54]. In addition, the discards and wastewater from fishing activity are harmful to the marine environment.

The development of mariculture has also had a significant impact on coastal and inshore marine ecosystems. Although the production of fed species, such as fish and shrimp, takes only 10% of the total mariculture production in China[55], they are the major source of pollution from mariculture. The feed for these species is composed mainly of trash fish or fishmeal, and its wide use may result in significant increase in N, P and organic wastes in the seawater[56]. Large-scale mariculture has posed severe stress on tidal and coastal ecosystems,

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[52] Zhang, B. and Tang, Q.S. 2004. Study on trophic level of important resource species at high trophic levels in the Bohai Sea, Yellow Sea and East China Sea. *Advances in Marine Science* 22 (4): 393-404.

[53] Jin, X.S. and Deng, J.Y. 2000. Variation in community structure of fishery resources and biodiversity in Laizhou Bay, Shangdong Province. *Biodiversity* 8 (1): 65-72.

[54] Tang, Q.S. 2006. Marine biological resources and habitats in China's exclusive economic zone. Beijing: Science Press.

[55] The Ministry of Agriculture, Bureau of Fisheries. China's Fishery Yearbook 1998 and 2009. Beijing: Chinese Agricultural Press.

[56] Cui. Y., Chen, B.J. and Chen, J.F. 2005. Evaluation of pollution caused by mariculture in the Yellow and Bohai Seas. *Chinese*

resulting in the shift of habitats including wetland, seaweed bed and coral reefs, all of which has destroyed the spawning ground and habitat of some fishery species, and has had a negative effect on the recovery of these fishery resources.

4.3.2.5 The proliferation of hydraulic engineering projects – impacts on estuarine environments

China has the largest number of large-scale hydro projects in the world. More than half of the world's large reservoirs (>15m in height) are found in China and these are mainly distributed around the Changjiang and Huanghe River basins. The construction of these projects has led to a dramatic decrease in river runoff and sediment load into the sea. The transported sediment from rivers decreased from 2 billion tonnes per year in the 1950-1970 periods to 3 to 4 million tonnes in the most recent decade, and that poses a serious threat to coastal environments. The Huanghe River, being one of the most important rivers historically in China, has decreased its sediment load by 87%. The Liaohe, Haihe and Luan Rivers have zero sediment transport into the sea and have experienced a 90% decline in runoff[57, 58, 59]. Although the rivers south of Haihe have not experienced such significant change in sediment load, the amount of sediment flux into the sea decreased dramatically, for instance, a 53% decline has been experienced in the Changjiang River[60, 61].

The decrease in river sediment leads to the erosion and retreat of deltas and coastal wetlands, and the decline in resources produces a dramatic change to the riverine ecological habitats. The Huanghe River delta experienced an annual *increase* of 23 km^2 during the 1980s, compared to an annual *erosion* of 1.5 km^2 since the end of the 20th century. This erosion phenomenon is also evident in the Changjiang River delta[62, 63]. There are a number of

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Journal of Applied Ecology 16 (1): 180-185.

[57] Dai, S.B., Yang, S.L. Gao, A., Liu, Z., Li, P. and Li, M. 2007. Trend of sediment flux of main rivers in China in the past 50 years. *Journal of Sediment Research* 2: 49-58.

[58] Liu, C., Wang, J.Y. and Sui, J.Y. 2007. Analysis on variation of seagoing water and sediment load in main rivers of China. *Journal of Hydraulic Engineering* 12: 1444-1452.

[59] Yang, Z.S., Li, G.G., Wang, H.J., Hu, B.Q. and Cheng, Y.J. 2008. Variation of daily water and sediment discharge in the Yellow River lower reaches in the past 55 years and its response to the dam operation on its main stream. *Marine Geology & Quaternary Geology* 28 (6): 9-17.

[60] Dai, S.B., Yang, S.L. Gao, A., Liu, Z., Li, P. and Li, M. 2007. Trend of sediment flux of main rivers in China in the past 50 years. *Journal of Sediment Research* 2: 49-58.

[61] Liu, C., Wang, J.Y. and Sui, J.Y. 2007. Analysis on variation of seagoing water and sediment load in the main rivers of China. *Journal of Hydraulic Engineering* 12: 1444-1452.

[62] Yang, S. L., M. Li, S.B. Dai, Z. Liu., J. Zhang and P.X. Ding, 2006. Drastic decrease in sediment supply from the Yangtze River and its challenge to coastal wetland management. Geophysical Research Letters. Vol. 33, L06408, doi: 10.1029/2005GL02550.

[63] Li, P., Yang, S.L., Dai, S.B. and Zhang, W.X. 2007. Accretion/erosion of the Subaqueous Delta at the Yangtze Estuary in Recent 10 Years. *Acta Geographica Sinica* 62 (7): 707-716.

estuarine and coastal habitat ecological problems that are associated with the construction of large-scale hydraulic engineering projects, these include changes in structure and population of planktonic communities, a decline in biodiversity and primary production, and increase in HABs, and the degradation and disappearance of fish spawning grounds and hatcheries. As these hydraulic projects continue to develop, the negative impacts on the ecological environment will be more pronounced.

However, there are key questions that remain unresolved concerning how the impacts on estuaries and coastal habitats caused by major hydraulic engineering projects interact with other influencing factors, such as climate change and human disturbances.

4.3.2.6 Sea level, temperature rise and ocean acidification as potential new threats

Climate change influences many well known aspects of the marine environment, including sea level, sea temperature and ocean acidification[64]. It is projected that changes to these will influence the health of the marine ecosystems and also the sustainable development of Chinese society. Due to the geography of coastal regions and the level of human activity there, the impacts of climate change will be more pronounced in these areas. In the past decades changes to sea levels have already been observed, and it is anticipated that future climate change will bring even more serious impacts.

In the past 30 years, China's sea level has risen at an average of 2.6 mm/year, higher than the global average[65, 66]. According to predictions, China's coastal sea level may increase from 80-130 mm in the next 30 years[67]. Areas that are particularly vulnerable include the Changjiang Delta, Zhujiang River Delta, Huanghe River Delta and coasts around the Beijing/Tianjin area. Sea level rise is a slow-occurring marine hazard, but the long-term accumulated effects may include increased flooding, coastal erosion, seawater intrusion, soil salinization and other marine hazards[68]. These represent a threat to the living environment of humans, and the most direct impact of sea level change will be coastal wetland, tropical coral reef and mangrove forest losses. There will also be valuable coastland lost within the most economically developed areas.

Monitoring results from the past few decades have shown an upward trend in sea surface temperatures of China's coastal waters, and the sea surface salinity levels are also

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[64] IPCC, 2007: Climate Change: 2007 Integrated Report.

[65] Lin, Y. 2010. The rate of sea level rise in China is higher than the global average rate. *Guangming Daily*. Available at: http://www.gmw.cn/content/2010-01/28/content_1045930.htm

[66] According to 2007 China Sea Level Bulletin, the world average sea level rise at the same time was 1.7±0.5mm/per year. http://www.soa.gov.cn/soa/hygbml/hpmgb/seven/webinfo/2008/01/1271382651226473.htm

[67] SOA 2010. Bulletin of China's Sea Level, 2009.

[68] See Footnote 68.

changing. For example, the Yellow Sea's temperature rise of 1.4℃, makes it one of the regional seas with the highest increase globally[69]. Changes in sea surface temperatures have important impacts on Chinese marine ecosystem, such as resource distributional modifications, restoration of mangroves extended to the north, and the calcification of tropical coral reefs. Chinese marine fishes have clear geographical characteristics, which means that rising sea temperatures will lead to changes in their geographical distribution and community structure. At the same time, warmer sea waters will affect human society in many ways including socio-economically and through the food chain as changes to habitats of marine organisms impact the fisheries and aquaculture industries. Sea temperature change will also modify patterns of marine biological resource exploitation and lead to a loss of marine ecosystem functions and services.

As atmospheric CO_2 concentrations increase, the impacts of ocean acidification are also more significant. Ocean acidification will affect the bone formation, metabolism and life histories of calcified organisms, leading them to fail at interspecific and community competition. These effects, passed down the food chain, will affect the entire ecosystem community, functions and services. Ocean acidification poses an especially serious threat to tropical coral reefs already facing pressures from human population expansion and human activities associated with economic development. For example, ocean acidification has led to the degradation and decline of Chinese coral ecosystems and a corresponding decline in coral reef marine tourism opportunities. In addition, China, as the worlds number one provider of global fisheries production, including shellfish, shrimps and crabs, needs to be mindful that these organisms are easily affected by ocean acidification.

Box 4-12 Atmospheric CO_2 Absorption

Seaweeds can transform dissolved inorganic carbon into organic carbon by photosynthesis. Filter-feeding mollusks can also clear out particulate organic carbon by feeding activity and through the process of calcification a lot of carbon can be imbedded in their shells. In this way, a significant amount of carbon is removed from the seawater by the harvesting of mariculture products.

Coastal areas are generally the worlds most highly populated and economically developed areas. In China, the Changjiang Delta, the Zhujiang River Delta and the Bohai Sea area are the three most important economic zones. Coastal areas are China's principal

[69] In the recent twenty years, the world average SST has been in an upward trend, with temperature increase at about 0.13 degree C/10 year period. Cited from IPCC AR4 report.

locations for key industries and economic development projects along the coast have become the driving force for China's economy. A point to note is that these coastal areas are particularly vulnerable to climate change, as sea level rise will lead to marine hazards, coastal erosion, seawater intrusion, and has led to serious impacts to the coastal economic and societal development. It is foreseen that sea level and temperature rise and ocean acidification are leading to an increased occurrence and degree of a variety of marine hazards in the future.

The need to adapt to the impacts of climate change is closely linked to China's economic development and the interests of the Chinese people. Currently, China's marine capacity to respond and adapte to climate change is inadequate to meet the forseeable challenges. In order to effectively decrease the impacts of climate change and to assure the sustainable development of the coastal economic zones, it is vital to understand the role and function of oceans in climate change adapation. As we move forward, China needs to establish integrated management and coordination mechanisms with which to handle the challenges of climate change; it needs to increase the capacity of coastal areas to adapt; it needs to strengthen basic research on air-sea interactions; it needs to establish a comprehensive monitoring network of the marine environment; and finally, it needs to put in place measures to increase the nations resilience to marine hazards.

4.3.3 The Bohai Sea-the Hotspot of Chinese Marine Environmental Problems

The Bohai Sea, China's only inland sea, has an area of 77 000 km^2. It is surrounded by what is already China's most important economic zone and is expected to continue growing at a higher rate than the other zones. In recent years, the Bohai Sea's ecological services and functions have deteriorated so badly that it has become the nation's most talked-about marine environmental problem region. Unlike other polluted sea-spaces in China, the Bohai Sea is a semi-enclosed shallow body whose natural flushing processes are weak.

The Bohai Sea is bordered by four of China's most populous coastal administrative regions and in addition to receiving the outflow of seven regional water systems, it is also the recipient of waters from distant catchment areas and therefore sees the effects of their land-based point and non-point sources of pollution. Domestic and international experts and scholars agree that the Bohai Sea is likely to become a 'Dead-Sea' if effective remediation measures are not adopted soon.

(1) Environmental pollution is still the main focus of the Bohai Sea's environmental problems and the area of polluted coastal water is increasing. The major marine pollutants include inorganic nitrogen, active phosphate and oil, all originating from land-based sources.

Pollution in the Bohai Sea had historically resulted from petroleum or heavy metal industries, but others have joined these sources such as light industry, domestic waste, agriculture, and air pollution.

The principal river systems around the Bohai Sea include: the Huanghe, Haihe, Liaohe, Luanhe, Shuangtaizihe Rivers; the Liaodong Peninsula Rivers and Shandong Peninsula Rivers. These river systems bring in large amounts of inorganic nitrogen and active phosphate, leading to increasingly serious eutrophication within the Bohai Sea and resulting in changes to the community structure of phytoplankton and the subsequent occurrence of HABs.

The shellfish within Bohai Bay have higher organic pollutants, oil and heavy metal residues than anywhere else in the area. DDT, petroleum products, lead, cadmium, and arsenic pollute the coastal sediment, and these have exceeded the Grade I Quality Standard for Marine Sediment. Hexachlorocyclohexane and polychlorinated biphenyls have exceeded the Grade Ⅲ Quality Standard for Marine Sediment. The monitoring stations south of Bohai Bay have shown levels above the Grade I Quality Standard for Marine Sediment in cadmium and arsenic, and levels of lead have also exceeded Grade Ⅱ Quality Standards. The monitoring stations north of Bohai Bay show that petroleum products, cadmium and arsenic have also exceeded Grade I Quality Standards.

Box 4-13 Strategic Environmental Assessments

SEA examines the environmental, and increasingly also the social and economic impacts and dimensions of policies, plans, and programs and other strategic undertakings. The trend for SEA in the marine domain is Regional-SEA, a proactive and futures-oriented approach to ensure that planning and assessment for a marine region supports the most desired outcomes rather than the most likely ones and informs subsequent project-based environmental assessments and decision processes.

(2) The Bohai Sea's ecosystem faces being significantly compromised by pollution. There are major threats to the health of marine ecosystems; fisheries resources are depleted, and ecosystem support to marine economic development is declining. Monitoring results have indicated that ecosystems within the Bohai Sea have all been classified as sub-healthy or unhealthy in recent years. The rapid development of the Bohai region's economy and people's rising standard of living have contributed to an increased dependence on coastal wetland resources, but the leading coastal wetlands and associated biodiversity are damaged. Reclamation, pollution, and the high level of sedimentation and over-exploitation have also

damaged important natural wetlands. The coastal wetland area is shrinking and there is a loss or weakening of ecological functions. These problems in turn cause the acceleration of coastal pollution. Coastal reclamation and damming prevents the migration of aquatic organisms to their spawning and feeding grounds and threatens the survival of species. Fish farms with open systems also increase the risk of the invasion of exotic species. Marine pollution, habitat destruction, overfishing and inshore ecosystem structural changes are causing the decline of traditional fishing industries and biodiversity reduction in the Bohai Sea. Currently, certain species of the Bohai's traditional commercial fishes, such as hair tails, sea bream and herring, are locally extinct.

As the pace of economic development in the coastal areas around the Bohai Sea increases, so does the scale of sea enclosing and reclamation. In 2009 alone, approved land reclamation in the Bohai region was about 60 km^2 (the real reclamation was far larger than this number however). Due to exploitational activities such as sea reclamation projects, road works, salt fields and aquaculture ponds, the coastal wetlands of the Bohai Sea are being lost permanently, or have become artificial wetlands providing weakened ecosystem services. Degradation of so many wetland ecosystems means a loss of ecosystem services, and there is a close connection between the loss of wetland ecosystems and increasing coastal pollution on the one hand, and the decline of fisheries resources and biodiversity on the other.

Forty rivers feed the Bohai Sea and these are the main source of water for marine ecosystems. In recent years, with the intensification of land development and construction, various activities have begun using increasing amounts of the available water, and this combined with declining rainfall has led to the drying up of some rivers and a resulting decline in the amount of water discharged into the sea. Along with a decrease in quantity, water quality has also become poorer. Salinity in river mouths has risen, as has the salinity of the whole of the Bohai Sea. This effect is particularly pronounced in the estuaries where an increase in salinity means the loss or degradation of spawning areas. The incidence of saltwater intrusion has also increased and the Bohai Sea area now accounts for more than 90% of the nation's total saltwater intrusion.

(3) The increase in marine hazards in the Bohai Sea area in turn increases the risk of oil spill incidents and these must become a top priority for mitigation amongst the various marine environmental problems.

The Bohai Sea contains many ports, and at the same time is the strategic base of the nation's oil reserves. Currently, the Bohai Bay is the largest marine oil field in China. Up until 2009, a total of 23 marine gas fields, 1 932 oil wells and 175 oil platforms had been built/operated in the Bohai Sea. It is forecast that the infrastructure for the oil, gas and

chemical industries will be increasing in this area. Oil transportation in the Bohai Sea will reach 210 million tonnes annually by 2020[70]. Such intensive oil transportation in the area and oil exploration activities mean that the risk of oil spillage will increase significantly.

The environmental problems in the Bohai were formed from long-term accumulation and involve a wide range of government and user conflicts and there is a need for the implementation of an efficient and integrated method as a solution. First of all, the sources of environmental problems are widely dispersed, from the upstream end of the Huanghe River down to the coastal zones at the river mouth, these areas all share economic and environmental benefits, making this a typical shared open resource. For example, a study showed that 60% of the Bohai Sea's pollution does not come from the 13 coastal counties, and fully 40% came from provinces that are not surrounding the Bohai Sea (only three provinces surround this area). So clearly the control of marine pollution has to consider the difficulties of working across administrative boundaries.

Secondly, each of the four coastal jurisdictions surrounding the Bohai Sea has its own economic development plan, and these tend to favour the further development of heavy chemical industries in coastal areas. Such ambition is feasible judging from the perspective of individual projects, however the cumulative impact of all these industries must also be considered.

Thirdly, oversight of marine resources and implementation of environmental management are carried out through divisional management. Various departments such as marine, transportation, agriculture, oil and gas and tourism have equal functions, and there is a lack of coordination of joint law enforcement systems or mechanisms. The lack of coordination between different departments has become an obstacle to the implementation of integrated marine management, causing difficulty in solving marine environmental protection issues that cross regions and departments.

Finally, the national government's marine and basin management of the Bohai Sea area on the one hand, and local government management on the other, cannot be well incorporated. The result is that relevant plans and standards or statistics cannot be correlated, and in some cases, conflicts may also arise.

Box 4-14 Ecosystem-Based Management

There are many explanatory definitions for EBM – Lackey (1998) illustrates it as follows:

[70] National Development and Reform Commission. 2009. *The Environmental Action Plan on the Bohai Sea 2008-2020.* Available at: www.pc.dl.gov.cn/qiye/ShuiWuFile%5C 渤海环境保护总体规划.pdf

Seven core principles, or pillars, of ecosystem management define and bound the concept and provide operational meaning:

1. Ecosystem management reflects a stage in the continuing evolution of social values and priorities; it is neither a beginning nor an end;

2. Ecosystem management is place-based and the boundaries of the place must be clearly and formally defined;

3. Ecosystem management should maintain ecosystems in the appropriate condition to achieve the desired social benefits;

4. Ecosystem management should take advantage of the ability of ecosystems to respond to a variety of stressors, natural and man-made, but all ecosystems have limited ability to accommodate stressors and maintain a desired state;

5. Ecosystem management may or may not result in emphasis on biological diversity;

6. The term *sustainability*, if used at all in ecosystem management, should be clearly defined — specifically, the time frame of concern, the benefits and costs of concern, and the relative priority of the benefits and costs; and

7. Scientific information is important for effective ecosystem management, but is only one element in a decision-making process that is fundamentally one of public and private choice.

A definition of ecosystem management based on the seven pillars is:

'The application of ecological and social information, options, and constraints to achieve desired social benefits within a defined geographic area and over a specified period'.

As with all management paradigms, there is no 'right' decision but rather those decisions that appear to best respond to society's current and future needs as expressed through a decision-making process.

Lackey, R. 1998. Seven Pillars of Ecosystem Management. Landscape and Urban Planning. 40: 21-30.

4.4 Lessons Learned and Trends in International Marine Management

4.4.1 Practicing Ecosystem-Based Marine Management and Marine Spatial Planning

Ecosystem-based management (EBM) is one of the new tools being used in international strategic marine management. The use of EBM as the basis for integrated marine management has consensus from the national agencies of many countries (including China), and specialists and scholars. In July 2010, for example, the USA Interagency Oceans Policy

Task Force[71] released their final report proposal for a national marine policy for the USA, and listed the implementation of EBM as one of its first priorities. Subsequently, President Obama signed an Executive Order to implement the proposal[72]. Canada, Australia, the UK and others have also taken similar steps to implement EBM. International bodies have also proposed a concept of dividing the global oceans into pan-ocean ecosystems known as "large marine ecosystems," as a means of integrating, for example, fisheries management in the open oceans, coastal seas, estuaries, and river basins. The technique is viewed as a way to encourage the collaboration of national, multi-national, and international agencies for the protection of these resources.

Box 4-15 Marine Spatial Planning

Similar to land use planning, MSP is a relatively new process which identifies sea areas most suitable for various types or classes of human activities in order to reduce conflicts among uses, reduce environmental impacts, facilitate compatible uses, and preserve critical ecosystem services to meet economic, environmental, security, and social objectives that have been prioritized by government. China was a world leader when it introduced MSP in 2002 however, with eight-years of experience it is now time for China to revisit its earlier zoning decisions and revise its MSP using sustainable development (rather than economic gains) as its foundational element.

Recently, marine spatial planning (MSP) has also evolved as a favoured new tool under integrated ocean management on the international scene. MSP uses ecosystem protection as a basis for strategically allocating space, and for regulating, managing and protecting multiple, cumulative and potentially conflicting uses of the oceans and coasts. At the moment, the UK, Germany and Australia have implemented marine spatial planning, whereas the European Union (EU) is about to start MSP in the North Sea. The US/NOAA ocean policy research report published in September 2009[73] states that MSP is an effective tool to advance EBM in ocean policy.

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[71] www.whitehouse.gov/administration/eop/ceq/initiatives/oceans

[72] www.whitehouse.gov/the-press-office/executive-order-stewardship-ocean-our-coasts-and-great-lakes

[73] Lindholm, J. and R. Pavia (Eds). 2010. *Examples of ecosystem-based management in national marine sanctuaries: moving from theory to practice.* Marine Sanctuaries Conservation Series ONMS-10-02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 33pp.

4.4.2 Implementing Regional Specific Environmental Management

To protect and restore the ecological environment of the Baltic Sea, the Baltic Nations signed The Convention for the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention-HELCOM) in 1974. The Helsinki convention is a good example of member nations agreeing to regulate their individual domestic behaviours in order to collectively improve the levels of pollution entering their shared waters. Other relevant experience includes: Laws Concerning Special Measures for Conservation of the Seta Inland Sea of Japan; the Barcelona Convention for the Mediterranean Sea; the Convention on the Protection of the Black Sea Against Pollution; and the 1983-2000 Chesapeake Bay Agreement of the USA, all of which are region-specific management agreements.

Experience has shown that setting up regional governance committees can ensure the effectiveness of regional multi-governmental agreements. The Baltic Sea experience indicated that strong political will and support from top government officials is necessary for successful environmental protection and management.

Box 4-16 No Net Loss

In Canada and some other nations a 'No Net Loss Policy' is one of the most important decision points within environmental impact assessments when considering approvals for marine and coastal works. The object of the policy is to achieve no net loss of habitat productive capacity by primarily avoiding any loss at the site of the proposed activity. In cases where this cannot be achieved, various levels of mitigation or compensation are invoked. In all cases, the proponent will fund whatever measures are agreed to, into the future.

4.4.3 Initiating an Ecological Compensation Scheme and Sustainable Financing System for Environmental Protection

The key to the successful implementation of an ocean or coastal management project is to have an effective and sustainable financing system. Since the issue of pollution management normally requires management across different administrative boundaries, areas to be managed have different financial capabilities and different economic development priorities, as well as varying levels of participation in environmental governance. However, downstream areas are the beneficiaries of environmental governance in upstream areas; hence, many nations and international organizations are attempting to establish financial mechan-

isms that are suitable for whole-of-basin environmental governance.

In addition to government-coordinated financial mechanisms for environmental protection, another important policy method for coastal jurisdictions such as in the USA and EU nations is regulating the use of economic leverage to control the interests of environmental stakeholders and to establish compensation and restoration systems for ecological damage. Ecological compensation is an important aspect of environmental economics policy, its core element being to internalize the external cost of potential ecological damage and ecological protection when undertaking marine works. Internationally, this system has two forms of compensation: the first is monetary compensation, where monetary values of the damage to ecosystem services are used to gauge the compensation. The other is in-kind compensation, which includes re-creation of the impacted ecosystem or mitigation and restoration of damaged ecosystems. One of the main aims of ecological compensation is that human activities will not cause a net loss of naturally-occurring resources. The Habitats Directive of the EU specifies that damage caused by reclamation projects for example, must be compensated, and the compensation plan must be completed before the proposed reclamation project is approved. Canada for example has had a compensation scheme attached to its no-net-loss policy for fisheries habitat since the 1980s.

4.4.4 Coordination of Marine Environmental Protection and River Basin Integrated Management

Since the late 1990s, in order to prevent marine pollution caused by land-based activities, the international community has promoted a ‘mountaintop-to-oceans’ strategy for marine pollution prevention. This approach emphasizes the coupling of integrated marine management and river basin management, to facilitate coastal area and ocean space planning, and to develop mechanisms for resolving inter-regional and national marine pollution issues. At the same time, the international community has also paid more attention to new marine pollution issues, such as eutrophication and hypoxia in estuaries, floating garbage collection, noise pollution affecting marine mammal behaviour, coastal pathogens, and the prevention of environmental issues caused by aquaculture and so forth.

Box 4-17 Hilltops to Oceans
Water in streams, rivers, reservoirs and groundwater serves as a vector to transport pathogens, nutrients, sediments, heavy metals, persistent organic pollutants, and litter large distances, from the

Hilltops to Oceans. Globally sewage remains the largest source of contamination by volume, although industrial and agricultural pollution, and increased sedimentation, also threaten the health and productivity of ocean and coastal resources. Through improvements made to China's sewage management in recent years, agricultural pollution is now the most significant source. For the most part, in China, transported sediment is at its lowest volume since measurement records began.

4.5 Conclusions

The ocean is an extremely important basis for the sustainable development of China's overall economy and the well being of its people. It is one form of the nation's valuable capital. The sustainable development of China's ocean and coasts faces a variety of ecological and environmental challenges. First, the complex nature of pollution in the offshore environment is worsening. Secondly, marine coastal habitats are degraded and ecosystems have undergone drastic changes, which makes this a critical moment to undertake protection and restoration. Thirdly, there is a high frequency of marine hazards, which represent ongoing threats to marine development. Lastly, the *primary* economic coastal zones are linked with many environmental problems, and represent a potential source of new challenges and threats to the upcoming and developing *secondary* economic coastal zones.

The environmental problems faced by coastal and marine ecosystems are fundamentally socio-economic problems and the solutions to these problems require integrative policies and strategies. The basic principle is to integrate marine development and environmental protection in accordance with the country's socio-economic development strategies, in order to achieve a balance between marine socio-economic developments and the utilization and preservation of environmental resources. Employing advanced international concepts, entire ecosystems should be viewed as the basis for research, decision-making and action, so that land, ocean and freshwater are treated as a whole, and so that socio-economic development of coastal and watershed regions is conducted in such as way as to encourage protection of marine/riverine ecosystems and sustainable land use. These concepts also support sustainable, safe and healthy marine usage. They encourage the development of new strategic industries to facilitate changes in marine economic growth. These concepts also suggest innovative management structures and systems that might include an authority that can oversee inter-departmental conflicts and interests, and that can support various linkages between governmental administrations at different levels so as to encourage the involvement and commitment of different interested bodies.

4.6 Policy Recommendations

4.6.1 Recommendation 1: Develop a National Strategy for the Sustainable Development of the Ocean and Coasts

The next 10-20 years is the key period during which China accelerates and fully develops into a moderately well off society, and reaches the peak number of its population, as well as the height of its industrialization and urbanization. Rapid development of the coastal areas, coupled with a lack of national planning or even a general development strategy, will make sustainable development of the ocean and coasts extremely challenging. We recommend the National Development and Reform Commission and other relevant government administrations, based on the evaluation of China's Ocean Agenda 21, study and formulate a new path for the sustainable development of China's ocean and coasts, and that they lay out the basic principles, policy directions, and strategic goals for the sustainable development of China's seas for the next 20 years. This macroscopic guideline should include listing priorities for the various aspects of the coastal regions' overall economic development, maritime economy development, marine environmental protection, and the care of resources. For guidance, one may wish to consult the Marine Policy Statement[74] approach currently being advanced by the UK Government and its Devolved Administrations, and the Obama Administration's recent Executive Order to implement the USA's National Oceans Policy.

Particular priority should be given in the Strategy to the following issues that need immediate and urgent attention:

(1) Land reclamation from the sea.

(2) Eutrophication caused by land sources including agriculture.

(3) Fisheries and aquaculture practices that damage ecosystems.

4.6.2 Recommendation 2: Create a National Oceans Council

Sustainable marine development requires integrated management of ocean and coastal activities. However, no single government administration can manage the complex and comprehensive nature of the associated problems. In the short term, it is not possible for China to centralize ocean management, thus it is likely that multiple agencies (and multiple jurisdictions) will continue to manage ocean and coastal affairs. Setting up an overall plan-

[74] See the 'Governance' report located in Annex Two of the Final Report for further details on the UK's Marine Policy State-

ning committee and a coordination mechanism between agencies will strengthen the existing system by ensuring the enforcement of agreements in policies, and will guarantee the effective execution of existing maritime laws and policies.

It is therefore recommended that a National Ocean Council be set up, led by a Vice-Premier of the State Council, with committee members selected from leaders of the relevant government administrations with marine-related responsibilities.

Due to the urgency of China's marine ecological issues, the Council's initial tasks are to:

(1) Develop the National Strategy;

(2) Strengthen communications between various government administrations; and

(3) Coordinate and direct multi-departmental, multi-industrial and multi-regional projects in ocean development.

At an early date the Council should also focus on the unique and pressing problems encountered in the Bohai Sea by:

(1) Coordinating major marine and coastal area development projects;

(2) Managing and monitoring the implementation of the various plans;

(3) Shepherding the development of a Bohai Sea Area Environmental Management Law; and

(4) Coordinating all development projects that may impact the Bohai Sea ecosystem.

4.6.3 Recommendation 3: Develop an Integrated Ocean Management Legal Framework

To resolve the ecological issues related to the sustainable development of China's ocean and coasts, the legal system and the administrative and economic policies have to be integrated. In the past, there was more emphasis on administrative measures, whereas in the future the implementation of legislation should be used as a foundation that can serve, for example, to strengthen law enforcement capabilities and to facilitate the greater use of economic instruments.

It is recommended that the National People's Congress and the State Council start studying and drafting a PRC Ocean Basic Law, which should govern the development of the ocean and coastal economy, protection of marine ecosystems, and the promotion of sustainable development. This law should embody the principles of ecosystem-based management. To further improve on the marine legal system and realistically push toward improved ma-

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ment.

rine ecological protection we recommend the relevant government administrations start drafting a PRC Coastal Area Management Law and a PRC Bohai Sea Area Environmental Management Law.

4.6.4 Recommendation 4: Implement Ecosystem-Based Integrated Ocean and Coastal Management

Ecosystem-based management and the integrated management approach emphasize using natural ecosystems as the unit of management, and scholars and oceans management experts globally view this as the most effective solution to environmental and ecological issues. We therefore recommend the following actions be undertaken:

4.6.4.1 Action 1: Review marine spatial planning using ecosystem functional units as a basis for decision making

China is a world leader in setting up and implementing marine spatial planning. However, the country's early mapping work emphasized economic development opportunities as the basis for making decisions. Along with the influence of the national coastal area development strategy, this gave rise to new conflicts regarding marine space, resource use and ecological damage. Therefore China must now objectively evaluate marine space, resource availability, and capacity, and must revise the existing mapping based on protecting ecosystem functioning. We recommend that, in a newly revised marine spatial plan, attention be paid to international ocean zonation theories and methods. We further recommend implementing ecosystem functioning as the basic principle for decision making so as to prioritize and manage marine economic activities and reclamation undertakings in a manner that meets the goals of sustainable development.

4.6.4.2 Action 2: Set up a red line system for coastal reclamation

In the context of a new marine spatial plan, China needs to fully consider the multiple applications and ecological value of marine resources and the ecological impact of reclamation in setting up an operational red line system. We recommend the use of scientific information to rank potential areas for reclamation, and to locate sensitive and vulnerable areas and ecological checkpoints as a way of prioritizing areas of protection within the red line for reclamation. As a priority, establish a red line system for bays, estuaries, islands and shallow beaches.

4.6.4.3 Action 3: Set up a compensation system for marine ecosystem services

Using integrated environmental and economic measures the government should require the identification of costs for marine development works including the costs of potential damage to coastal ecosystems. Due to the uniqueness of marine ecosystems, there

is a need for a specialized compensation scheme to be developed. Such compensation is especially important with regard to large development projects, but should also address coastal reclamation, oil spills, damage to marine protected areas, and river basin-estuary-bay areas. There will also be a need to initiate ecological compensation research and to build a few case studies for evaluation and learning. The focus in the short-term should be on coastal reclamation projects, where every proposal for the use of ocean space should be accompanied by a compensation proposal to ensure that project approvals are not provided until adequate ecosystem compensation is included. Options include the use of in-kind compensation, economic compensation and other methods to compensate the loss of ecosystem services. The aim of the exercise is to practice a policy of 'No Net Loss' of productive habitat.

4.6.4.4 Action 4: Set up Marine Protected Area (MPA) networks

MPAs are an effective means to protect marine ecosystems and biodiversity. The Task Force recommends that China further strengthen its current set of MPAs and, by 2020, designate 5% of the area of China's ocean and coasts as MPAs. Also, identify new candidate MPAs that complement the existing MPAs and help to build towards having a representative network of MPAs for the protection of various types of ecosystems and rare and endangered species.

4.6.4.5 Action 5: Augment restoration and re-creation of damaged marine ecosystems

In the past decades many Chinese marine ecosystems have been damaged. It is recommended that China set up marine ecological restoration/re-creation pilot projects at biodiversity hotspots, sites impacted by exotic species, islands, and climate-sensitive areas to carry out typical ecological restoration work, so as to sustain marine biodiversity and increase resilience to natural disasters and climate change.

4.6.4.6 Action 6: encourage conservation and enhancement of marine biological resources

Set-up management systems for the conservation of marine biological resources in the context of ecosystem-based management by: developing sustainable capture fisheries to promote effective resource stewardship; increasing the regulation of coastal and inshore fisheries; setting up species-specific marine protected areas; protection, restoration and conservation of critical fisheries habitats and biodiversity; optimizing artificial reef and sea ranching activities; and by improving the efficiency of wild stock enhancement.

4.6.4.7 Action 7: Develop new methods of fisheries with lower carbon footprints

Improve aquatic ecosystems and encourage the development of environmentally friendly marine algae aquaculture. Also, promote polyculture systems and initiate shellfish-dominated aquaculture to lessen the carbon footprint of the fisheries industries.

4.6.5 Recommendation 5: Implement an Optimal Plan to Minimize the Negative Impacts of River Basins on the Ocean and Coasts

Land-based pollution and major hydraulic engineering projects have severe negative impacts on estuaries and coastal areas. To minimize these impacts, we recommend the following actions:

4.6.5.1 Action 1: Establish best practices for controlling river-basin-to-estuarine pollution

Pollution reduction involves massive costs. Different tributaries impact the estuaries and coasts in different ways. It is necessary to formulate well-devised plans that are adapted to different types of river basins and agricultural pollution pathways. The objective should be to minimize the cost incurred while balancing the scale and effectiveness of pollution reduction measures.

In the light of escalating eutrophication problems along China's coasts, priority should be given to controlling the nutrient concentrations of nitrogen, phosphates and COD in river systems. We recommend using total nitrogen concentration as a controlling factor, and using a mass-balance approach, based on the carrying capacity of the receiving estuaries, to set the guideline levels for land-based pollution. We also recommend a fair distribution of nitrogen release quotas in the regions along the river system, and recommend increasing the monitoring of total nitrogen and air quality to cut down eutrophication in coastal areas.

4.6.5.2 Action 2: Reinforce the regulating of flow and sediment discharges due to hydraulic engineering projects

It is suggested that — under the coordination of the National Ocean Council — the Ministry of Water Resources, River Basin Management Committees and Sea Area Management Administrations should implement a plan to regulate river water and sediment discharges, taking into consideration the amount of sediment needed to sustain deltas, the minimum water requirement by cities along the delta coasts, and the minimum water level required to sustain estuarine and coastal ecosystems.

4.6.6 Recommendation 6: Strengthen the Long-Term Monitoring and Forecasting for Terrestrial and Aquatic Ecosystems, and the related Fields of Science

Long-term and constant monitoring of the marine environment, together with in-depth studies of marine science, are the foundations for effective resolution of problems existing in marine ecosystems. It is suggested that:

4.6.6.1 Action 1

Under the coordination and guidance of the National Ocean Council, government administrations that are involved with the marine environment should work together to monitor the watershed, estuary and the sea as a unit, standardizing monitoring indices and technology, and establishing a unified monitoring system for the atmosphere, watershed, and oceanic/coastal areas. A platform for information exchange should be launched to promote data sharing.

4.6.6.2 Action 2

To prevent eutrophication in the coastal environment, it is suggested that the Ministry of Environmental Protection and the State Oceanic Administration collaborate in strengthening the utilization of NO_x as a monitoring and control index for the atmosphere in the near future, and that nutritional salts (total nitrogen and total phosphorus) be used as the corresponding index for river basins. To control the volume and quality of freshwater entering the sea and to protect the estuarine ecosystems, various governmental administrations such as the Ministry of Environmental Protection, the Ministry of Water Resources and the State Oceanic Administration should work together to monitor the watershed, estuary and sea as a single unit.

4.6.6.3 Action 3

In the near future, emphasis should be placed on developing integrated research for addressing scientific questions concerning river basin and marine ecosystems. Management of ecosystems can be supported by scientific knowledge i.e. a deeper understanding of the mechanisms behind marine ecology and coastal ecosystem services. As an example, research should be conducted on the effects of large-scale coastal reclamation and climate change on marine ecosystems. Close attention should be paid to coastal areas that are densely populated and have thriving economic activities. A coordinating body for monitoring the marine environment should be established, and should be responsible for an environmental monitoring network that conducts laboratory studies and field observations and carries out demonstrations on regional ecosystem recovery.

4.6.7 Recommendation 7: Enhance the Early Warning and Emergency Response System for Major Marine Pollution Incidents

There are increasing risks associated with marine development since many heavy industries in China are clustered around the coasts and the scale of petroleum transport and oil extraction has grown. For example, painful lessons are learnt from accidents such as the Gulf of Mexico oil spill in 2010 and the explosion of oil pipelines in Dalian also in 2010.

Therefore there is a need to follow the international framework for protection of marine ecological systems through prevention and early warning signals, and to establish a system of early warning and emergency response for severe marine pollution incidents. A subcommittee should be formed under the National Ocean Council to deal with emergency response for severe marine pollution cases, and to lead and coordinate the efforts of different government administrations. In addition, there is a need to build a reporting system for severe marine pollution events; to conduct environmental risk assessments evaluating potential risks; to organize a scheme to facilitate early warning and information exchange; to improve the regional emergency response system; to strengthen the supervision of organizations responsible for potential environmental risks; and to ensure the implementation of various emergency response measures.

4.6.8 Recommendation 8: Establish a Campaign to Promote Ocean Awareness and Public Participation

Various media should be employed to provide wide publicity and to educate the public about the importance of the ocean and coasts, and to thus induce them to be actively involved in safeguarding the marine environment. In the face of massive coastal developments, this will help to create an atmosphere of marine ecological systems protection in society. A platform to support and enhance public participation in decision-making processes concerning important ocean development projects should be established. This will permit and encourage more stakeholders to take part in policy decisions.

Chapter 5 China Ecological Footprint Report 2010

5.1 Humanity's Ecological Footprint: Global and Asia Context

5.1.1 The Global Context

In 2007, humanity's global Ecological Footprint was 18 billion gha or 2.7gha per person while Earth's biocapacity was only 11.9 billion gha, or 1.8 gha per person representing an ecological overshoot of 50 per cent. This means it would take 1.5 years for the Earth to regenerate the renewable resources that humanity used in 2007 and to absorb the CO_2 waste that we emitted. Put another way, in 2007 we used the equivalent of 1.5 planets to support our activities.

People in different countries place very different demands on ecosystems. In 2007, the average Ecological Footprint per capita in China was 2.2 gha, which is 0.5 gha lower than the global average. This places China 74th among the 153 countries for which a Footprint was calculated.

5.1.2 The Asia Context

Asia's total biocapacity is 2 867 million gha, which accounts for 24% of the global biocapacity. Asia has 0.72 gha of biocapacity per person, less than half the global average, and the lowest biocapacity relative to population of any of the world's regions. Asia's average per capita Ecological Footprint is 1.8 gha, which is same as the global average biocapacity and well below the global average Ecological Footprint of 2.7 gha per person. Despite its low per capita Ecological Footprint, Asia as whole used 60% of the world's biocapacity and accounted for 40% of humanity's ecological footprint. This is due to its large population, which represents for 60% of the world's total population.

Asia's total Ecological Footprint is 2.5 times its biocapacity. Asia as a whole is an importer of biocapacity with net imports from the rest of the world representing an embedded Footprint equal to 12 percent of Asia's total Footprint of consumption. Asia thus partly meets its ecological deficit by drawing on other regions' biocapacity and using the global commons

to absorb its CO_2 emissions. (Source: Global Footprint Network)

Asia has the largest ecological footprint growth among all the world's continents. Between 1961 and 2006, the total Ecological Footprint of Asia increased by about 3.5 times or about 4 000 million gha. The increase in Ecological Footprint is a result of an increase both in population and in per capita in Ecological Footprint: per capita Ecological Footprint increased by 46 percent, while Asia's total population grew by 138 percent.

Carbon footprint is the fastest growing component of Ecological Footprint in Asia just as in other regions. In 2007, similar to other regions, carbon footprint accounted 53% of Asia's Ecological Footprint. This compares to just 5% in 1961. Since the per capita Ecological Footprint of Asia is smaller than the global average, the per capita carbon footprint is also lower.

The disparity in per capita Ecological Footprint amongst Asian countries is larger than any other region. This is due primarily to differences in affluence and consumption patterns among the countries. Residents of the United Arab Emirates have the world's highest per capita Ecological Footprint, 10.3 gha, while the per capita Ecological Footprint in Pakistan is 0.75 gha per person. On current trends, and as a result of their large populations, China and India will become the two countries with the largest total Ecological Footprint.

5.2 China's Ecological Footprint and Biocapacity

China has experienced an all-round growth during nearly half a century, creating a steadily increasing Ecological Footprint. China now has the second largest total Ecological Footprint; trailing only the United States. China is also, however, endowed with significant biocapacity, behind only Brazil and the United States in terms of total biocapacity.

Prior to the 1970s, China had a yearly Ecological Surplus – the excess biocapacity over Ecological Footprint. However, this changed in the mid-1970s, when China's Ecological Footprint began to exceed its biocapacity. This excess Ecological Footprint is known as Ecological Deficit, and since China first experienced an Ecological Deficit in the 1970s, the deficit has steadily increased.

Both economic-social systems and ecosystems vary across China's provinces (including provinces, municipalities and autonomous regions). The report uses the global average productivity of all bio-productive land types in the year 2005 as the benchmark to measure changes of regional Ecological Footprint (demand on biological natural resources) and biocapacity (the available supply of biological natural resources) resulted from changes of local production and consumption in defined provinces of China during 1985-2008. We made the assumption that 23 percent of the carbon dioxide emissions are absorbed by the ocean and

the other 77% of CO_2 emissions depend on forest absorption. Carbon dioxide emissions from power plants are determined based on the method of national average energy consumption per unit power, while thermal system carbon dioxide emissions are calculated based on the actual energy consumption of heat supply in various regions. Carbon dioxide emissions in the energy processing and conversion links are amortized to end-users. Under this calculation model, Footprint of consumption/ production and biocapacity in time series reflect the consumption and production pattern changes.

Ecological Footprint and Biocapacity are not evenly distributed across China. In 2008, Guangdong, Shandong, Jiangsu, Henan, Sichuan, Zhejiang, Hebei, Hunan, Hubei, Anhui, Liaoning, Guangxi and Fujian were the provinces with over 75 million gha of total regional Footprint. Their combined total Footprint account about two-thirds of the national total, 9 percent higher than their fraction of China's overall biocapacity. The 5 western provinces of Xinjiang, Gansu, Ningxia, Qinghai and Tibet, as well as Tianjin and Hainan only accounted for 5.9 percent of China's Ecological Footprint, but have 12.3 percent of total national biocapacity. In comparison with the Ecological Footprint, regional biocapacity is more unevenly distributed across mainland provinces of China. The five provinces with the highest per capita Ecological Footprint growth during this period were Shanghai, Beijing, Tianjin, Guangdong and Chongqing, each of which, except for Guangdong, is a Central Government-controlled municipality.

Because population density varies across China, per capita Ecological Footprint varies significantly (Figure 5-1), and differs from total regional Ecological Footprint distribution. For example, in 2008, Beijing had the largest per capita Ecological Footprint, 2.7 times larger than that of Yunnan.

Despite the varied amounts and changes of Ecological Footprint, both in total and by component, in each province of China during 1985-2008, growth provides a common trend: eleven provinces saw their per capita Ecological Footprint double, ten experienced increases between 85 and 95 percent with the remaining ten experiencing between 40 and 84 percent growth. Moreover, this increase is being driven in large part by carbon, which has become the largest component of the regional Ecological Footprint. Indeed, in 2008 the carbon component accounted for over 50 percent of the Ecological Footprint in 29 of China's 31 provinces, including levels exceeding 65 percent in Shanghai, Beijing, Tianjin and Shandong. Put differently, the carbon component of per capita Ecological Footprint of each province rose by 0.4-2.0 gha, while all other components increased by 0.25 gha or less (1990 was the starting year for calculating Footprint changes in Tibet). This dominance of carbon as the primary and overwhelming component of Ecological Footprint is not expected to change based on current development patterns.

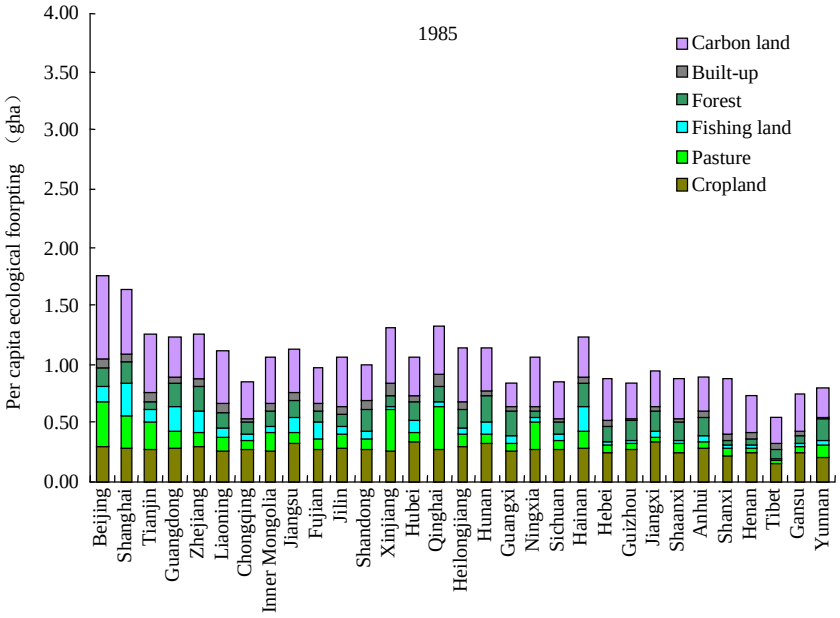

Figure 5-1a Regional Per Capita Ecological Footprint in China (1985)

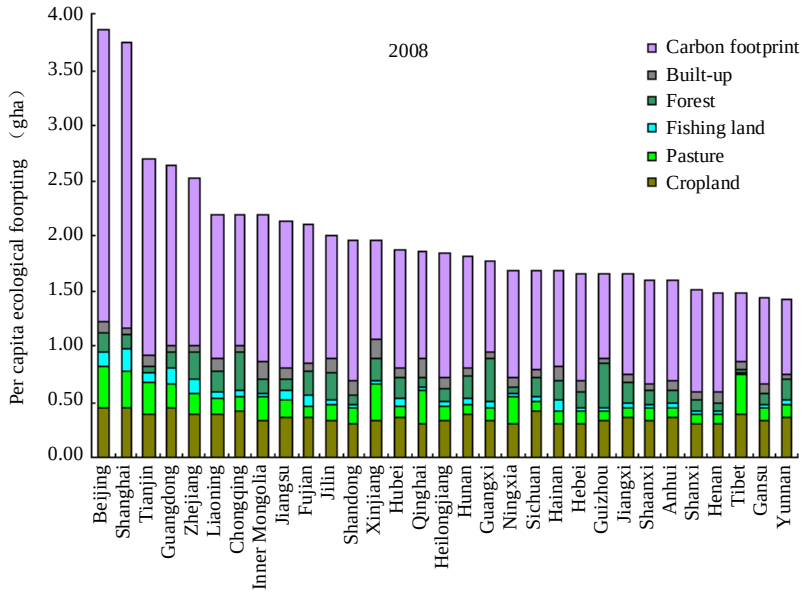

Figure 5-1b Regional Per Capita Ecological Footprint in China (2008)

Note: In 1985, Hainan and Chongqing were not yet independent provincial regions and their Ecological Footprint was averaged with the levels of Guangdong province and Sichuan province, which they fell under the jurisdiction of, respectively.

Data source: IGSNRR, 2010

Per capita Ecological Footprint rise slowed down in most mainland provinces in China during 2005-2008 by comparison with rises during 2000-2005, illustrated by Beijing (Figure 5-2). The reduction in the rate of increase in Beijing can be explained by urbanization stabilization and energy saving activities, as well as a transition towards service industry, rather than goods production, to drive economic growth. In some provinces such as Shandong, per capita Ecological Footprint rise mainly tracked urbanization increase.

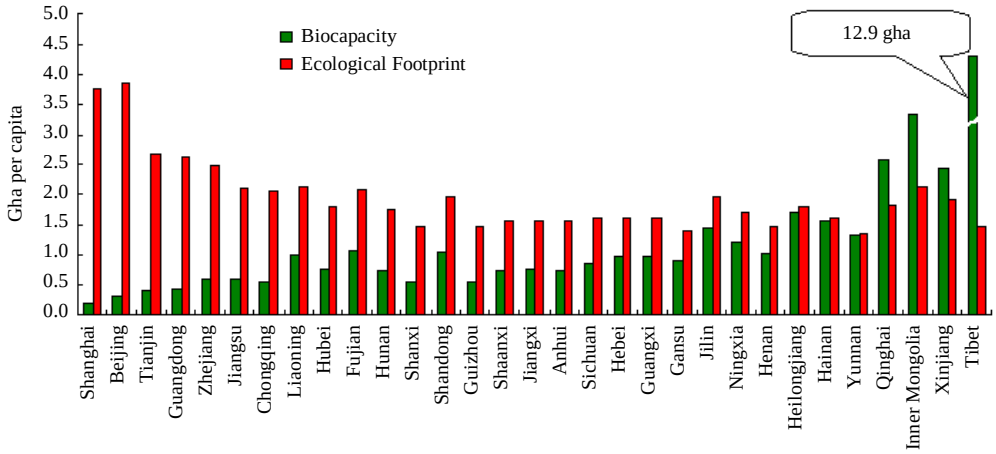

Figure 5-2 Province-based Ecological Pressure and Biocapacity in Mainland China (2008)

Data source: IGSNRR, 2010

Carbon's overwhelming impact on Ecological Footprint creates the situation where a region can have an Ecological Footprint Deficit but it's total non-carbon based Ecological Footprint Surplus (available biocapcity exceeds non-carbon based Ecological Footprint) (Figure 5-3): yellow regions represent this situation, green regions represent an Ecological Footprint surplus, and red regions represent areas with an Ecological Footprint deficit and a non-carbon based Ecological Footprint deficit. Of provinces with an Ecological Footprint deficit in 2008, 70% had a non-carbon based Ecological Footprint Surplus (yellow regions).

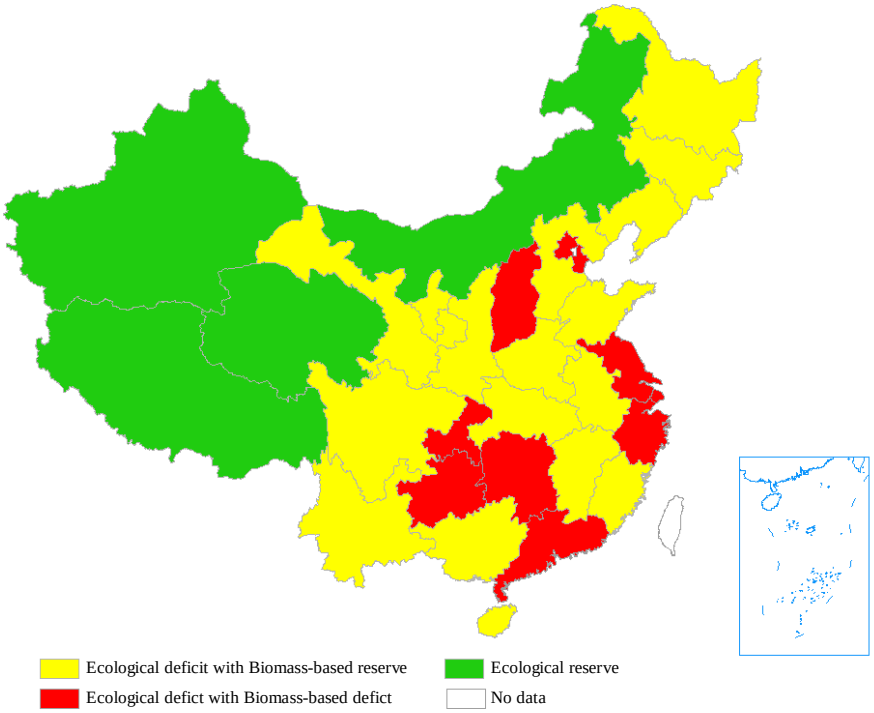

Figure 5-3 China's Ecological Footprint Surplus/Deficit Distribution (2008)

Data source: IGSNRR, 2010

5.3 The Challenge of Urban Ecological Footprint

Cities are the center of world economic and technological innovations, the stronghold for the distribution and development of global knowledge-intensive industries as well as the habitat of a large portion of the population. Since 1900, the urban population has increased by 20 times worldwide while the rural population has increased by less than its one-eighth worldwide. Urban population also sees its percentage of the global total population climbing from 10 percent to around 50 percent. As a spatial unit, cities now place the largest demand on natural resources products and services. It is estimated that 80 percent of the world's carbon dioxide emissions are the result of fossil fuel emissions and 75 percent of the timber consumption occur in urban regions (O' Meara, 1999). High population density, high material consumption, high energy consumption and high waste discharge are the main causes of high ecological pressures in cities. Some cities may require an area almost 100 times their

own biocapacity to support their socio-economic operation.

The fact that cities worldwide are facing high ecological pressures and high ecological deficits gives China an early warning on the ecological pressure and risks which may arise in its urbanization process. Nevertheless, cities may achieve good results in reducing ecological pressures.

In China, there exists a very notable difference in per person Ecological Footprint between urban and rural areas and this gap may widen fast in the near future. Currently, the gap varies from 0.9 to 1.8 gha from province to province, mainly due to the urban and rural income gap and consequently the combination of consumption gap and energy utilization structure differences. The changes in residential and living styles during urbanization may increase the challenge and risks of fast Ecological Footprint growth for China.

5.4 The National Impact of China's Ecological Footprint

As a result of market mechanisms and trading systems, human consumption of ecological resources and services is no longer confined to administrative boundaries. Biocapacity, both local and imported, is embedded in goods and services through the production process ('embedded biocapacity') and transferred to other provinces through inter-provincial and international trade. Generally, the non-carbon component of China's Ecological Footprint is sustained by domestic ecosystems. However, the uneven distribution of biocapacity in China means that transfer of embedded biocapacity through inter-provincial trading can create net importers and exporters of biocapacity through their shipping or receiving embedded biocapacity. Development at the provincial level is associated with an increase in the volume of embedded biocapacity involved in cross-provincial flows and an increase in the distances over which this is transported.

Data concerning China's inter-provincial trade is sparse or nonexistent, making it difficult to calculate the scale of inter-provincial biocapacity flow in China. We can get the conservative value of trans-regional biocapacity flows by looking at the difference between Ecological Footprint of Production and Ecological Footprint of Consumption.

These calculations suggest that cross-provincial Ecological Footprint flows in China exceeded 678 million gha in 2008, accounting for 27 percent of the national Ecological Footprint. Energy and goods and services consumption accounted respectively for 60 percent and 40 percent of this cross-provincial flow. Biocapacity inflows are greatest for provinces with a high level of urbanization, dense population, intensive industrial production but relatively meager energy resources such as Guangdong, Shanghai, Zhejiang and Beijing.

Elsewhere, a decrease in biocapacity and bio-productive land due to high-intensity industrial production in Zhejiang province has contributed to its demand for imported biocapacity.

Inter-province flows of embedded biocapacity still represent a relatively low proportion of China's total Ecological Footprint of Consumption. This is mainly because production facilities are established close to end users in China. On the other hand, power plant and agriculture production are concentrated in coal and land rich provinces.

5.5 Development and Ecological Footprint

Progress towards meeting the goals of sustainable development, allowing all people the opportunity to live fulfilling lives within the means of nature, while optimizing development and societal well-being can be examined through the combination of Ecological Footprint, which indicates demand on nature, and the Human Development Index (HDI), a summary composite index that measures a country's average achievements in three basic aspects of human development: health, knowledge, and a decent standard of living, as calculated by the United Nations Development Program (UNDP).

UNDP considers countries with HDI values of 0.8-0.899 to be experiencing "high human development" (HHD) and 0.9 or greater to be experiencing "very high human development." Accordingly, this report considers the lower boundary of HDI to be the minimum level of optimized development. As noted above, the global, average per capita Biocapacity is 1.8 gha, so, in order to meet the minimum levels of sustainability, per capita Ecological Footprint must be also be 1.8 gha. If a nation is fulfilling both of these requirements it is sustainable and optimized development.

Analysis of data for China's provincial units suggests that when the average person begins earning more than he or she needs for basic survival, excess income can become a driving factor for the increase in footprint once basic needs have been satisfied. For provincial units where per capita GDP is lower than 30 000 *yuan*, the average per capita Ecological Footprint is approximately 1.8 gha and variations between provinces can be largely explained by the influence of geography, climate and food preferences. On the other hand, for provincial units where per capita GDP exceeds 30 000 *yuan* the per capita Ecological Footprint shows a positive association with per capita GDP, meaning that as wealth increases above the level needed for basic survival, Ecological Footprint increases accordingly, rendering influences of geography, climate and regional food preferences unimportant (Figure 5-4).

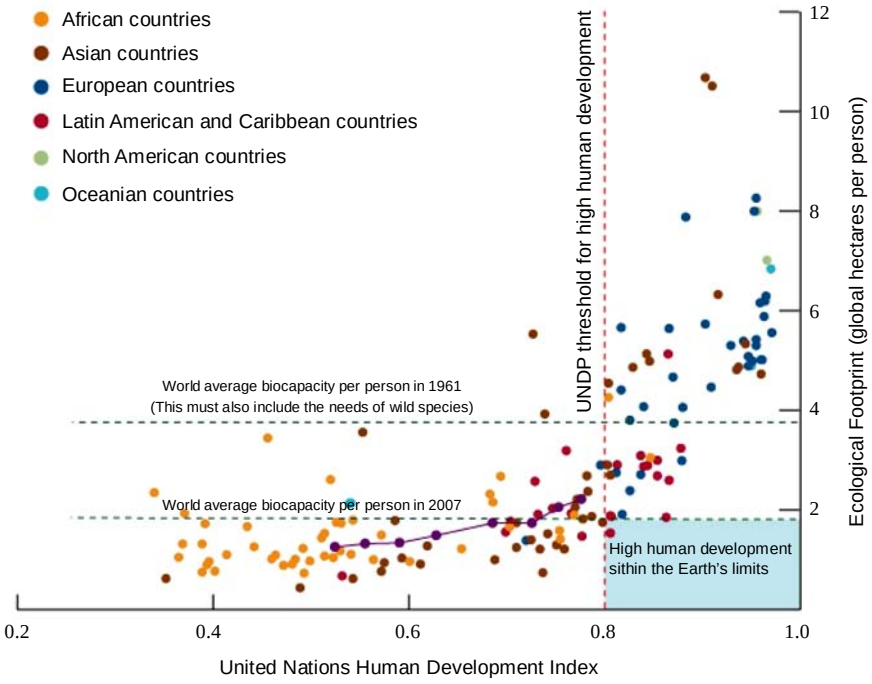

Figure 5-4 Human Development and Ecological Footprint

An HDI value of more than 0.8 is considered to represent "high human development" while a ecological footprint lower than 1.8 global hectares per person, the average biocapacity available per person on the planet, represents a lifestyle that could be sustainably replicated on a global scale. Together, these indicators form a "sustainability box" which defines the criteria that must be met for a globally sustainable society. As world population grows, less biocapacity is available per person and the quadrant's height shrinks.

Data source: Global Footprint Network, 2010; UNDP, 2009b

5.6 Global Impact of China's Ecological Footprint

China's economy also impacts the global flow of Biocapacity. As with the *Ecological Footprint Report of China 2008*, trade data continues to be based on biomass-based footprint, but with traded product items expanded from 43 to 132 categories. In 2008, China's was a net importer of 44.1 million gha of Biocapacity; importing 160.4 million gha in total. Our calculation in this section is based on biomass resources and their product embedded biocapacity flows.

Forestland is the most active Biocapacity component of both China's imports at 41.3

percent, and exports at 29.1 percent. The net import scale is about 32 million gha. Forest land is in such high demand because of China's relative shortage of forest resources and large export businesses of furniture, paper and printed products.

Arable land is the second most active part of China's cross-country trade flows, and is the second active net-imported component of Biocapacity, accounting for 40.2 percent of imported Biocapacity and 37 percent of exported Biocapacity. In 2008, the arable land capacity included in China's import and export was 64 million gha and 37 million gha respectively. Arable land's large demand was mainly due to China's need of vegetable oil and China's exportation of fruit, vegetables and textiles.

Improving livestock production capacity has pushed China to be a net exporter of grassland biocapacity to the world. In 2008, China's trade resulted in a net exportation of 3 million gha grassland biocapacity, which mainly came from wool textile trade.

China continues to be a net exporter of fishing grounds biocapacity. In 2008, its net fishing ground export reached 13 million gha, making notable contribution to reducing China's net biocapacity import.

In the international trade with China's 23 major trading partners (MTPs), China was a biocapacity importer: inflow-primarily from Russia, Canada, Brazil, the United States and Indonesia-totaled 126 million gha, while total outflow-primarily from Japan, South Korea, Saudi Arabia, Germany and Britain-totaled 83 million gha, resulting in a 43.7 million gha surplus.

The flow of biocapacity in China's international trade is relatively concentrated, with imports being even more concentrated than exports. This concentration is particularly glaring when considered by component. For example, 78.2 percent of the forest land biocapacity imported by China 2008 came from five countries – Russia (42.3 percent), Canada, the United States, Indonesia and Brazil – while the largest share of exports went to the United States (18 percent); 17 percent to Japan, South Korea and Britain, and about 10 percent to Saudi Arabia, Russia, Canada and India. Arable land and grassland have similarly uneven distributions, more than 50 percent of each being imported from two countries, respectively, while neither is exported to any one or group of countries as a similarly large percentage.

Another notable feature of China's biocapacity international flow is trade reallocation. Trade reallocation analyzes imported biocapacity's ultimate fate: a) local consumption, b) domestic reallocation through trade as embedded biocapacity or c) international reallocation through trade as embedded biocapacity. In 2008, the distribution of imported biocapacity was 20 percent consumed directly, 35 percent relocated domestically and 45 percent relocated internationally. The biocapacity involved in international trade reallocation mainly

arises with the international trade of products processed from wood, aquatic products, and cotton and wool textiles.

5.7 The Water Footprint

Water is one of the basic elements of the natural environment; together with land and energy these three are indispensable factors for human survival and underpins sustainable socio-economical development.

Water footprint measures the total volume of water that is used to produce the good and services that we consume. It consists of three components: the blue, green and grey water[1] footprint. Blue and green water footprints quantify the water that we use in production of goods and services, while grey water quantifies the water that we pollute. By considering all three types of water use, the water footprint broadens the traditional assessment of water resources to better reflect the demand placed on water resources by humans.

5.7.1 Water Footprint of Production

The water footprint of production of a region is the volume of freshwater used to produce goods and services within the region, irrespective of where it is consumed. With the support of water stress analysis, the water footprint of production can be used to evaluate the pressure that national or regional production has put on local ecosystem. The water stress is defined as the ratio of water use (total of surface water withdrawn for domestic, agriculture and livestock use, polluted volumes of fresh water) to water availability. This is mainly calculated on an annual basis as the ratio of total blue and grey water footprint to total renewable water resources available in a region. The present status of China's water resource is serious. In 2007, 5 out of 31 mainland provinces were facing severe stress (>100%), they are Beijing, Tianjin, Hebei, Ningxia and Shanghai; 4 regions were under high stress (40%-100%); 7 regions experienced moderate stress (20%-40%) and 12 regions were under minimal stress (5%-20%). Among 31 mainland provinces only Yunnan, Qinghai and Tibet had no stress (Figure 5-6), where there was a low level of water footprint of production. The five regions under serious water stress are because of high population (Beijing, Tianjin and Shanghai), intensive agriculture (Hebei and Ningxia) and local climate conditions (Ningxia) respectively. We can tell from the figure that the regions with serious and high stress are mostly concentrated in North-China and Central-China.

[1] Blue water is surface and ground water, green water is in the soil, and grey water is associated with production of goods and services.

Compared to blue water, green water has relatively low opportunity cost and environmental impact. It plays an important role in water resource and food safety. However, green water resources have been neglected in traditional water resource assessment systems. According to our research, for 26 of 31 mainland provinces the footprint of green water account for more than 30% of the total water footprint of production and among them 11 provinces have green water footprints larger than 50% (Figure 5-5). Given that green water footprint contributes so much to the water footprint of production, perhaps another way to tackle water resource problems is by improving green water management.

The grey water footprint evaluates the impact of water pollution from production activities. In 2007, two-thirds of Mainland China's provinces grey water footprint account for more than 25% of local overall water footprint of production. Among them most grey water footprint comes from the chemicals used in agriculture. For example, in the production of wheat and maize in north China, 22.5% and 26.1% of their water footprint of production is grey water footprint. The improvement of fertilizer and chemicals service efficiency is significant for solving water problems.

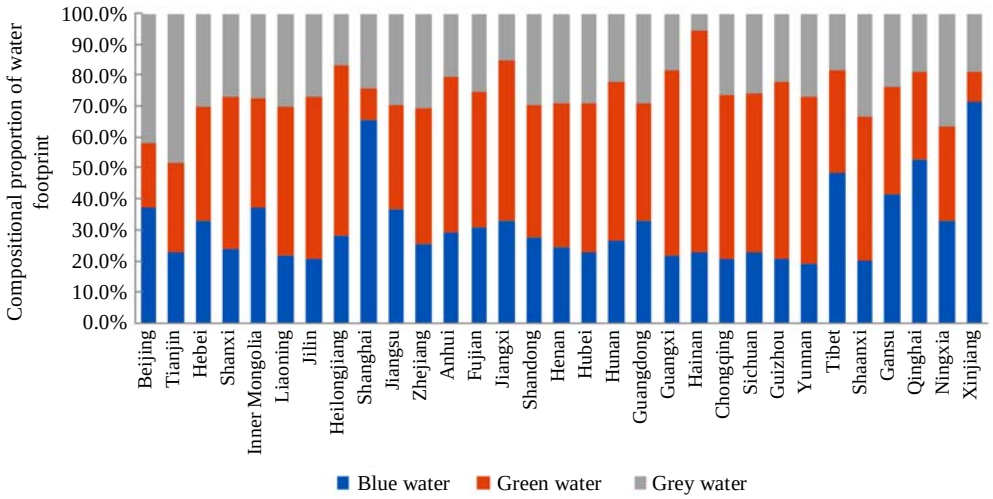

Figure 5-5 Water Footprint of Production in China's Provinces (2007) and Listed for 31 Mainland Provinces

Data source: IGSNRR, 2010

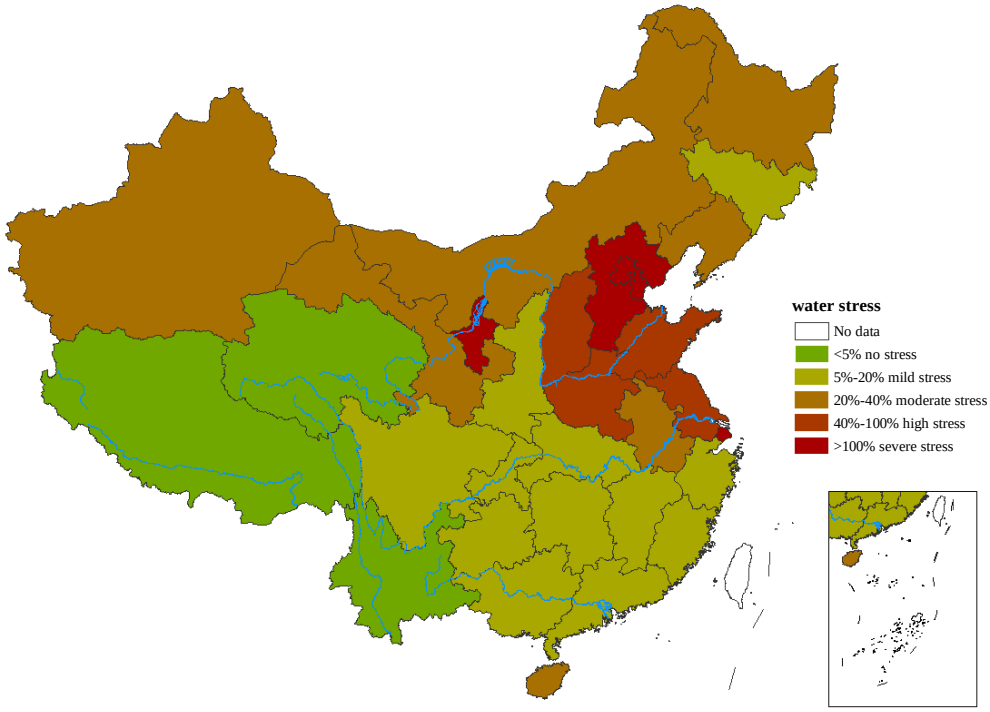

Figure 5-6 Water Resources Stress in China's Provinces (2007)

Data source: IGSNRR, 2010

5.7.2 Water Footprint of Consumption

The water footprint of consumption of a region is the volume of water used in the production of goods and services consumed by the inhabitants of the concerned region, irrespective of where the goods and service are produced. According to the source, the water footprint of consumption includes internal water footprint and external water footprint. Internal footprint is the volume of total water volume used from domestic water resources to produce the goods consumed by inhabitants of the country. The external water footprint of a country/region is the volume of water resources used in other countries/regions to produce the goods consumed by the inhabitants of the concerned country/regions.

In 2007, the average water footprint of consumption in China is only 679m^3/capita/year, which is about 43% of global average (1 564 m^3/capita/year). However, there is a large spatial variation across different regions in China. The top six provincial units with water footprint higher than national average were Xinjiang, Shanghai, Guangdong, Jiangxi, Fujian and Beijing, which apart from Xinjiang because of its intensive agriculture are municipalities or

more developed coastal provinces (Figure 5-7). From the figure we can tell that the major influential factors for water footprint of consumption in China include economic development level, agriculture and living style.

Most regions in China have high self-sufficient level on the water footprint of consumption. In 2007, two thirds of the regions have a self-sufficient rate larger than 90%. The biggest external water footprint is found in Beijing, which is amount to 50% around. While in Guangdong, Shanghai, Tianjin and Jiangxi about 18%-26% water footprint of consumption is external water footprint. For water shortage regions, externalizing water footprint to water surplus regions may be a very effective solution.

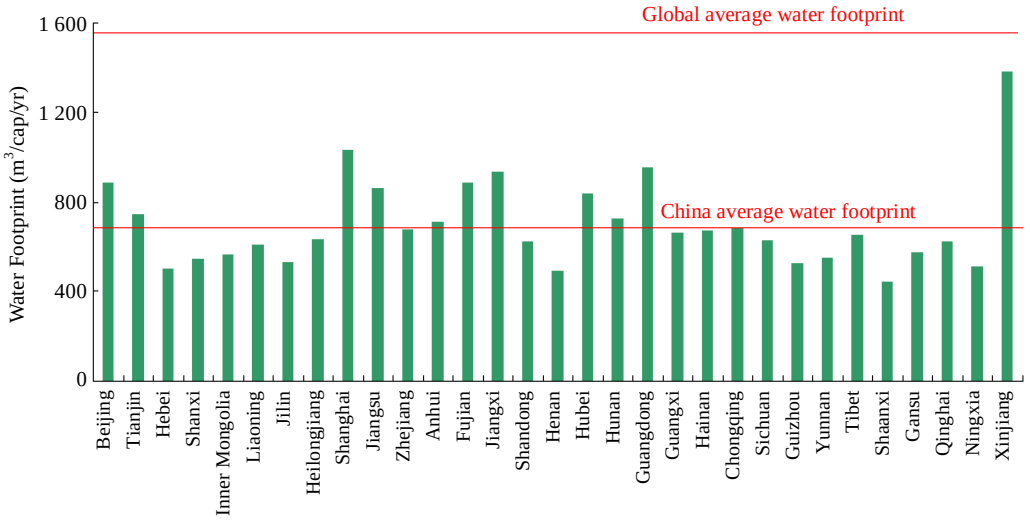

Figure 5-7 Provincial Variations in Average Water Footprint per Person in China (2007)

Data source: IGSNRR, 2010

According to preliminary data, considerable water has been exported to other countries embedded as part of the production of Chinese agriculture products. As a water intensive industry, the exportation of agriculture products may make water shortage in some regions worse. It is important for the government to establish monitoring mechanism to control the exportation activities, optimize local industry structure and promote efficient use of water resource.

5.8 China: Transforming Toward Sustainable Development

In a world with limited resources and regeneration capacity, if humanity is to realize sustainable development and continuously improve human welfare, then we have to live

within the capacity of the ecosystems of the planet Earth. The results presented this report clearly indicate that humanity's Ecological Footprint is continuing to grow with the average per capita Ecological Footprint reaching 2.7 gha in 2007. This mean we now need one and a half planets to keep up with humanity's demand for resources, or, put another way, the global ecosystem would need one and half years to regenerate the natural resources consumed and absorb the carbon dioxide emitted in 2007. In China, the average per capita Ecological Footprint has reached 2.2 gha. While China's per capita Footprint is lower than the global average level, China's total Ecological Footprint was two times greater than its available biocapacity, and its ecological deficit is continuing to increase year by year.

The Earth's fate will determine the common destiny of all people. In the face of a global ecological credit crunch, China has long taken a highly responsible attitude, actively committing itself to seeking sustainable consumption, efficient production and the maintenance of a sound ecological foundation. While raising the level and quality of human life, the country has set out to improve the carrying capacity of its life support systems and slow the growth rate of its Ecological Footprint and Water Footprint in order to improve the sustainability of development.

The analyses presented in this report show that in last half century China achieved a rapid increase in its human development as measured by the 'Human development index' (HDI) and is in 2007 was close to the threshold for high human development. Per capita income increased more than 50 times over the same period while per capita Ecological Footprint increased only by around 4 times. China per capita Footprint has just overtaken the level of available per capita bio-capacity on a global basis, some 30 years after the world as a whole crossed this threshold.

There are signs that China is at important turning point. For example, the rate of Footprint growth slowed in two thirds of China's provinces between 2005 and 2008, compared to the previous five year period. However, overexploitation of natural resources is a concern and has led to loss of ecosystem services in some areas even in resource rich provinces that enjoy an ecological surplus. The growth in Ecological Footprint of China is influenced by levels of urbanization and individual wealth. China is fully engaged in establishment of an ecological society and is facing up to the challenge of reducing its ecological deficit by increasing biocapacity and curbing growth in Ecological Footprint. At the heart of this challenge is the need to decouple economic growth and from growth in Ecological Footprint.

Based on the analyses presented in this report we propose the following policy suggestions:

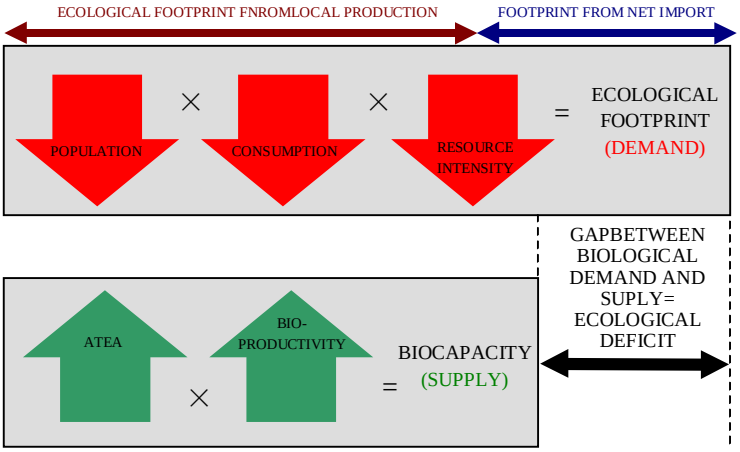

Figure 5-8 Five Major Factors Affecting Ecological Overshoot

Data source: Global Footprint Network, 2010

5.8.1 The Relationship between Ecological Footprint and Bio-Capacity can be Used to Analyze Whether a Society is in Ecological Balance

This report suggests that 'ecological society', as the next step in societal development after an agriculture society and an industrial society, is now the strategic choice for China's future development. 'Ecological society' is based on the premise that Ecological Footprint must be reduced and biocapacity must be increased in order to create a Society that is ecologically sustainable. By comparing human demand on the environment, represented by Ecological Footprint, with the capacity of natural ecological system, represented by biocapacity, in order to determine whether the demand creates an ecological surplus (where biocapacity exceeds Ecological Footprint) or an ecological overshoot (where Ecological Footprint exceeds biocapacity), we can assess the environmental impact of human development. We suggest using the measures of Ecological Footprint and biocapacity as a method for determining whether or not a society is on track to becoming an ecological society. This can be monitored by establishing a national Ecological Footprint and biocapacity accounting and monitoring system to track, in real time, utilization of, and changes in, local ecological resources. This system can, in turn, be used to support industry policy-making and local development plans by offering straightforward scientific analyses.

5.8.2 Strengthen Ecosystem Management and Improve Bio-Capacity

China has limited natural resources, and increasing this ecological base is a key strategy

for China to ensure national ecological security and reduce ecological overshoot. Hence, China should continuously strengthen ecosystem management and increase biocapacity through the following measures:

(1) ***Maintain ecological land and bio-capacity.*** As a country with very scarce ecological resources on a per capita basis, it is vital that China preserves its existing natural ecosystem for future generations. This can be accomplished by ① enforcing strict land utilization policies; ② implementing ecological restoration and nature conservation policies; ③ increasing the scale of ecological land and optimizing the land utilization types according to local geographical and climate conditions; ④ implementation of ecological compensation policies that compensates net biocapacity exporting regions through a variety of economic measures; and ⑤ recovering or restoring ecologically degraded regions and improving their productivity and pollution absorption capacity.

(2) ***Increase land productivity and promote increases in bio-capacity.*** Unlike most other countries, the biocapacity of China has continuously increased; for example, forest coverage has increased continuously over the last 30 years and the scale of production of aquaculture and agriculture has expanded one fifth of the world's grain, half of its vegetables and one third of its meat products were produced in China. We suggest that the government work to reinforce this trend by ① investing in agriculture, forestry, animal husbandry and fishery; ② optimizing the distribution of agricultural products; ③ developing high-efficiency agriculture; ④ promoting three-dimensional breeding; ⑤ increasing agriculture production concentration and the degree of mechanization; ⑥ encouraging comprehensive utilization of agriculture residues; and ⑦ increasing land productivity and quality.

5.8.3 Reduction of Carbon Footprint should be the Primary Focus for Decreasing Ecological Overshoot and Realizing an Ecology Society

Carbon footprint has become the primary force driving the increase in Ecological Footprint and any effort to reverse this trend and reduce Ecological Footprint must therefore focus on reducing carbon footprint. The following are suggestions for reducing carbon footprint.

(1) ***Establish and promote a low carbon economy*** by ① adjusting and optimizing industry structures according to local biocapacity; ② restricting and prohibiting certain industry sectors while encouraging energy conservation and production patterns that are ecologically friendly and resource efficient; ③ increasing the utility and conversion efficiency of fossil fuels throughout their life cycles; and ④ increasing the proportion of renewable energy in the energy portfolio. For regions where per capita GDP is less than 30 000 *yuan*, the

focus should be on investment patterns that will slow or prevent increase in Ecological Footprint.

(2) ***The urbanization process in China should focus on low carbon and sustainable development.*** Based on the preliminary study of the relationship between urbanization and Ecological Footprint, we found that although urbanization is associated with higher Ecological Footprint, there are ways this relationship can be optimized. To that end, the urbanization process in China should follow a low carbon and an "ecologization" plan that includes restricting living space and transportation patterns, controlling the expansion of cities and towns, promoting centralized residences with locally available facilities such as shops and schools, improving ecological efficiency in residential areas, and decreasing carbon footprint in buildings and transportation.

(3) ***Introduce low carbon consumption patterns*** by: ① advocating and promoting low carbon and resource efficient consumption patterns through encouraging rational consumption and choice of environmentally friendly goods and services, ② and stimulating the development of an eco-market where the government should set an example by establishing green procurement policies and low carbon offices; and ③ improving the lifespan of public facilities and optimizing their design in order to avoid waste and ecosystem pressure created by repeated construction and poor quality control.

Plans for encouraging changes in carbon footprint should account for regional development and ecology consumption levels. For examples, in provinces where per capita GDP is above 30 000 *yuan*, the plan should focus on changes in consumption patterns that will slow or eliminate increase in Ecological Footprint.

5.8.4 Balance Ecological Deficit through Resource Allocation

Biocapacity and water resources are unevenly distributed both globally and in China. There is limited correlation between resource availability and population distribution meaning it is often impossible to meet consumption demand within local limits. Trade is one means to redress this imbalance but poorly planned and profit-oriented trade can lead to overexploitation of natural resources and weakening of local natural capital. Accordingly, special attention should be given to the biocapacity, virtual water and other resources embedded in international and domestic trade through measures that promote sustainable ecological resource flow as a basis for long term economic development, such as the following:

(1) ***Formulate a domestic trade policy that encourages reasonable biocapacity flow.*** China should adopt a range of economic and administrative measures that promote efficient allocation of regional ecological resources and minimization inappropriate exportation and

trans-regional transfers of biocapacity and water resources through (a) innovative tax system systems such as an energy resource tax and a carbon tax that encourages enterprises to invest in new technologies that conserve energy and reduce emissions; and (b) development of trade policies that promote rational flows of biocapacity, minimize the export of biomass resources from degraded areas, and strictly control and punish damaging and purely profit-oriented trading activities.

(2) ***Encourage international cooperation in order to promote rational flows of biocapacity through international trading activities.*** Global trade reflects the ecological interdependency amongst countries and highlights that ecological problems are global in nature. Pay attention to unsustainable imports and exports of ecological biocapacity in order to lessen the ecological impact of trade on China and other countries. Through international cooperation, improve bio-capacity based on promoting efficient utilization of ecological resources and improved bio-capacity.

Chapter 6 Policy Framework Research on Improving Service Functions of Aquatic Ecosystems

6.1 Characteristics of China's Water Resources

China's water resource mainly exists in surface aquatic ecosystems including rivers, lakes, reservoirs and swamps, and in ground aquatic ecosystems. China's river systems consist chiefly of the Songhuajiang River, the Liaohe River, the Haihe River, the Yellow River, the Huaihe River, the Yangtze River and the Pearl River (Zhujiang River). The fresh lake ecosystems include the Poyanghu Lake, the Dongtinghu Lake, the Hongzehu Lake, the Chaohu Lake, the Honghu Lake, the Nansihu Lake, the Baiyangdian Lake, the Hulunhu Lake, the Changbaishantianchi Lake, the Jingpohu Lake, the Dianchi Lake, and the Bositenghu Lake, etc..

Various factors, such as climate conditions, geography, and socio-economic conditions of the large population, affect China's water resources. The following sections present the characteristics of China's water resources.

6.1.1 Rich Water Resources but a Low per-Capita Water Availability

The total volume of China's average annual precipitation is 6 085.4 billion m^3, which is equivalent to a rainfall depth of 643mm. China's annual average water resources totals 2 774.1 billion m^3, taking the sixth place in the world with a surface water resources volume of 2 669.1 billion m^3, which is equivalent to a runoff depth of 282mm and ground water resources volume of 808.7 billion m^3. With a vast territory and large population, China's volumes of water resources per capita and per *mu* (1 *mu*=666.6 m^2) are 2 200 m^3 and 1 440 m^3 respectively, accounting for only one quarter and 60% of the world average.

6.1.2 Uneven Spatial Distribution of Water Resources and a Mismatch between the Distribution of Water Resources and Production Resources

In China, there are rich water resources in the south but few in the north, and the gap is large. The six water resources areas (the Songhuajiang River Area, the Liaohe River Area, the Haihe River Area, the Huaihe River Area, the Yellow River Area and the Inland Rivers in Northwest China) take up large percentage of the total area, population, GDP and cultivated land in China (63.5%, 46.1%, 44.5%, 60.5%, respectively). However, the area of these six main water resources areas only account for 19.1% of the total Chinese water resources area.

The area, population, GDP and cultivated land of the four water resources areas in the south (the Yangtze River Area, the Pearl River Area, Southeast Areas and Southwest Areas) constitute 36.5%, 53.9%, 55.5%, respectively, of China's corresponding totals. Yet, the water resources account for 80.9% of its total. Figure 6-1 and Figure 6-2 show the first-tier zoning of China's water resources and their respective total water resources.

Figure 6-1 First Tier-Zoning of China's Water Resources

Data source: comprehensive planing for national water resources, 2010

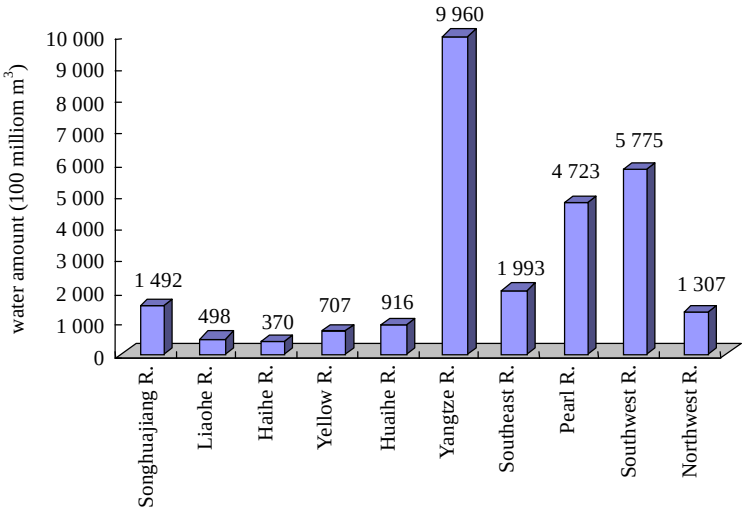

Figure 6-2 Total Water Resources in the First-Tier Zone of China's Water Resources

6.1.3 Uneven Distribution of Intra-Year and Inter-Year Water Resources, causing frequent Droughts and Water-logging Disasters

Due to influences from the southeast monsoon climate, the intra-year distribution of precipitation in China is extremely uneven. In most areas, the precipitation in four consecutive months accounts for 70% of the annual total. In the southern water resources areas, strong precipitation usually takes places from April to July. While strong precipitation occurs during June to September in the north. The large inter-annual variation in China's water resources leads to cyclical patterns, featuring consecutive plentiful or dry seasons in the seven river basins. The ratio of plentiful and dry seasons in southern water resource areas is 3.0 to 5.0, while it can be as high as 10.0 in the north.

The uneven temporary distribution of water resources has caused droughts in the northern water resources areas and frequent water-logging disasters. Seasonal droughts also cause water shortages in the southern areas.

6.1.4 High Sediment Content in some of China's Rivers

The Yellow River of China is the most sediment-concentrated river in the world, with an annual average sediment concentration as high as 35kg/m^3. In addition, the Liuhe River, one of the primary tributaries of the Liaohe River, is also laden with high sediment concentration. The sediment problems exert urgent pressures to improve service functions of river

ecosystems and to achieve water and soil conservation.

China's large population and its limited water resources, its uneven spatial and temporary water resources distribution, and the distribution mismatch between its water resources and productive forces all generate present and long-term national challenges to China's water management efforts.

6.2 China's Actions to Improve Aquatic Ecosystem Service Functions

Since the early 1990s, under the guidance of such thoughts as sustainable development, harmonious coexistence between man and nature, scientific outlook on development and ecological conservation, and scientific research, comprehensive planning compilation on water resources, project construction and regulation implementation have been carried out to improve aquatic ecosystem service function actions in response to the drying up of rivers, water body pollution, water and soil losses, wetland shrinkage, land subsidence, sea water intrusion, vegetation degradation, and reduced biodiversity caused by inappropriate exploitation and ineffective protection of aquatic ecosystems.

6.2.1 Scientific Research Actions

From early 1990s to 2005, the Ministry of Science and Technology (MOST), the Ministry of Water Resources (MWR) and the Chinese Academy of Engineering (CAE) have organized experts to conduct research studies on rivers, lakes, vegetation and eco-oriented water demand for water and soil conservation. Some of these efforts are listed as follows: the Rational Water Resources Allocation and Its Carrying Capacity in Northwest Regions under National Key Scientific and Technological Project During the 9th Five Year Period Planning of Research on Rational Water Resources Development and Utilization and Its Eco-Environmental Conservation in Northwest Regions; the Water Use Standards for Ecological Purpose in Different Regions under National Key Scientific And Technological Project During the 10th Five Year Period Planning of the Research on Water Security Guarantee Technologies; the Eco-environmental Building and Water Resources Protection and Utilization under CAE's major consulting project of the Research on Water Resources Allocation, Eco-environmental Building and Sustainable Development in Northwest Regions.

6.2.2 Comprehensive Water Resources Planning Compilation Actions

From April 2002 to May 2009, a nationwide comprehensive water resources planning

compilation was organized through the joint efforts of the National Development and Reform Commission (NDRC), the MWR, the Ministry of Land and Resources (MLR), the Ministry of Environmental Protection (MEP), the Ministry of Housing and Urban-Rural Development (MOHURD), the Ministry of Agriculture (MOA), the State Forestry Administration (SFA), and the China Meteorological Administration (CMA). Comprehensive water resources planning achievements were put forward at the national, seven-river-basin and provincial administrative (municipal and autonomous regional) levels. Control indexes of eco-environmental water consumption for major cross-sections of the Songhuajiang River, the Liaohe River, the Haihe River, the Yellow River, the Huaihe River, the Yangtze River, the Pearl River, and other rivers were proposed in the national comprehensive water resources plans. Such effort has provided an important basis for improving China's river ecosystem service functions in the upcoming period of time.

6.2.3 Project Implementing Actions

After the serious flood in 1998, large-scale projects of lake restoration from the fields in lakeside areas and displaced people resettlement in newly built towns were implemented in the Dongtinghu Lake and the Poyanghu Lake. These projects represented a historic transition from the thousands of years of lake reclamation for farmlands and competition between lakes and farmlands, to large-scale lake recovery of up to 2 900 km^2 in the Yangtze River Basin (13 billion m^3 of flood storage volume increase). Since 1999, unified regulation of water resources in the Yellow River contributes to the River's continuous water flow for 10 consecutive years. From 2001 to 2009, a total of nine water and sediment regulations were conducted via the adoption of an integrated regulation of Xiaolangdi Reservoir. All lines of river main channels in lower reaches were flushed with 356 million tons of sediment, leading to 575 million tons of sediment into seas and significantly improvements of the discharge capacity.

Eco-fragile rivers such as the Heihe River and the Tarim River were comprehensively treated and their water resources were managed and regulated through an integrated approach. As a result, the lower reaches of the Heihe River east to the seas have not dried out for five successive years, and the ecology in lower reaches of the Tarim River has been restored gradually. Eco-emergency response water compensation projects were implemented in some important water-short wetlands such as the Zhalong Wetland, the Nansihu Lake, the Xianghai Wetland and the Baiyangdian Wetland, greatly improving the eco-environment of the wetlands. The water diversion project in the Yangtze River, aims at improving the quality of water bodies and reducing losses caused by water pollution, diverted 14.7 billion m^3 of

water into the Taihu Lake in eight successive years.

Substantial achievements have been obtained by setting up pilots for aquatic ecosystem protection and rehabilitation in cities of Guilin, Wuhan, Wuxi, Laizhou and Lishui City, etc.. Since 1992, five natural reserves have been built in Yichang City and estuaries of the Yangtze River to protect six kinds of rare aquatic animals, including the white dolphin, white sturgeon, Chinese sturgeon, Yangtze River sturgeon, finless porpoise and sucker fish, all of which were affected by the Three Gorges. To protect the Chinese sturgeon, artificial propagation and release have been conducted in China and a cumulative total of 5 million Chinese sturgeons have been released to the Yangtze River and the Pearl River. National projects for water and soil conservation were launched in the middle reaches of the Yellow River, upper reaches of the Yangtze River, warp land dams[1] in the Loess Plateau, Beijing-Tianjin dust storm source areas, black soil zones in Northeast, and the Karst rocky desertification areas. A grand total of 1.016 million km^2 of water and soil losses were treated, reducing the soil intrusion by an annual average of 1.5 billion tons and increasing water storage by over 25 billion m^3.

National ground water function areas and over-exploitation areas have been delimited, while water resources protection has been strengthened in priority water source areas of the South-to-North Water Diversion Project, water source areas of drinking water, and over-exploited areas of ground water. By means of shutting down wells and limiting exploitation and compensation, the continuous decreasing trend of ground water level in some parts of areas have stopped [2]. All the aforementioned projects have played a demonstrative and leading role in gradually improving China's aquatic ecosystem service functions.

6.2.4 System Implementing Actions

In accordance with the Law on Environmental Protection, the Law on Water and the Law on Water and Soil Conservation, China has implemented the EIA system on project construction, the water resources demonstration system, and the water and soil conservation plan compilation system, taking the overall water resources conditions, the carrying capacity, as well as the impacts of project construction on eco-environment into full consideration. It also adopted a guarantee system for eco-oriented water usage and basic flows in river

[1] "Warping dam is a dam built on gully in soil and water loss area for the purpose of creating newly arable land by silt deposition in front of dam, decreasing gully slope, and mitigating gully erosion by gully bed raised step by step." http://unesdoc.unesco.org/images/0013/001381/138198e.pdf

[2] Chen Lei, Address on Congress of MWR Celebrating the 60th Anniversary of New Chinas Foundation, China Water Resources, 2009, (18): 21-30

courses. The most stringent water resources management system has also been implemented, drawing three "red lines" on water resources management which are intended to clarify the bottom lines of water resources development and utilization in the following aspects: the first bottom line is to strictly control the total water consumption and the pollution sheltering in water functional zones; the second is to control the total pollutant discharge into rivers; and the third is to raise water use efficiency and to keep water wastage within limits. The implementation of all the aforementioned measures have served as a legal guarantee for gradually improving China's aquatic ecosystem service functions.

6.3 Analysis on Aquatic Ecosystem Service Functions

Aquatic ecosystem service functions, including socio-economic service functions and natural ecological service functions, refer to the aquatic ecosystem, the eco-environmental conditions, and the eco-processes that humans use, rely, and are sustained by [3, 4].

6.3.1 Socio-Economic Service Functions

Socio-economic service functions of aquatic ecosystem mainly consist of six items, including water supply, aquatic product supply, hydroelectricity, inland navigation, recreation, culture and aesthetics.

6.3.1.1 Water supply

Water supply is the most fundamental service function of rivers, lakes and ground ecosystems. It constitutes the major venues for fresh water storage and conservation and the main source of fresh water for man's existence. In the light of different water qualities in water bodies, water usages can be classified into waters for domestic, industrial, agricultural irrigation, and municipal eco-environmental purposes.

6.3.1.2 Aquatic product supply

One of the most distinct features of aquatic ecosystems is their forms of bio-productivity. By means of primary (higher plants and algae) and secondary production (animals, bacteria), aquatic ecosystems can produce an abundant supply of raw materials and foods for man's production and life, and forage for animals.

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[3] Li Wenhua, Zhang Biao, Xie Gaodi. Research on ecosystem services in China: Progress and Perspectives, Journal of Natural Resources, 2009, 24 (1): 1-10

[4] Ouyang Zhiyun, Meng Qingyi, Ma Dongchun. Water ecosystem services and water management of Beijing. Beijing Water, 2010 (1): 9-11

6.3.1.3 Hydroelectric power

Potential energies are produced and stored as a result of water falling due to differences in terrains and landforms. Hydropower is considered to be a clean and renewable source of electrical energy with great development potential. Currently, 20% of the total power in the world comes from hydropower. There are 24 countries relying on hydropower for 90% of their energy usage, and 55 other countries for 40%. China's installed capacity has reached 117.2 billion kW, making it first in the world with an annual power generation of 600 billion kWh representing 20% of its total installed capacity and 15% of its total power generation.

6.3.1.4 Inland navigation

Rivers play an important role in transportation. Compared with other transportation methods such as railway, road, and air, inland navigation boasts advantages such as low cost and energy consumption, high efficiency, and large transportation volume. Therefore, men chose to build canals such as the Great Beijing-Hangzhou Canal in China to make full use of the natural rivers and to develop inland navigation. Such functions of the river ecosystem are of great significance to land resources conservation, environmental pollution reduction and sustainable development of regional economy and society.

By the end of 2008, there were 123 000 km of inland navigation ways in China, which are concentrated in the four major river systems of the Yangtze River, the Pearl River, the Huaihe River, and the Heilongjiang River. These systems span over 23 provinces, autonomous regions and municipalities, all directly regulated by the central government. The annual transportation volume of the Yangtze River arteries is over 1.1 billion tons, which is equivalent to the transportation capacity of 16 Beijing-Guangzhou Railways. The mileage of inland grade navigation pass amounts to 61 000 km, approximately 50% of the total navigation mileage in China. 7% of the inland grade navigation pass mileage is navigable by 1 000 tonne-class shipments (8 800 km), and 20% are navigable by 300 tonne-class shipments (24 600 km). However, China's navigation grade is still rather low, with only 11.3% of advanced level navigation pass above Grade 4. Consequently, further improvements are still required for its navigation capacity.

6.3.1.5 Recreation

Within the same river basin, rivers, lakes and wetlands are all interdependent. The unique landscapes of aquatic ecosystems provide important venues for recreation and nature experiences. From a vertical perspective, forests and grassland in the upper reaches and lakes, beaches and wetlands in the lower reaches are integrated into a diversified landscape; from the horizontal view, the inlaid pattern of highland, river bank, river surface and water body make

the landscape features distinctive with a harmonious integration of river landscapes, exemplified by a sharp contrast between the dynamic flow and static river bank, swimming fishes and flying birds and forests and grasses at a standstill. Since 2001, the MWR approved 370 national water resources landscape areas of various types in the forms of reservoir, wetland, natural or municipal river and lake, irrigation area, water and soil conservation.

6.3.1.6 Culture and aesthetics

Cultural and aesthetic functions refer to the role of aquatic ecosystem and the cultural, aesthetic, educational and scientific research values it brings to human. Different aquatic ecosystems, especially different river ecosystems, give birth to different regional cultures and religious arts and diversified ethnic traditions and dispositions. Thus they directly influence scientific and educational, as well as civilization development. For example, the Nile gave birth to Egyptian culture, Euphrates and Tigris Rivers to the old Babylon culture, and the Yellow River and the Yangtze River to the Chinese civilization.

6.3.2 Natural Ecological Service Functions

Natural service functions of aquatic ecosystems mainly include five items: flood regulation and storage, biodiversity protection, environmental purification, substance transportation, and climate adjustment.

6.3.2.1 Flood regulation and storage

Lakes and wetland are capable of flood storage, adjustment for runoff from rivers and mountains, flood peak reduction, and flood process detention, thus aggregately reducing the economic losses caused by floods.

6.3.2.2 Biodiversity protection

Water is the source of life. Various bio-environments such as rivers, lakes, wetlands, and flood plains provide habitats for a great diversity of species and for their reproduction, conditions for bio-evolution and the emergence and formation of biodiversity, and a gene base for the protection of naturally superior species and the improvement of their economic qualities. Some aquatic ecosystems serve as places for wild animals to habitat, reproduce, migrate and live through the winter, others may serve as transfer stations for rare amphibians and special varieties of fishes.

6.3.2.3 Purification

Water provides and maintains an excellent metabolizing environment for physical and chemical pollutants, and improves the clarification ability of regional environments. By absorbing chemical substance from their surrounding areas, aquatic ecosystems have accomplished the process of pollutant transfer, transformation, dispersal and enrichment. During

this process, the formation, chemical composition and attributes of the pollutant change, resulting in clarification effects. Moreover, as many water pollutants tend to absorb or adsorb on the surface of sediments, the slow streams of swamps and flood plains accelerate the deposition of floating substances. Meanwhile, pollutants (such as heavy metal) can attach to the floating materials, which will be deposited into water column, eventually forming polluted sediments that can slowly transform.

Water can increase air humidity through evaporation and transpiration, which can assist in the reduction of air pollutants. For instance, humidity may greatly shorten the remaining time of SO_2, speed up the deposition of air-borne particulates, and facilitate the decomposition and transformation of air pollutants.

6.3.2.4 Substance transportation

Rivers possess a series of ecological service functions such as sand and nutrient transportation and deposition. River currents may wash out the sand from the riverbed, so as to dredge the watercourse naturally. On the other hand, low currents may lead to mud sediments being deposited, with a rise in the riverbed and the infill of lakes. Moreover, the ability to store flood water and flood control will be dramatically decreased. Rivers transport large amounts of nutrients such as C, N, and P, which serve as important elements for global biogeochemical cycles and the main nutrition sources of the ocean ecosystems. This process plays a vital role in maintaining the high productivity of the receiving ecosystems. The bed-load of sediments carried by river are deposited at the river mouth and estuaries, gradually and consistently forming into small islands and deltas, leading to an increase of land area on one side and effectively protecting the seashore from storm erosion on the other. Related survey shows that the annual amount of sand transportation from rivers to the sea is about 3.35×10^8 t (Table 6-1).

Table 6-1 Sand Transportation Amount of the Main Sea Branches in China

(Unit: 10^8 t)

Sea	Bohai sea				Yellow Sea	East China Sea				South China Sea	
Branch	Liaohe river	Luanhe river	Haihe river	Yellow river	Huaihe river	Yangtze River	Qiantang-jiang	Oujiang	Min-jiang	Zhujiang	Han-jiang
Sand amount	0.123	0.190	0.001 3	0.771	0.093	1.30	0.02	0.025	0.060 1	0.753	0.017 9

6.3.2.5 Climate adjustment

Aquatic plants and algae absorb CO_2 through photosynthesis and reserve the resultant

organic substance as their own nutrients. Meanwhile, peat bogs cumulate and reserve large amounts of carbon as organic substance for soil, which also absorbs and stores carbon to a certain extent. Consequently, aquatic ecosystems help to decrease atmospheric CO_2 levels. In addition, aquatic ecosystems have significant effects in stabilizing regional weather and adjusting local climate by improving humidity, giving rise to rainfall, and influencing temperature, rainfall and wind. As a result, aquatic ecosystems may abate the negative influence of extreme weather events on human beings.

Water ecological service functions depend on the structure and ecological attributes of the ecosystems, and are fundamentally influenced by the water's natural characteristics. These characteristics include water quantity, water quality, water depth, speed of flow, and water temperature. Water quality and quantity deserve the most attention as they are the most prominent manifestation of human disturbances in water. These two elements are usually used to evaluate the freshwater ecological service functions (Table 6-2).

Table 6-2 Ecological Response to Flow and Water Quality Change

Hydrological elements	Change	Ecological response
Scale and frequency of flow	Flow changes frequently and on a big scale	Sensitive species disappear; algae increase; organic substance can be washed away; life cycle can be disturbed; energy flow changed
	Stable flow	Water transported to river floodplain abates, seeds cannot be dispersed efficiently
After seasonal flood peak	Gradually slow down	Fish are disturbed, when spawning, holding, or migrating; water plants change their net structure; vegetation grows slowly
Low flow	Slow flow prolongs	Physiognomy changes; water organic substance collects; aquatic diversity decrease; riverside vegetation decreases, species change
	Flood prolongs	Vegetation change its type; water plant living riffle fade away
Water quality	Worse	Eutrophication of water; fish die in large amounts
	Better	Clear water, nice sunlight, high biodiversity

Natural ecological service function of river, lake, swamp and groundwater system (Table 6-3).

Table 6-3 Aquatic Ecosystems Service Function and Its Evaluation Guide Line System

Service Function / Type	Floodwater storage	Sand trans-portation	Clarification	C fix	Biodiversity maintenance
River	√	√	√	—	√
Lake	√	—	√	—	√
Swamp	√	—	√	√	√
Groundwater	√	—	—	—	√

Note: "√" possesses this kind of ecological function; "-" does not possess this kind of ecological function.

6.4 Current Situation and Evolution of China's Major Aquatic Ecosystems

China boasts the world's grandest and highest mountains and plateaus, and verges on the world's deepest and largest ocean. It nourishes various kinds of complex aquatic ecosystems, including long rivers, famous lakes, and swamps, and all kinds of land ecosystems. China's aquatic ecosystems functioned well and exhibited great resilience in the past. These ecosystems have protected a large number of rare species dating back to the ancient times during a number of global catastrophes and mass extinction, including the giant panda and the metasequoia. Since the 1970s, the integrity of our aquatic ecosystems has been compromised under the influences of climate change and human activities, resulting in scale shrinkage, simplified structure, decreased quality, regressive functions, and loss of biodiversity in some areas with intensive human activities.

6.4.1 Rivers

China boasts a large number of rivers, more than 50 000 of which cover 100 km^2 or more. Data from nearly 600 hydrological stations of major rivers shows that 76% recorded human activities that influenced the flow process, such as water withdrawal, with the measured flow evidently less than its natural run off. The change of hydrological situation is obvious, with the most prominent changes in the north. The proportion recorded from most hydrological stations in northern China since the 1980s is much lower compared to that before the 1980s. In Yellow River, Huaihe River, Haihe River and Liaohe River areas, the average measured flow is 50% to 80% of the natural flow, while in some parts 20% to 60% or even 10% have been recorded. Yet, years of complete drying-up has been recorded in other parts of river reaches. If 10% of the average annual natural flow is the criterion to maintain

the basic ecological functions, the major function of the river ecosystems will be seriously destroyed with withered riverbed, exposed areas, and dried rivers when the natural flow fall below this criterion. Data of monthly flows between 1960s-1990s show increasing months of drying of major riverbeds in the Yellow River, the Huaihe River and the Haihe River. (Table 6-4)

Table 6-4 "Drying" Situation of First Class River
——the Yellow River, Huaihe River and Haihe River in different decades

First-class water resources	Name	Control station	Total Months of "Drying"			
			1961～1970	1971～1980	1981～1990	1991～2000
Haihe River areas	Luanhe River	Luanxian	0	1	24	34
	Xiatuohe River	Huangbizhuang	15	40	68	64
	Tanghe River	Xidayang	19	33	35	43
Yellow River areas	Yellow River	Lijin	4	13	19	56
	Fenhe River	Hejin	1	26	27	58
Huaihe River areas	Yihe River	Linyi	26	29	63	38
	Yinghe River	Fuyang	13	35	16	54

Data between 1956 and 2000 show slight differences in the total annual amount of water flow into the sea, but major differences are recorded when comparing the northern regions and southern regions. With the increase of the exploration and utilization of water resources, four first class water resources, including Yellow River, Huaihe River, Haihe River and Liaohe River has experienced downward trends in the amount of water flow into the sea (Figure 6-3), and such trends are particularly prominent in the Yellow River and the Haihe river. In the 1950s, the proportion of water flow into the sea to the surface water resources was 70%, while it has declined to less than 30% in the 1990s. Figure 6-4 describes the annual change of run off water in the Haihe River areas.

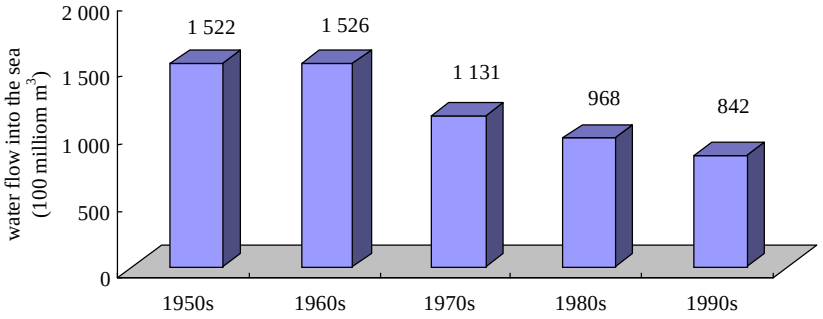

Figure 6-3 Annual Change of Water Flow into the Sea in North China 1950s to 1990s

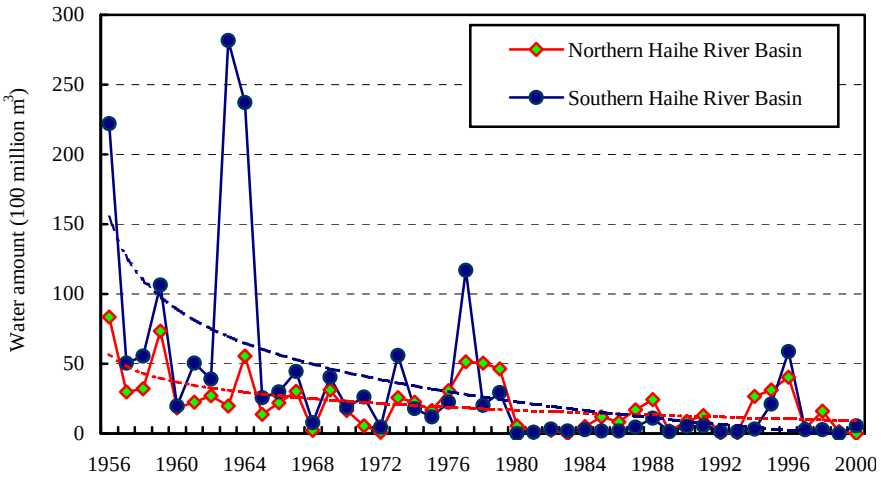

Figure 6-4 Annual Change of Water Flow into the Sea in Haihe River Areas

6.4.2 Lakes

China is dotted with a large number of lakes. In 2000, we have 2 941 natural lakes that are more than 1 km^2 in area, amounting up to an area of 85 000 km^2. These natural lakes are mainly dispersed in lake areas of the Qinghai-Tibet Plateau, eastern plains, and Mongolian Plateau. The total acreages of the northeast river areas and the Yangtze River areas account for 60% and 20% of the total river areas across the country, respectively. 27 lakes with an area of more than 500 km^2 spread across the country, amounting to a total of 36 000 km^2. Table 6-5 to check the classification of Chinese lakes.

Table 6-5 Classification of Lakes in China

Classification (km^2)	Number	Area (km^2)	Water storage (billion m^3)	Remarks
F①≥500	27	39 000	362	Water storage is related with the average water line for years. The total amount of water storage means that for lakes more than 10km^2.
100≤F＜500	106	22 200	253.4	
10≤F＜100	504	16 500	126.8	
1≤F＜10	2 304	6 900		
Total amount	2 941	84 600	742.2	

Note: ① F represents the lake area.

Since the 1950s, the trend of lake shrinkage in China became increasingly obvious. Compared to the 1950s, the lake area had decreased by 14 767 km^2 by 2000, which is approximately 14% of lake area loss since the 1950s. 229 lakes among the lakes of more than 10 km^2 began to shrink, with a reduction in area of 13 776 km^2. 89 lakes dried up, amounting to a total of 4 289 km^2. The recessed area of freshwater lakes makes up 82% of the total amount of recession, while saltwater lakes account for 12% and saline for 6%. (Table 6-6).

Table 6-6 Recession Report for Lakes more than 10 km^2

First-class water resources areas	Recession lake number			Losing lake acreage			Decreasing amount of lake storage ability	
	Total number	Drying up number	%	Total km^2	Drying up km^2	%	Decreasing amount of storage ability (billion m^3)	%
Songhuajiang River areas	16	7	7.0	184	123	1.3	0.16	0.3
Liaohe River areas	3	3	1.3	69	69	0.5		
Haihe River areas	5		2.2	1 013		7.4	1.02	2.0
Yellow River areas	11		4.8	602		4.4	1.81	3.5
Huaihe River areas	10	3	4.4	816	113	5.9	1.11	2.1
Yangtze River areas	139	60	60.7	7 387	1 466	53.6	28.39	55.0
Pearl River areas	4		1.7	35		0.3	0.19	0.4
Rivers in NW China	41	16	17.9	3 670	2 518	26.6	18.98	36.7
Nationwide	229	89	100	13 776	4 289	100	51.66	100

Note: The decreasing amount of lake storage ability does not include the amount for drying up of areas.

6.4.3 Swamp wetlands

Results of the wetland investigation in China from 1995 to 2000 show that there are 2 895 swamp wetlands with an area of about $1\,370\times10^4$ hm^2. The swamp wetlands are widely distributed in China, but generally develop centrally in the frigid-temperate zone and temperate zone humid regions, such as the Xing'an Mountains, the Changbai Mountain, the Sanjiang Plain, the Liao River Delta, the south of the Qinghai-Tibet plateau and the east Ruoergai Plateau, the river source area of the Yangtze and Yellow Rivers, the flood plains near rivers and lakes, the sea delta areas, and the seashores full of sand and mucky soil.

The Sanjiang Plain is China's most centralized swamp wetland area, with an area of

about 534.5×10^4 hm^2 in the beginning of the 1950s, accounting for about 80.2% of the total area of the Sanjiang Plain. However, a long period excessive cultivation caused significant reduction in the swamp wetlands area by 74.76% since the 1950s, resulting to approximately 134.9×10^4 hm^2 of total swamp wetlands area in 2000. By the year 2008, the swamp wetlands area was reduced further to 100×10^4 hm^2, totaling 81.29% reduction since the 1950s. Declines of swamp wetland area greatly reduce their ecological service function and biodiversity, and further destroy the ecological systems.

6.4.4 Groundwater systems

China's shallow groundwater exploitation amount grew from 55.7 billion m^3 in 1980 to 108.1 billion m^3 in 2008, 90% of which arise from the northern parts of China. The exploitation quantity in many areas has surpassed the exploitable amount, leading to a continuous decline in groundwater levels, growth of regional groundwater over-exploitation areas, and increase of many environmental and geological problems. Groundwater over-exploitation is concentrated mainly in plains in the north of China. In 2000, the groundwater over-exploitation area in the Haihe Plains amounted to about 100 000 km^2, which represents 91% of plains in the Haihe River Basin and 55% of China's total over-exploitation areas. Groundwater over-exploitation in Grade Ⅰ water resources areas is indicated in Table 6-7.

Table 6-7 Groundwater Over-Exploitation in Water Resources Areas at Grade Ⅰ

Grade Ⅰ Water Resources Areas	Over-exploitation areas in Year 2000 (km^2)		Over-exploitation quantity in Year 2000 (100 million m^3)	Cumulative over-exploitation quantity (100 million m^3)
	Total area	Serious over-exploitation areas		
Songhuajiang River Areas	6 374	2 377	1.6	29.3
Liaohe River Areas	3 790	1 304	2.3	68.1
Haihe River Areas	102 353	41 528	61.6	975.3
Yellow River Areas	10 140	4 213	11.3	170.4
Huaihe River Areas	26 719	10 610	8.4	126.3
Yangtze River Areas	17 940	7 380	3.2	58.1
Rivers in SE China Areas	1 584	444	0.3	1.2
Pearl River Areas	2 134	635	0.3	10.6
Rivers in NW China Areas	14 424	4 835	10.6	92.1
Nationwide	**185 457**	**73 325**	**99.6**	**1 531.3**

Note: In terms of the total amount in Haihe River Basin, 14 890 km^2 of the overlying areas in over-exploited areas of shallow ground-water and deep artesian water and 11 000 km^2 of overlying areas in serious over-exploited areas have been deducted.

6.5 Analysis on Changes in Service Functions of China's Aquatic Ecosystems

Along with the evolution of natural aquatic ecosystems, China's ecological service functions also change accordingly. Overall, the provision of products from China's aquatic ecosystems has been greatly improved while its natural ecological and environmental service functions have degenerated dramatically due to the following aspects.

6.5.1 Water Regulatory Ability Declines

The decrease in the volume of China's major lakes, and the shrinkage of wetlands have caused a decline of natural storage capacity of aquatic systems. For example, over the past 50 years, the Dongtinghu Lake has shrunk 45% due to reclamation, resulting in reduced areas, and a decline in storage ability, and increased outlet volumes from the lake, which further caused a continuous rise of flood levels in the middle and lower reaches of the Yangtze River during the past decades. Due to farmland reclamation, the Sanjiang Plain Wetlands have also disappeared in large quantities, and the flood storage capacity and water conservation of aquatic ecosystems has declined sharply.

6.5.2 Substance Transportation Capability Degenerates

The increase in dam and reservoir construction, water withdrawal outside river courses, and changes in water volumes and dynamic conditions have impaired the river's capability in transporting sediments. This not only leads to the accumulation of nutrient salts, sedimentation, and eutrophication in reservoir bays, but also poses problems for maintaining the high production rates of the coastal ecosystems. For example, there are sedimentation problems in all 12 major estuaries in the Haihe River Basin. The total sediment volumes have reached 950 million m^3, reducing the flood discharge greatly. Meanwhile, since gates are constructed in succession to prevent saline water intrusion and store fresh water in estuaries, fish migration routes have been destroyed. The basin ecosystems were gradually transformed from open-type to enclose or inland-type, the ecology of estuaries were destroyed, and river species diversity has changed into lower grades.

6.5.3 Water Quality Purification Gradually Weakens

Large amounts of water diversion outside river courses and hydro projects hinder the self-purification of the water bodies in river courses. Added to the increase in pollutant dis-

charges into rivers, prominent pollution takes place in water bodies in China. According to *State of the China Environment in 2009*, there is widespread organic pollution in China's seven key river systems, and only 57% of mainstream sections of all the river basins could satisfy Grade Ⅲ water quality requirements. Yellow River, Liaohe River and Haihe River are moderately or heavily polluted. In addition, there is severe eutrophication in China's major lakes. Among 26 major government-controlled lakes (reservoirs), those at Grade Ⅴ and worse than Grade Ⅴ add up to 14, accounting for 53.8% of the total. Major pollution indicators are total nitrogen and total phosphorus.

6.5.4 Service Functions of Providing Habitats Decrease

Rivers, lakes, and wetlands provide habitats for many species, but their decrease causes a similar decline in the usability of these habitats. Diversified vegetation communities in wetlands provide wild animals, some being rare and endangered species, with appropriate habitats for reproduction, migration, and winter refuge by birds and amphibians. According to latest research findings, China's wetland areas have decreased 11.46% during the past twenty years, from 366 000 km^2 in 1990 to 324 000 km^2 in 2008. Furthermore, of this 2008 figure, only 210 000 km^2 are stable, while most of the others are temporary wetlands formed by glacier snow and spring melt, resulting in damages to habitats needed by many migratory organisms.

6.5.5 Decline in Biodiversity

The degradation of aquatic ecology and pollution of water environment have resulted in the loss, fragmentation, and destruction of the environment for many living things. These factors have consequently caused a decline in the biodiversity of the ecosystem. Relevant findings suggest that the threatened species in China make up 20%-40% of all the existing species. In particular, the percentage of threatened plant species exceeds previous estimations with 4 000 to 5 000 advanced plants under threat, 15% to 20% of the total. The degradation of the aquatic ecosystem is the main contributing factor to this loss in biodiversity.

6.6 Major Contributing Factors to the Degradation of Service Functions of China's Aquatic Ecosystems

In addition to natural hydrological fluctuations and global climate change, other major contributing factors leading to the degradation of service functions on China's aquatic sys-

tems and the nature of this include the following five parts.

6.6.1 Fast Growth in Socioeconomic Water Consumption Robs the Available Water Needed for Ecological and Environmental Purposes

The water supply was 100 billion m^3 in the early 1950s, 400 billion m^3 in 1980, during which water was mainly used for agricultural purposes. Water supply in China surpassed 590 billion m^3 in 2008, during which water was primarily used for industrial and municipal purposes (Figure 6-5). Rapid increases in water use has led to a decrease in the water resource available for ecological and environmental purposes, especially in the north of China where basic level of ecological water use cannot be guaranteed, which has caused aquatic ecosystem degradation.

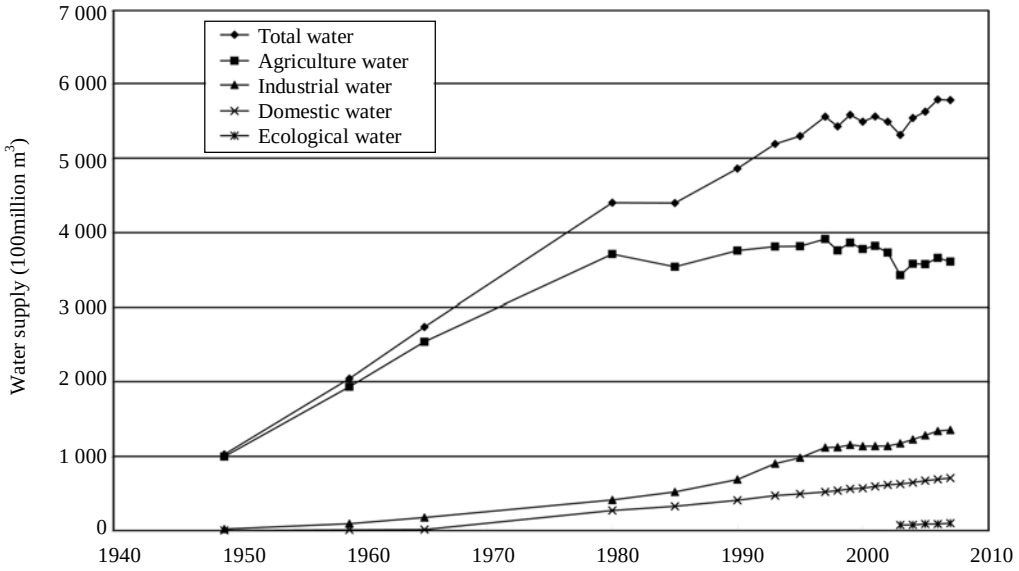

Figure 6-5 Water Supply Change Process of China's Water Supply Systems since 1949

6.6.2 Land Use Changes Leading to the Shrinkage of Natural Aquatic Ecosystems

Along with the agriculturalization around 1949 and urbanization and industrialization drive in the late 1980s, the increase in large-scale socio-economic land use resulted in reclamation from lake swamps, with some natural lakes, wetlands and swamps being replaced by farmlands and lands for construction, causing loss in area of aquatic ecosystems, or fragmentation and weakened service functions of aquatic systems. According to investiga-

tions, among all the lakes that have been reduced in size, sedimentation and reclamation make up 2/3 of the total.

6.6.3 Irrational Exploitation of Water Resources Exerts Influence on the Natural Aquatic Ecosystem Functions

Rivers and lakes consist of aquatic ecosystem resources, but some regions are driven by economic benefits to exploit other resources in water areas, causing the degradation of service functions of aquatic ecosystems. The most prominent problems are sand excavation in river courses and breeding in lakes. Disordered sand excavation in river courses causes excessive corrosion of river beds, damaging the living environment of river ecosystems, changing river course formation, lowering the ability for river courses to conserve water sources, and causing serious damage to river ecosystems.

6.6.4 Pollution Discharges into Rivers are Beyond Carrying Capacity of Water Environment

China's industrial and domestic sewage reached 75.8 billion t in 2008. Pollution discharges into rivers beyond the self-purification capacity of water bodies in many regions have caused environmental pollution and degradation of service functions of the aquatic environment. In Taihu Lake, the perennial average water amount was 17.7 billion m^3. However, water withdrawal in 2005 reached as high as 35.5 billion m^3. Sewage discharges from households, secondary and tertiary industries surpassed 6 billion m^3. The pollutant discharges have been beyond the bearing capacity of the water environment, which has led to the deterioration of water quality in the cycle processes.

6.6.5 Water and Hydro Project Construction has Exerted Negative Impacts on Ecological Environment

At present, there are over 86 000 reservoirs in China with a total capacity of nearly 700 billion m^3, and 44 000 gates of various types with a total installed capacity of over 170 million kW. While playing their roles of flood control, irrigation, water supply and power generation, various water and hydro projects will have negative influence on natural ecological environments such as river flow interception, changing hydraulic characteristics, and causing bio-environmental changes.

6.7 Impact of Reservoir and Dam Construction on River Ecosystem Service Functions in China

6.7.1 Impact on Socio-economic Service Functions of River Ecosystems

By the end of 2008, 86 000 reservoirs have been built in China with over 4 860 dams above 30m high. They have played an enormous and irreplaceable role in promoting socio-economic service functions of aquatic ecosystems. Since the 21st century, dams have been of great significance in the sustainable development of the nation's socio-economy[5].

6.7.1.1 Improve water supply capability to ensure water supply security

China's climate and topography have determined that China's water supply problems cannot be solved only by relying on natural adjustments and storage of river ecosystems. Thanks to the dam construction, the water supply capacity of river ecosystems has been improved, the irrigation area has been expanded, and imbalances between water resources and seasonal variation of river flows overcome and stability of water supply of river ecosystem maintained.

At present, various types of reservoirs with total of 86 000 have been built and have a total capacity of 692.4 billion m^3. Water diversion works, water raising projects, water diversion projects, and ground water source projects can supply a total of 591 billion m^3. This is sufficient to supply China's demands. China is a large country with a population of 1.3 billion. Its agricultural security mainly relies on irrigated agriculture and its annual irrigated area stands at 58.47 million hm^2, which is around 48% of the total cultivated lands. However, there are still 63.34 million hm^2 of cultivated lands that cannot be irrigated—with 20 million hm^2 of drought-stricken cultivated lands. China is in the process of accelerated urbanization and industrialization. There are over 400 cities in shortage of water. The conflicts between water supply and demand will be more serious by 2030 when China's population reaches a new record high of 1.5 billion. Therefore, dam construction, along with the increased capacity of river water supply, is an important remedy to ensure the safety of drinking water, food security, and socio-economic development.

6.7.1.2 Reduce natural aquatic product supply and increase artificial aquatic product supply

Eutrophication in reservoirs produces some aquatic plants such as poor quality algae which will affect aquatic forage supply. Changes in river beds, river courses and estuaries,

[5] Dam reservoir and the coordinating development, Chinese exploration and practice. China Water Resources, 2009 (12): 1-3

and the shrinkage of wetlands, swamps, and flood plains have exerted an impact on the habitat, spawning reproduction and growth of many species of animals. These include fishes, amphibians, mollusks, insects, birds, and other riparian species that inhabit areas along beaches and rivers. This has led to a decrease in the supply of natural aquatic product. However, expanded waters due to reservoirs from dam construction provide immense space for breeding and promoting the existence and development of wildlife such as aquatic birds, thus increasing the artificial aquatic product supply.

6.7.1.3 Hydroelectricity to ensure energy security

Hydropower is the most important clean energy which can be developed on a large commercial scale in the world. Along with the sustained growth of energy demand and increasing impact of global climate change, countries all over the world consider hydropower development as a top priority for energy development and as a common response to climate change and sustainable development. At present, hydropower satisfies about 20% of the power demand. There are 55 countries relying on hydropower for half of their demand and other 24 countries for over 90% of their demand.

Due to a shortage of petroleum, China is increasingly relying on coals to provide the necessary energy. This will definitely lead to excessive CO_2 emissions. China should develop diversified renewable energy, including hydropower, wind, solar and biomass energy. China's total water energy take the first place in the world with a potential storage of 689 million kW and technical exploitation amount as 542 million kW only next to conventional energy such as coals. Currently, 172 million kW of water energy have been exploited in China, ranking first in the world, but only with a low exploitation rate of 30% compared to 65% in developed counties, including 82% in America, 84% in Japan, 65% in Canada, 73% in Germany, and over 80% in France, Norway, and Switzerland. Therefore, China still has a great potential for developing water energy as an alternative compared with developed countries.

As for now and in the long run, China is and will be at a critical juncture for fully building a moderately prosperous society in an all-round way and accelerating modernization drive, which requires a stable growth of power demand for socio-economic development. Hydropower, as a clean renewable energy, will be of more significance in national energy security strategies. Dam construction and development of water energy resources are in the interest of the international energy development and will play an important role in promoting low-carbon economic development.

6.7.1.4 Raise water level to increase inland navigation capacity

Dam construction increases navigation capacity of rivers by raising the river water level

and expanding the area of the basin. The Three Gorges Dam, for example, has promoted further development of navigation of trunk lines and major tributaries in the Yangtze River. It is accessible to ten thousand tons of fleet navigating from Chongqing Municipality directly to Wuhan and Shanghai Municipality, navigation capacity of one-way launch from Wuhan to Chongqing Municipality up to 100 million tons, a 35% reduction in transportation costs in the Yangtze River.

6.7.1.5 Exert both positive and negative impacts on entertainment and recreation, culture and aesthetics

Dam construction on rivers and reservoirs will damage the environment of river ecosystems and exert an impact on entertainment and recreation, culture and aesthetics of rivers. However, the imposing dam and broad expanse of waters will both bring new perspectives of entertainment, recreation, aesthetics, and new cultures to the public. Currently, China has constructed over 60 national-level water landscape areas in the form of reservoirs.

6.7.2 Impact on A River's Ecosystem Services

The construction of dams and reservoirs will affect a river's ecosystem services – both in positive and negative ways. On the positive side, they will increase capabilities for flood regulation and storage, reduce greenhouse gas emissions, and improve regional climate. Negative impacts include damages to aquatic habitats, reduction in biodiversity, blockage to the channels of migratory fish fauna, and alterations to the balance of flushing and silting in river courses[6, 7].

6.7.2.1 Increased flood regulation, storag, and safety

With numerous rivers and under the effect of the Southeast Asia's monsoon climate, China has always been affected by frequent floods. There are more than 60 major floods since the early 20th century, with one occurrence in less than two years. China's floods are mainly caused by torrential rain episodes. Along the middle and lower reaches of the rivers are dense population, highly urbanized areas and developed industries and agriculture. These communities would suffer from tremendous losses from a major flood.

Since the founding of the People's Republic of China in 1949, massive construction of flood facilities including dams has greatly reduced flood-related fatalities, but economic losses have risen due to the growing economic size of flood-prone areas. Flood damages are

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[6] Peng Hui, Liu Defu, Value evaluation of the effects of a dam on river ecosystem services. J. Huazhong Univ. of Sci. & Tech (Natural Science Edition), 2010, 38 (1): 125-128

[7] Xiao Jianhong, Shi Guoqing, Mao Chunmei, Xing Zhenxiang, River ecosystem service function and dam-construction, Chinese Journal of Ecology, 2006, 25 (8): 969-973

estimated to be around 110 billion *yuan* since 1990 on a national annual basis. Considering the limited flood discharge capability of many river courses, the only way to reduce flood damage is to build a comprehensive system composed of reservoirs, levees and flood retarding basins, particularly large capacity reservoirs. The flood control reservoir of the Three Gorges Project, for instance, has a capacity of 22.15 billion m^3, which can reduce the occurrence of floods from once every ten years to once every 100 years.

By the end of 2008, China has constructed 86 000 reservoirs with a total capacity of 692.4 billion m^3. These reservoirs, together with other flood facilities such as levees, have provided China's major rivers with basic capabilities to prevent floods. Compared to developed countries, however, China's reservoirs and dams have a limited runoff control, which is 21.6%, while this figure is 33.7% for the United States and 27.0% for Russia.

6.7.2.2 Replacement of coal-fired power generation to reduce greenhouse gas emissions

The construction of dams for hydropower will replace coal burning and reduce greenhouse gas emissions such as CO_2 and SO_2. China currently has an installed hydropower capacity of 172 million kW, which is set to increase to 300 million kW by 2020 with an annual power generation capacity of 982.5 billion kWh. Hydropower will annually reduce coal consumption by 326 million tce, CO_2 emission by 820 million tons, SO_2 emissions by 5.7 million tons, NO_2 emissions by 2.52 million tons, and soot emissions by 2.27 million tons. Hydropower will play an important role in reducing greenhouse gas emissions and securing some forms of environmental safety.

The Three Gorges Project has an installed capacity of 18.2 million kW with an annual power capacity of 84.7 billion kWh, ranking first in the world. It has an equivalent effect of annually reducing 50 million tons of raw coal burning, 125 million tons of CO_2 emissions, two million tons of SO_2 emissions, 10 000 tons of CO emissions, and 370 000 tons of nitrogen oxides.

6.7.2.3 Increased surface area of water body in reservoirs and improved regional climate

The storage of water in reservoirs has greatly increased the surface area and evaporation of the water body. Evaporation will change air humidity, slightly increase rainfall in the river basin, and absorb the heat from solar radiation to avoid excessive increase in local temperature. It has the effect of regulating air temperature, and water vapor maintains humidity conditions that facilitate rainfall. On the whole, dam construction has a positive influence on the regional climate around the reservoir area and beyond, resulting in prolonged frost-free period, less variation of day and night temperatures, lower high temperatures, and higher low temperatures. In general, when air temperature around a reservoir drops by four to five degrees centigrade in a hot summer, relative humidity will rise by 10% to 15%. This

has reduced the biological threat of environmental factors to some extent and facilitated biological growth and development.

6.7.2.4 Damaged aquatic habitat and less biodiversity

The construction of dams and reservoirs has greatly altered the hydrological and hydrodynamic conditions like flow regime, water temperature, water quality, substrate, and the terrains of existing rivers. This is damaging to the growth, spawning, and breeding habitats of aquatic organisms and hence, their diversity is reduced.

(1) **Altered flow regime.** After dam construction, the water level of a reservoir will rise, water surface will expand, flow rate in the reservoir will slow down, and the flow regime will stabilize. As a result, existing water channels will lose torrents, shoals, and bends. For cascading portions of rivers in particular, the torrent regime will be totally eliminated. Such changes to the aquatic habitat are good for calm water or still water fish, but devastating for torrential fish. As a result, there will be a smaller population of torrential fish fauna and a smaller population of calm water fish fauna.

(2) **Water discharge of dams will alter natural seasonal flow in the downstream.** Water storage during the flood season will reduce discharge flow, while water discharge in the dry season will normally increase flow. Less flood duration and amount in flood season will reduce spawning area, prevent favorable conditions for spawning, and cause fish eggs and brood fish to die in the spawning area. Moreover, hydropower plants need to discharge water during peak electricity demand. This sometimes causes river level to change by several meters, causing the destruction of fish habitats.

(3) **Altered water temperature.** For deeper storage of water in reservoirs, there is an obvious phenomenon of vertical distribution of temperatures. The deepest water in the reservoir perennially maintains a low temperature. Alteration to water temperature will negatively affect aquatic organisms in the river. For fish fauna in the lower stream, frequent discharge of low temperature water at the bottom of reservoirs will cause water temperature in the lower reaches to be lower than usual. This will affect the spawning of fish fauna in certain sections of a dam's lower reaches. It will also delay the spawning period, and negatively affect irrigated crops and aquatic organisms. In addition, for diversion and mixed type hydropower plants, a certain length of the river will become dry or lose water for a particular season or for the whole year.

(4) **Altered water quality.** After a dam and reservoir are constructed, the flow rate will decrease and the water body's self-purification capacity will decline due to deeper water storage. Not long after a reservoir begins to store water, due to limited sedimentation of silt and nutrients, there is a limited impact on water quality in the reservoir area and lower

stream. But with the progression of time, pollutants in the upper stream will accumulate in the reservoir area, which may deteriorate water quality in the reservoir area and lower stream. Eutrophication will occur gradually in reservoir bays with limited flow rate and shallow water, as well as reservoir tails of tributaries, causing fish to die of hypoxia. For the fish fauna in the lower stream, when a large dam discharges water from a high water level, the rapid water flow will develop a high permeation of oxygen in the surface, absorbing air into discharged water. As a result, the water body will have intense aeration and the gas dissolved in the water will become saturated. This may cause air bubbles in the blood of fish and even cause fish to die of air bubble disease.

(5) **Altered river bed substrate.** Due to silt in the reservoir, there will be less sand content in the discharged water after dam construction. This will increase the erosion of a river bed in the downstream, scouring away its silt and changing the composition of sand and stones in the substrate of a river bed. Fish spawn in different places in the water such as in the weeds, on the underwater ground or rocks. When a river bed's substrate changes, certain fish species will not be able to spawn, or their eggs will not survive. Less silt will cause massive deaths of organisms and slash fish population in the dam's lower reaches.

(6) **Altered river course terrains.** Complex and changing river course terrains form a complex habitat. The more complex the habitat, the greater the biodiversity there will be. After water is stored in a reservoir, the central shoals of a river course will be inundated, the cross-sectional of a river course will change from compound cross section into a single cross section, and the cross-head of backwater area and bend of river courses are reduced. If river course terrains are the same, there will not be much diversity in habitat and fish fauna as well.

6.7.2.5 Blocked migration channels and destroyed migratory fish fauna

Most of China's estuary brackish migratory fishes are distributed in the downstream river mouth waters of various river systems. Some of them are in the middle and upstream waters. Most of them are rare and valuable species, including anadromous migratory fish and catadromous migratory fish, as well as near-shore migration and offshore migration between oceans and inland rivers. The most direct impact of dam and reservoir construction is the blockage of migration channels, and this impact is destructive and irreversible. Millions of Chinese sturgeons crashed into the Gezhouba Dam during anadromous migration and died. A barrage at the inflow river of Qinghai Lake suffocated thousands of anadromous scale-less carp (*Gymnocypris przewalskii*). The barrage blocked the gene communication of fishes from both sides, which is unfavorable to the breeding of multiple fish varieties.

6.7.2.6 Altered flushing and fill balance of river courses

Once silt-containing rivers enter a reservoir, the sediment will gradually settle in the reservoir, which reduces the reservoir's capacity. Sedimentation greatly affects a reservoir's functions and may even disable the entire hydropower plant. If silt is stopped by the dam in the reservoir, it will reduce the normal quantity of silt in the lower stream. Clean water discharged by the dam will more fiercely scour the river beds and riverbanks in the lower stream to offset insufficient silt to reach a new balance. River beds of lower reaches are usually washed by a few meters within ten years after dam construction began, so that the river course in the lower stream will become deeper and narrower and the otherwise broad and compound river courses with many reefs and sand banks will become straight, flat, and simple. Intense scouring of discharged water to river beds and riverbanks in the lower stream will have an adverse impact on the levees and buildings in the lower stream.

6.7.3 Win-Win Strategies for Achieving Socio-Economic Service Functions and Natural Ecological Service Functions

6.7.3.1 Hydropower planning, design, operation, and management at a basin level geared to developing in green direction

The comprehensive planning of a whole river basin serves as a basis for standardizing various exploitation actions over the basin and a guidance for formulating hydropower development and planning. The relationship between hydropower development and integrated water resources utilization (including flood control, navigation, water supply and irrigation, etc), eco-environmental protection, and regional socio-economic development should be well coordinated. Orderly exploitation of water energies should be conducted following the principle of giving priority to eco-environmental protection.

In the development and planning of hydropower within a basin, we should fully discuss the negative impacts of eco-environmental cascade-hydropower development of the whole river, adopt the necessary ecological protection measures and green operation and management methods, and build eco-friendly hydro projects that minimize the negative impacts to the lowest degree.

According to the integrated eco-environmental characteristics and biodiversity distribution within the entire basin, river sections that require protection should be clearly delimited with a ban on dam construction so as to check the disorderly hydropower development now occurring in some regions. For those hydropower cascades with water diverting methods, necessary basic ecological flows should be guaranteed for the lower reaches. For endangered plants and animals, protection areas should be built according to their living distribution

conditions. Dams that would block passages for rare and endangered migratory species and for aquatic plants and animals under national first-grade protection should be stopped. For dams blocking aquatic plants and animals under national second-grade and third-grade protection, it is necessary to build migratory channels, conduct artificial reproduction, and release work and to construct protection areas, etc.. For sediment deposit caused in reservoirs by dam construction and flushing problems in river beds in the lower reaches, it is important to set up silt orifices in hydro projects and adopt the operation method of "storing the clean water and discharging the sediment" (making use of flood discharge holes and silt orifices to release sediment in the flood season when there is much flow and sediment deposition, and reserving clean water within the reservoir at the end of the flood season) so as to reduce the silt in the reservoir.

6.7.3.2 Implementation of EIA on hydropower development and planning in a river basin

It is important to implement EIA on the planning level so as to avoid any negative impacts of dam construction on the environment at the source. EIA on basin planning should be carried out according to the Law on EIA for coordinated and sustainable development between hydropower development and eco-environmental protection before compiling new plans or revising previous editions of hydropower development at a river or basin level.

6.7.3.3 Development of green hydropower certification systems

The development of green hydropower certification systems is an effective way to solve eco-environmental constraints of dam construction. It should be a particular encouragement for the owner to take effective ecological protective measures to minimize the negative impacts of dam construction and management on the eco-environment in order to realize a win-win progress in economic development and eco-environmental protection.

6.8 Policy Recommendations for Improving China's Aquatic Ecosystem Services

In the light of the existing aquatic ecosystem problems in China and the underlying causes, policy recommendations for improving China's aquatic ecosystem services are proposed as follows.

6.8.1 Establish and Improve Water-Related Laws and Regulations and Enact Law on the Yangtze River and Law on the Yellow River

As the implementation of the basic strategy *Rule of Law* deepens, China has formulated a series of water-related laws and regulations with *Water Law* at the core and a complete set

of others including *Flood Control Law*, *Water Pollution Prevention Law*, *Soil and Water Conservation Law*, *Environmental Impact Assessment (EIA) Law* as a guarantee for the protection and rehabilitation of aquatic ecosystems and the improvement of aquatic ecosystem services. The seven rivers of the Yangtze River, the Yellow River, the Haihe River, the Huaihe River, the Songhuajiang River, the Liaohe River and the Pearl River constitute China's most important aquatic ecological system, especially the Yangtze River and the Yellow River. The Yellow River is the mother river of the Chinese nation, which has played an irreplaceably vital role in sustaining China's socio-economic development.

However, there is no water resource protection law at a basin level in China so far while the current water-related regulations that are irrelevant, not systematic and operational cannot achieve stringent management and effective protection of the Yangtze River and the Yellow River. Therefore, it is urgent to promulgate *Law on the Yangtze River* and *Law on the Yellow River*, by drawing upon managerial approaches on river law formulation in other countries, and in line with the actualities of the Yangtze River and the Yellow River. These laws should emphasize strict management and effective protection so as to promote harmonious development between human use and ecological needs associated with the rivers.

6.8.2 Strengthen Current Enforcement and Management of Water Resources

For construction projects, the EIA system, water resources verification system, water resources demonstration system, soil and water conservation plan compilation system, drinking water source area protection system, planning environmental impact assessment (PEIA) system and others are being fully implemented in China. Ground water protection system, optimized water resources allocation system, aquatic function zone management system, sewage outlet management system, total inlet sewage volume control system, unified regulation system of water volume and quality, sewage discharge trading system, water body pollution accountability system and others are being widely adopted. System of eco-oriented water demand and basic flow guarantee in river course and ecological regulation system are initially applied. Moreover, the most stringent water resource management system is being strongly promoted by delimiting three bottom lines of: total volume of water withdrawal, aggregate sewage inlet volume, and water use efficiency. The bottom line of water resources development is clarified by a stringent control on total water use volume. The bottom line of accommodating pollution in water function zones is defined clearly by aggregate sewage input volume control. The bottom line of water use efficiency control is made clear by firm prevention of water waste. In addition, water quota-setting and water volume dispatch systems have been set in place in the Yellow River basin and the Heihe

River basin. However, some systems are not strictly enforced in practices, such as "three-simultaneity" in the EIA system, "three-simultaneity" in soil and water conservation plan compilation system, total sewage input control system, and the PEIA system, etc.. The enforcement of existing water-related laws and regulations should be further strengthened in a strict manner, and unlawful practices should be investigated and prosecuted.

6.8.3 Develop a Concept of Water Resources Management and Improve the Natural Ecological Aspects of Aquatic Ecosystems

Conventional water resource management, which focuses only on the socio-economic services of the aquatic system such as water supply, aquatic product supply, and hydroelectric generation, neglects its natural functions including flood regulation and storage, biodiversity maintenance, environmental purification, substance transportation, and climate regulation. As a result, the water resource is locked in a vicious cycle of relentless degradation due to the overexploitation of the resource. By extending aquatic ecosystems to a maximum degree without sacrificing natural ecological services of aquatic ecosystems such as flood regulation and storage, biodiversity maintenance, and substance transportation, water resources management should be optimized[8].

6.8.4 Enhance Theoretical Research and Accelerate the Establishment of Ecological Compensation Mechanisms for Aquatic Ecosystems

The establishment of ecological compensation mechanisms for aquatic ecosystems, in terms of economic theory, is the economic internalization and externalization of water resources and aquatic ecological service protection with the aims to make people who have put great efforts in protecting aquatic ecological services to enjoy economic returns brought by follow-up outcomes. It will also make the beneficiaries of aquatic ecological services pay for relevant expenses so that the justice of aquatic ecological function, a special "public good", between producers and users or consumers can be achieved through institutional design. And so that rational returns for investors in aquatic ecological products can stimulate the sustainable production of aquatic ecological services.

Currently, at the local level, ecological compensation mechanism of aquatic ecosystem has only been introduced initially in a few areas such as Huangshan City, Anhui Province, and Luoyang City, Henan Province. At a national level, The Ministry of Water Resources has issued guiding principles to direct theoretical research on ecological compensation mechan-

[8] Ouyang Zhiyun, Meng Qingyi, Ma Dongchun. Water ecosystem services and water management of Beijing. Beijing Water, 2010 (1): 9-11

ism of aquatic ecosystems. It will require further study to determine the compensation range, compensation body, compensated body, compensation standards and ways, ecological service values provided by compensation areas, and compensation fund raising and usage. According to the mechanism of aquatic ecosystem services and aquatic ecological system protection cost, administrative and market methods should be applied to regulate the relationship between stakeholders for aquatic ecosystem protection.

6.8.5 Develop Green-Oriented Watershed Hydropower Planning, Design, Operation, and Management and Build Eco-Friendly Hydro Projects

Integrated watershed planning, the basis of standardizing various watershed hydropower development planning, should be under the guidance of an overall watershed planning approach that coordinates hydropower development with unified watershed water resource utilization (flood control, navigation, water supply and irrigation); eco-environmental protection; and water energy exploitation under the principle of giving top priority to eco-environmental protection in an orderly manner. When developing watershed hydropower, *EIA Law* should be abided by, strategic environmental impact assessment (SEIA) must be conducted in a strict sense. The negative impacts of cascade development on eco-environment of the whole river should be fully revealed, necessary protection measures should be taken, and green operation and management should be implemented to build eco-friendly hydro projects. All of these measures will help to reduce the negative impacts to the lowest level.

In accordance with the overall eco-environmental characteristics and biodiversity distribution, rivers or river segments under protection from dam construction are clearly defined to prevent inappropriate development of hydropower in some areas. For those hydropower cascades of water withdrawal type, necessary ecological bases in lower reaches must be guaranteed. For rare and endangered species, natural reserves should be built according to their living environment and distribution conditions. Dams that block national first-grade rare or endangered migratory or special varieties of aquatic animals must be prevented. For dams that block national second-grade and third-grade migratory aquatic animals, migratory channels should be built or artificial reproduction release should be adopted or natural reserves should be built. For problems of dam-induced reservoir sedimentation and erosion on river beds in lower reaches, sediment flushing holes should be built on hydro projects. The method of “storing clean water and discharging muddy water” should be adopted (which aims at discharging sediment by sediment flushing holes or discharging flood water by flood-relief holes during flood seasons and when there are heavy loads of sediment, blocking

clean water in reservoirs at the end of flood seasons) to reduce sedimentation in reservoirs.

The green hydropower accreditation system, an effective solution to eco-environmental constraints of dam construction should be established for hydro project construction. Owners of hydropower stations should be encouraged to take effective ecological protection measures to reduce the negative impacts of dam construction and management on eco-environment to a maximum extent. This will help to achieve a win-win progress between economic development and eco-environmental protection[9].

6.8.6 Increase Input and Fully Implement Protection and Rehabilitation of the Aquatic Ecosystem

Based on experiences from aquatic ecosystem protection by countries such as the USA, Japan, UK, Germany, Denmark, and Austria, some trials on aquatic ecosystem protection and rehabilitation have been set up in 14 cities including Guilin City in Guangxi Autonomous Region, Wuhan City in Hubei Province, Wuxi City in Jiangsu Province, Laizhou City in Shandong Province, Lishui City in Zhejiang Province, Songyuan City in Jilin Province, Xingtai City in Hebei Province and Xi'an City in Shaanxi Province. These examples have provided reliable support for comprehensive aquatic ecosystem protection and rehabilitation nationwide in terms of technology, management, institution, and financing channel. China should increase input for aquatic ecosystem protection and rehabilitation so as to change the general trend of aquatic ecosystem imbalances.

[9] Yu Xuezhong, Liao Wengen, Luo Huihuang, Discussion and Establishing Green Hydropower Certification in China. Water Power, 2007, 33 (7): 1-4

Chapter 7 Developing Policies for Soil Environmental Protection in China

7.1 Status Quo and Development Trend of China's Soil Environment Protection

7.1.1 Status Quo of China's Soil Environment Protection

7.1.1.1 Development of China's soil environment protection

Since the People's Republic of China was founded, the country's soil environment protection can be roughly divided into the following stages (Figure 7-1).

7.1.1.1.1 The first stage (1949-1978)

Since the People's Republic of China was founded, the grain production has been facing huge challenges from the growing population. The country's priority for soil environment at this stage was to increase soil fertility and grain output. Since the 1960s, China began to produce and use massive organochlorine pesticides[1]. With the use of chemical fertilizers and pesticides, concerns began to rise regarding China's soil environment in the early 1970s. In 1973 China held the first national environmental protection meeting at which the environmental problems existing in China were raised. Subsequently, the country gradually carried out investigations on pollution in key regions. Environmental quality assessments, pollution control and other research efforts were undertaken. A preliminary environmental management system was developed. At this stage, environmental problems focused on were mainly air and water pollution. Soil pollution was not a priority.

[1] *Report on Case Study on Soil Protection Strategies*, Study on Macroscopic Strategies of China's Environment: Task of Environmental Element Protection Strategies, 2008.

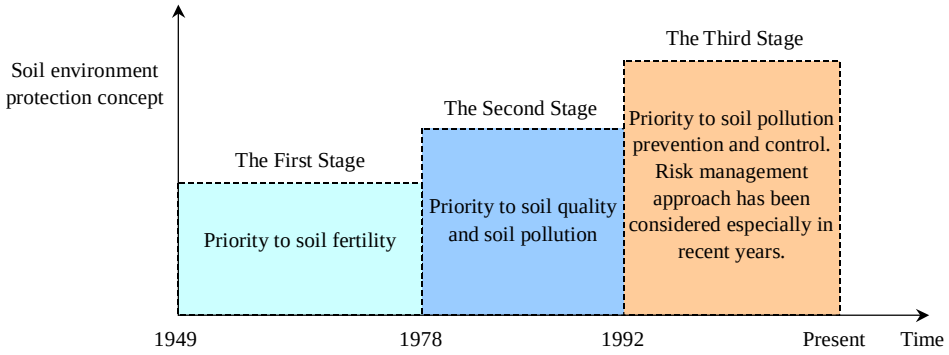

Figure 7-1 Chart of China's Development Stages of Soil Environment Protection

7.1.1.1.2 The second stage (1979-1992)

Since the implementation of China's reform and opening-up policy, rapid economic and social development had been made. Accordingly, soil environment protection entered into a new age of reform and innovation. More and more attention was paid to the soil pollution issue. China's overall system for environmental protection policies, laws and codes was being created. The law on soil pollution prevention in China's legislation is the Environmental Protection Law of the People's Republic of China (For Trial Implementation) issued in 1979. Also provisions on rational utilization of land are included the Constitution of the People's Republic of China, issued in 1982, and Land Administration Law of the People's Republic of China, issued in 1986. Relevant provisions on soil pollution prevention and control were included in the Law on Environmental Protection of the People's Republic of China issued in 1989. Soil environment and pollution became a priority at this stage.

7.1.1.1.3 The third stage (1993-Present)

In this stage, more and more attention was paid to the soil pollution prevention and control. And risk management approach has been considered especially in recent years. Since the United Nations Conference on Environment and Development in 1992, consensus of the world's nations is to implement a sustainable development strategy. In 1996, the State Council of the PRC issued a Decision of the State Council on Some Issues of Environmental Protection. This decision defined the orientation of China's soil environment protection in the age of sustainable development. In 2005, the State Council issued a Decision on Fulfilling the Concept of Scientific Development to Strengthen Environmental Protection, which requires a "focus on soil pollution prevention and control and the strengthening of environmental protection in rural areas". In 2006 the Ministry of Envi-

ronmental Protection carried out a special investigation on current situation and pollution control of soil throughout the country jointly with the Ministry of Land and Resources. Through a lot of investigation work, information on current situation, scope, key pollutants and level of soil pollution throughout the country has been obtained. Currently the investigation result is in process of statistics and analyses. When finished, the project will lay a foundation for supervision of soil environment in China. In 2008, the Ministry of Environmental Protection issued Opinions on Strengthening Soil Pollution Prevention and Control, which proposes measures for strengthening soil pollution prevention and control.

To facilitate effective prevention and control of soil pollution, China has successively organized and carried out a series of fundamental investigations. These investigations include the national soil environment background value survey, soil environment quality assessment of "Vegetable basket"[2] planting bases, main wastewater irrigation areas, pollution analysis and an overall national soil pollution status report. In addition, a series of standards and technical codes were prepared, issued and implemented. These include Standard for Soil Environment Quality and Technical Code for Soil Environment Monitoring. Emphasis was placed on strengthening monitoring over pollution sources, control of pollution sources, research on assessment of regional soil environment quality, and soil pollution risk management. Organized demonstration pilots for restoration and comprehensive harnessing of polluted soil were initiated. International exchanges and cooperation were pursued.

7.1.1.2 Main soil environment problems of China

Soil parent materials in China can be divided into two major categories-bedrock efflorescence and loose sediment. The bedrock efflorescence can be further divided into 4 types: light crystalline rock efflorescence, dark crystalline rock efflorescence, clastic sedimentary rock and corresponding metamorphic rock efflorescence, and calcic sedimentary rock and corresponding metamorphic rock efflorescence. The loose sediment includes 9 types: proluvium, red clay, alluvial deposit, lacustrine deposit, littoral sediment, coral reef deposit, loess, storm sand and glacial till. There are many soil types in China and almost all the main soil types of the world can be found in the country. According to the soil genesis classification method, China's soil types have 12 soil orders, 61 soil types and 235 subtypes altogether.

Soil degradation is the main problems for China's soil environment. Land productivity is reduced by unreasonable development and utilization. With substantial population growth and rapid economic development in recent decades, China's soil degradation has been get-

[2] *In 1988, the Ministry of Agriculture started this project against a background that the country could not produce enough non-grain food with rich diversity.* http://www.gov.cn/jrzg/2010-03/28/content_1566658.htm

ting worse and worse. Soil degradation includes erosion, desertification, salting, sterility and pollution.

7.1.1.2.1 Soil erosion (water loss and soil erosion)

China is one of countries in the world having serious water loss and soil erosion. The areas with serious water loss and soil erosion include Loess Plateau, middle and upper reaches of Yangtze River, stone mountainous areas in North China (such as Taihang Mountainous Area), red earth hilly areas in South China, black soil areas of Northeast China, and intersection mountainous areas on the border of Sichuan, Yunnan and Tibet. According to Report on the State of the Environment in China 2009, China's existing area of water loss and soil erosion was up to 3 569 200 km^2, accounting for 37.2% of the total soil area, of which: the water erosion area was 1 612 200 km^2, accounting for 16.8% of the total soil area; and the wind erosion was 1 957 000 km^2, accounting for 20.4% of the total soil area.[3] The soil erosion leads to reduction of soil fertility and deterioration of the ecological environment. The causes for China's water loss and soil erosion include natural factors, such as geography and hydrology, and human factors. The latter include some agricultural practices, deforestation, over-cutting of forest areas, heavy grazing of grassland, mining, road building and other large-scale capital construction.

7.1.1.2.2 Soil desertification

The soil desertification is a result of mutual actions of natural and human factors. China is one of the countries in the world with a vast distribution of deserts and desertified land. So far the area of desertified land nationwide is as high as 2 636 200 km^2.[4] The serious desertification areas are mainly distributed in the north and northwest of China, especially in agriculture-husbandry cross-over areas. Generally these areas have such phenomena as excessive reclamation, grazing or cutting, affecting the ecological equilibrium. Serious desertification may result in the loss of overall land productivity, deterioration of the ecological environment and reducing China's agricultural production. One of main causes for desertification is the production activities of the mankind. So far the land desertification in some regions of China has been inhibited or improved effectively. The situation of 'destroying more than control' has been transformed into 'control equal to destroying'. The ecological regime of key control areas has been improved noticeably. The controlled area has been bigger than the destroyed area in a great majority of provinces. The total area of desertified land of the country has been transformed from an annual extension speed of 3 436 km^2 at the end of the

[3] http://jcs.mep.gov.cn/hjzl/zkgb

[4] http://www.moa.gov.cn/fwllm/jrsn/200906/t20090616_1292117.htm

last century to an annual reduction speed of 1 283 km^2.[5]

7.1.1.2.3 Soil salting

Soil salting refers to a process of salt accumulation in the soil. It mainly happens in areas with a dry, semi-dry or semi-humid climate or in coastal lowland areas vulnerable to being soaked and irrigated by seawater. The salinized soil area of China is about 3.69×10^7 hm^2, and arable land affected by salinization is mainly distributed in Huanghuaihai Plain, the west of the Northeast Plain, Hetao Area of the Yellow River, the inland area of Northwest China and coastal areas of East China. The area totals 6.24×10^6 hm^2, accounting for about 7% of the country's total land area.[6] The majority of China's arable land is slightly salinized, without a big impact on agricultural production. A minority of the land is salinized in a medium or high degree, having a big impact on agricultural production.

7.1.1.2.4 Soil sterility

Soil sterility is one of the most fundamental results of soil erosion and degradation. The content of nutrient elements reduces from top to bottom in the soil profile. With increasing soil degradation, the content of organic substances, whole nitrogen and whole phosphorus in the soil decreases. In particular, the content of organic substances and nutrients in the red soil of the granite parent material is reduced. In the past few decades, China has made huge efforts in improving crop yields. The increase of grain yield requires more consumption of nutrients from the soil. These nutritive elements are brought out of the soil with harvest of the grain. Generally the organic content in China's arable land is low. Due to excessive reclamation, the nutrients in the soil are unbalanced due to a lack of organic substances, and the low input yet high output of the soil over time has led to the reduction of nationwide soil fertility. Reports of soil sterility can be found throughout the country. State of the Environment Reports undertaken from 2000 to 2007 have stated that over 50% of China's arable land is short of microelements, 51% is short of phosphorus and 60% is short of potassium. The average content of organic substances in China's arable land is 1.8%, with the content of organic substances in brown soil and earth more than 2 times lower than similar soil types in Europe.[7]

7.1.1.2.5 Soil pollution

At present China's overall situation of soil pollution is not optimistic. The soil pollution is serious in some areas. Heavily polluted soil posing risk to human health, safety and the environment is the legacy of enterprises or industries, mining areas, and commercial activity

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[5] http://www.cctv.com/news/china/20050614/100231.shtml

[6] Xuelei Zhang and Zitong Gong, *Human-induced Soil Degradation in China*, Ecological Environment, Vol. 3, 2003.

[7] http://jcs.mep.gov.cn/hjzl/zkgb

in cities and suburbs. The soil pollution is diversified, complex, can be historical or current, and inorganic or organic. There are many means of and complex reasons for soil pollution. Consequently, pollution control is rather difficult.

The system for soil environment supervision and management is not sound. The investment in soil pollution prevention and control is insufficient. The public awareness of soil pollution prevention and control is weak. Safety of agricultural products from contaminated areas is of concern. Mass events caused by soil pollution have increased year by year and soil pollution has become a key concern of the public affecting social stability.[8]

Currently the foundation for control of domestic pollution is weak in rural areas of China; the non-point pollution is increasingly getting worse; the industrial and mining pollution is being highlighted in rural areas; and the transformation of city pollution into rural areas tends to speed up. According to the 1997 Report on the State of the Environment in China, the pollution of China's arable land was rather severe. An estimated 10 million hectares has been polluted. According to the 2000 Report on the State of the Environment in China, 300 000 hectares of basic farmland protection areas that was sampled and monitored for harmful heavy metal found that 36 000 hectares were beyond the standard by 12.1%.[9]

The pollution of soil through industrialization is rather serious in China. The unreasonable disposal, storage or management of hazardous or other waste results in pollution of soil and groundwater. In China, heavily soil polluted and high risk areas have occurred in aggregation at or near heavy pollution enterprises or industries, mining areas and their surroundings, cities and suburbs[10]. In addition, pollution of soil caused by leakage of dangerous goods due to emergencies during production, traffic accidents or natural disasters further contributes to the problem. This study will address the soil pollution issue.

7.1.2 Characteristics and Causes of China's Soil Pollution

In all environmental elements, the soil is the final acceptor of pollutants. A lot of water and air pollution is transferred to or from the soil. Economic and social sustainability is directly affected by soil pollution. Soil pollution can be invisible and affect humans slowly over a long period of time. Soil pollution can also affect a population directly over a short period. A serious threat to social and economic sustainability, human health and national

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[8] The Ministry of Environmental Protection: *Opinions on Strengthening Soil Pollution Prevention and Control*, Document No. (2008)-48

[9] http://jcs.mep.gov.cn/hjzl/zkgb

[10] The Ministry of Environmental Protection: *Opinions on Strengthening Soil Pollution Prevention and Control*, Document No. (2008)-48

ecological safety exists if it is not addressed. The dangers of soil pollution are: reducing the available amount of healthy land resources; yield reduction of crops; pollution of agricultural products; threat to food safety; harm to the human health directly or indirectly; and other environmental problems.

7.1.2.1 Increasingly highlighted problems of soil environment

The CPC Central Committee and the State Council have paid great importance to the rural environment protection. Through many years of efforts, great strides have been made in rural environment pollution control and ecological protection. However, the present situation of China's rural environment is still very severe. Point source pollution from factories, industries, farms, and non-point pollution from fields is still adding to the problems created by historical practices. Transfer of industrial and city pollution to rural areas exacerbates the problem further having an impact on social stability. This has affected economic and social sustainability in China's rural areas.[11] Most garbage is directly piled on the fields or roads and even thrown into ditches and pools without any treatment. A great majority of domestic sewage is directly discharged onto the ground, into ditches or pools without any treatment. The site selection and layout of township enterprises is improper resulting in industrial pollution. The unreasonable use of chemical fertilizers and pesticides has led to heightened non-point pollution in some areas. Pollution from livestock and poultry breeding has been increasingly highlighted.[12]

With China's economic and social development, rapid urbanization, industrial restructuring and with implementation of the policy on 'scale down the secondary industry but scale up the tertiary industry' in recent years, a number of industrial pollution sites remained after relocation or abandonment of industrial enterprises in city centers and suburbs. In western countries such locations are often called "brownfields". Many of these sites have been redeveloped into residential environments but were not properly assessed or remediated to ensure public health, safety or the environment was protected. Since the 1990s, the relocation of large-scale industrial enterprises has taken place in most middle and big Chinese cities. Most of the sites, abandoned by those industrial enterprises due to relocation, shutdown or closedown, are located in the city centers and are attractive to developers. Toxic and harmful substances are in the sites' soil and underground water due to such out-of-date or malfunctioning equipment and poor management of any emissions or discharges including "running, bubbling, dropping and leaking" during production. Therefore, those sites have

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[11] The State Administration for Environmental Protection: *Opinions on Strengthening Rural Environment Protection*, Document No. [2007]-77

[12] http://jcs.mep.gov.cn/hjzl/zkgb

become highly polluted and high-risk areas to public health, safety and the environment. After enterprises were relocated, some environmental pollution events adversely affecting local residents occurred due to pollutants or soil pollution.[13]

7.1.2.2 Complex causes for soil pollution

With rapid development in China's industrialization, urbanization and agriculture over the last 30 years, China's soil environment has been facing huge pressure. Pollution sources include: industrial (waste water, waste gas and waste residue); domestic waste from urban residents (domestic sewage and urban refuse); agricultural chemicals (pesticides, animal remedies, chemical fertilizers, growth substances, modifiers and additives); and waste from breeding of livestock and poultry. The soil pollution types are diversified, with coexistence of old and new pollutants and inorganic-organic chemical combinations. There are many reasons for soil pollution and the causes are complex, so the soil pollution control is rather difficult. In developed areas where industrialization development began earlier, the quality of partial or regional soil environment reduces more or less. Heavily polluted soil posing risk to human health, safety and the environment appears in areas of heavily polluting enterprises or industries, mining areas and surrounding areas, cities and suburbs.[14]

In China, the activities causing the site pollution include heavy chemical industry, oil extraction and distribution, mining, metal smelting, chemical production and use and industrial waste stockpiling, treatment and disposal. The sources and means of soil pollution of industrial enterprises and surroundings are mainly displayed in the following aspects: improper storage and use of production raw materials and intermediate products; discharge of environmental pollutants during production; discharge of atmospheric pollutants subsiding to the ground surface; leakage of underground pipelines; and unreasonable stockpiling of industrial solid waste. The relocation of enterprises puts an end to the continual pollution to the environment at a specific site, but the pollution to soil and underground water will continue. On the whole the emission of industrial 'three wastes' (waste gas, waste water and industrial residue) is a direct cause for regional soil pollution. The emission of massive pollutants will finally go into the soil directly or indirectly, pollute the soil surface through diffusion or different means and result in severe soil pollution through long-term accumulation.

7.1.2.3 Danger of soil pollution

After the soil is polluted, its original characteristics will be destroyed and the quality of

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[13] Ministry of Environmental Protection, *Circular on Effective Prevention and Control of Environmental Pollution in Relocation of Enterprises*, Document No. [2004]-47

[14] Ministry of Environmental Protection, *Opinions on Strengthening Soil Pollution Prevention and Control*, Document No. (2008)-48

crops will lower accordingly. Polluted soil in the surface stratum is vulnerable when acted on by wind and water forces. This may result in such ecological environment problems as atmosphere pollution, surface water pollution and ground water pollution.

The quality of agricultural products is an important foundation for food safety. In recent years the problems on quality, sanitation and safety of China's agricultural products have been highlighted. Due to unreasonable use of chemical fertilizers and pesticides in planting and cultivation as well as environmental pollution of origins, the chemical residue and harmful substances in some agricultural products are not acceptable.[15] Currently there are frequent occurrences of events on safety of agricultural products and human health caused by soil pollution, which becomes a key factor in affecting agricultural production, public health and social stability.[16] It's estimated that nationwide, grain polluted by heavy metal is up to 12 million tons every year, with direct economic losses exceeding 20 billion *yuan*.[17]

The contaminated soil in cities and industrial sites is a serious threat to human health and ecological environment in China. For example, the petroleum hydrocarbons pollutants in the soil of industrial sites of the petrochemical industry have a big impact on yield and quality of crops; the soil polluted by petroleum may result in changes in other environmental elements; the petroleum hydrocarbons can go into human or animal bodies in such forms as breathing, skin contact or food intake, resulting in cancers, mutagenesis and teratogenesis. When solid waste is piled up in the open area, the pollutants may dissolve, seep, drain and permeate into the ground surface with rainwater after being washed by rain for long, thus polluting groundwater plus rivers and lakes, and further endangering farmland, aquatic products and human health.

Contaminated sites remaining after relocation, shutdown or closedown of industrial enterprises could be located in the city's downtown, and attractive for development of commercial or civil real estate. Though the enterprises have been relocated or shut down, their impact on the environment of the original sites has not been addressed. The pollutants accumulated in the soil and underground water of the original sites will not degrade naturally. If those sites can't be harnessed and restored, the pollutants will go into the human body via underground water or air. Those that live near or on a site have a right to know if their health or well being is or can be affected by past practices or current practices of a site owner/operator.

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[15] Circular of The State Council on *Strengthening 'Vegetable basket' Work at the New Stage*, Document No. [2002]-15

[16] *Speech of Shengxian Zhou at the First National Working Meeting on Soil Pollution Prevention and Control*, http://www.zhb.gov.cn/ gkml/hbb/qt/200910/t20091023_180126.htm

[17] http://news.xinhuanet.com/environment/2006-07/19/content_4852888.htm

Soil pollution is a key factor in threatening the public health, ecological environment and safety of underground water and food. It has a strong impact on China's social and economic sustainability and on the fulfillment of the objective of building up a well-off society. How to keep a safe and healthy environment for production of agricultural products is not only necessary for protecting resources of agricultural production, producing safe agricultural products, making Chinese agricultural products more competitive and realizing agricultural sustainability, but inevitable for guaranteeing the public health for a harmonious society and promoting people's livelihood.

7.1.3 Development Trend in Soil Environment Protection and Pollution Control Field

The future 5-10 years is a critical period for fulfilling the objective of building a well-off society by 2020. Currently China's soil environment is facing a severe situation. It's estimated that in the future 5-10 years China's population will continue to grow, with rapid development in industrialization, urbanization and agriculture integration. A balance between social and economic development must be struck in order to protect soil. In the future 5-10 years, China's soil environment protection will not face an optimistic situation if this balance is not achieved.

As agricultural development enters a new stage, people's living standard has been improving constantly. China is opening wider and wider to the world. The 'vegetable basket' work is facing new situations and tasks. It's required to control safety of agricultural products to ensure people's health. Keeping a safe and healthy environment for production of agricultural products is critical to making Chinese agricultural products more competitive, achieving agricultural sustainability, guaranteeing the public health, building up a harmonious society and promoting people's livelihood.

With step-by-step implementation of industrial restructuring, a lot of enterprises in petrochemicals, metallurgy, electroplating, printing and dyeing, pesticide and pharmacy will be relocated, closed or shut down. The sites remaining after relocation or closedown of those enterprises will become an important source for land redevelopment of cities. With urbanization, a majority of industrial pollution sites may be redeveloped into housing estates. Guaranteeing a safe living environment for both urban and rural residents is an urgent problem to be solved. There is a huge quantity of industrial residue and domestic refuse from the past in China. Some industrial residues or domestic refuse are located in environmentally-sensitive areas, such as the upper reaches of basins or water source areas, exerting potential risks on the soil, water bodies and human health of the sites.

The existing operations of industries and enterprises need to be inspected and laws en-

forced so that further degradation of Chinese soil does not occur.

7.1.4 Problems Existing in Soil Environment Protection and Pollution Control

China's soil environmental protection and pollution control began in the late 1960s. Through nearly 40 years of research and development, noticeable results have been achieved. Compared with atmospheric and aquatic environment pollution control, however, there are still some problems existing in China's soil environment protection and pollution control.

7.1.4.1 Absence of specific laws and codes for soil environment protection and pollution control

China's soil environmental protection and pollution control legislation needs to be improved. There are such defects as dispersed legislation, subsidiary legislation and a low legislation level. Legislation contents need to be improved. Repetition, conflicts of legislation, excessive legislation that does not go beyond principles, poor operability and absence of basic law systems must be addressed. The existing laws and regulations on soil environment protection and pollution control are fragmented, unsystematic, unfocused, unworkable and not enforced allowing soil to be adversely affected.

7.1.4.2 Weak supervision ability to address soil environment issues and absence of perfect risk management system

At present, China's measures for soil environment supervision and control are incomplete. Knowledge of a site's soil pollution history, the category of soil pollutants (especially organic pollutants), environmental transport behaviours and risk of pollutants is fundamental to proper management. The soil pollution monitoring system is incomplete without an information management system that documents all aspects that affect health, safety and the environment. There is no complete risk evaluation or risk management approach to soil environment management. So far only 9 provinces, autonomous regions and municipalities of the country have carried out supervision of contaminated sites and no relevant work has been conducted yet in the other provinces, autonomous regions and municipalities.

7.1.4.3 Unsound soil environment standard system

The current Standard for Soil Environment Quality (GB 15618-1995) is applicable for soil environment protection management of agricultural land, but there is only a small number of pollutant items covered by the standard; in particular, it lacks standards of some organic pollutants, thus the standard can't meet the need for identification of all kinds of soil pollution in regions and specific sites; and the standard only specifies the national uniform values, which can't fully show differences of regional soil in background and nature.

China's current soil environment standard system lacks the pollution assessment and remediation components. Systematic and complete standards on how to investigate and assess the risk posed by sites to human health and safety are required. Standards and technical codes for site restoration after it is deemed contaminated need to be developed. The existing standards do not meet the need for soil environment assessments and management of the sites, especially carrying out investigations, risk evaluation and pollution restoration of the sites when transforming industrial land into residential and commercial estate. Depending on what land ultimately will be used for has an impact on how its restoration should be addressed.

The current standards for soil monitoring and analysis methods only include monitoring methods for eight kinds of heavy metal and typical pesticides; there are only standard samples for heavy metal pollutants but no standard samples for organic pollutants. The present standards for monitoring and analysis methods for soil environment and standard samples are far from meeting reasonable environmental monitoring needs. In addition, "measurability, quality assurance and definite identification" are critical if affected stakeholders are to have confidence in the system.

7.1.4.4 Weak technical support for restoration of polluted soil

The technologies of soil pollution remediation are not mature yet in China. At present, the costs for soil pollution remediation measures are high with a long purification period. Currently, technologies for polluted soil restoration are not mature yet and most of technologies are still at the stage of laboratory simulation and research, without practical engineering practice. The existing restoration technologies have many problems, so there are no currently available restoration technologies, which are feasible economically, technically sound for different types of polluted soil and acceptable to Chinese conditions. So far, China hasn't established a screening system for restoration technologies and the existing technical support conditions can't meet the need for restoration work of contaminated sites.

7.1.4.5 Absence of funds safeguard for remediation of polluted soil

With full consideration of remediation and control of polluted soil and underground water, there is a huge demand for fund. At present the surveys, evaluation, control and remediation of polluted soil in China are generally funded by relevant governmental departments and land developers, so the fund sources are limited and not guaranteed. Therefore, it's difficult to carry out remediation and control, and the fund problem has become a principal obstacle in redevelopment of many contaminated sites.

7.2 International Experiences and Implications in Soil Environment Protection and Pollution Control for China

7.2.1 Establishment of Policies on Soil Environment Protection

7.2.1.1 Attach importance to measures for soil environment protection

Before the 1970s, Western developed countries had shown little concern on the soil pollution problem. However, the problem began to catch attention with occurrences of all kinds of pollution events. Box 7-1[18] for typical events of soil pollution in the 20th century. There is a huge fund demand for remediation and control of polluted soil. For example, the remediation costs of soil pollution of the Netherlands from 2000 to 2009 amounted €335 million/year, of which the government's investment was €160 million/year. Therefore, the developed countries attach importance to pollution prevention in the soil environment protection and have established complete systems of laws, codes and standards in soil environment protection and pollution control. Based on experience in developed countries in Europe and America, the costs for soil protection, the costs for land sustainability management, and the costs for site restoration increases in a proportion of 1:10:100, so the lowest-cost measure for soil protection is to attach importance to soil protection policies. The general management of soil environment should begin with prevention as well as supervision and remediation of contaminated sites.

Box 7-1 Typical Events of Soil Environment Pollution in the 20th Century

Itai-Itai Disease Event in Toyama Prefecture, Japan: From the beginning of the 20th century, the rice in Toyama Prefecture, Japan didn't grow well in general. In 1931 a weird disease occurred. The symptoms of its patients included pains in joints like waist, arm and leg. At the late stage of the disease, the patients would face softening and atrophy of bones, bending of limbs, deformation of spinal columns and brittle bones. Even coughing would cause fracture of bones. From 1946 to 1960 medical professionals of Japan engaged in general clinic, pathology, epidemiology, animal experiment and analytical chemistry carried out long-term study and found that Itai-Itai Disease was caused by cadmium (Cd) poisoning due to mining wastewater of Kamioka Mining Station in the upper reaches of Jinzu River.

[18] http://www.people.com.cn/GB/huanbao/259/6899/

Love Canal Event, USA: Love Canal, CA, USA was out of use as it was dry in the 1940s. In 1942 an American electrochemistry company bought this disused canal as its waste storage, and dumped all kinds of waste up to 8 million tons into the canal within 11 years. After that, a lot of houses and a school were built on it. Since 1977 residents there had suffered from all kinds of weird diseases, such as abortion of pregnant women, death of children, deformity of infants, epilepsy and hemoproctia. Those diseases occurred frequently. In 1987 a black liquid began to seep from the ground there. Through inspection, it contained many poisonous substances, like chloroform, trichlorophenol and methylene bromide, which did huge harm to the human health.

7.2.1.2 Inter-Ministerial cooperation and decision making are crucial in developing effective soil environmental management policies

Defining soil policies are institutionally and legally an extremely complex issue. It relates to many pieces of legislation (e.g., building construction, agriculture, spatial planning, water and waste management) and many different Ministries. Stakeholder support-i.e. involvement of the most relevant Ministries-is an important factor in developing effective soil environmental policies. Setting up a clear institutional structure for the various aspects of soil environmental management, and assigning clear tasks for both public and private parties are essential prerequisites to effectively put these policies into practise. It's an effective measure adopted by developed countries for soil environment protection and pollution control to set up a cross-departmental 'workgroup' to set soil protection goals and formulate laws and regulations. It is an effective measure to set up a cross-departmental 'workgroup' to determine the protection objectives and draw up laws and regulations. Stakeholder support-i.e. involvement of the most relevant Ministries-is an important factor in developing effective soil environmental policies (Box 7-2).

Box 7-2 Cross-departmental Cooperation Is Vital for Making Effective Policies on Soil Environment Management

The soil environment management involves many departments, sectors and fields, and it's necessary to set up a mechanism of cooperation and coordination among departments. It's vital for making policies more enforceable to establish a clearly-defined institutional structure for all aspects of soil environment supervision; and it's an effective measure to set up a cross-departmental "workgroup" to set soil protection goals and formulate laws and regulations. The departments concerned include: environmental protection, land management, building, agriculture, water administration, quality supervision and so on.

Based on the assumption that the contaminated sites issues could be solved in one decade-in the 1980s – the Netherlands failed to muster sufficient inter-Ministerial support. Soil policies were essentially sectorially focused on soil environment only. This led to stagnation in for example spatial planning, building project development and construction of infrastructure. Upon recognition of this situation, soil policies were redefined by the following three Ministries: Ministry of Housing, Spatial Planning and the Environment (lead position); Ministry of Transport, Public Works (i.e. Infrastructure) and Water Management; Ministry of Agriculture, Nature and Food safety.

7.2.1.3 Information disclosure is an important part in establishing soil protection policies

Many developed countries have established polluted soil information databases for the public to inquire. For example, the Superfund Information System in the USA contains more than 10 000 sites and the public can get basic information on a site online in many retrieval forms, like the site's name, number, street, city, county, state, region or postal region. The federal contaminated site directory, set up by the Real Property and Material Policy Division of the Treasury Board Secretariat, has been open to the public since July 2002. There are 6 700 active contaminated sites identified in the directory, and the public can get information on a site, including its location, pollution level, polluting media, pollutant nature, current progress on identifying and clarifying pollution problems, and the quantity of treated liquid and solid media. There are many key word retrieval forms including: typing in the site's name, province or region, population census metropolis, federation electorate, pollutants of the site, the schedule of federal action plans for contaminated sites, and site management plans. This approach has been taken in order to allow all stakeholders to access the available information. It recognizes that depending on your viewpoint, you may be trying to access information in a different way. A scientist may search with different key words than a citizen. Such information can be exported in two forms: table and drawing.

7.2.2 Soil Environment Supervision

7.2.2.1 Soil environment supervision with risk-based methods

At present developed countries generally adopt the modes based on environmental risk assessment and risk management in soil supervision (Box 7-3). For soil quality supervision with risk-based methods, the protected objects are human health, soil ecology and underground water (if possible).

Box 7-3 Adopt the Risk-based Method for Soil Environment Supervision and Give Priority to Treatment of Sites Having the Biggest Risks to Human Health and Environment

Based on experience in developed countries, there is a huge fund demand for remediation and control of polluted soil. For example, there are more than 30 000 contaminated sites in Canada and 294 000-400 000 sites in the USA. It's specified in both Superfund of the USA and Action Plan of Contaminated site of Canada that priority should be given to solving those contaminated site with the highest risks. Generally developed countries adopt the risk-based management mode in accordance with the degree of soil pollution risks to human health and environment: first reduce risks to human health and then risks to ecology and underground water to reduce costs, clean as many contaminated sites as possible and promote local economic and social development.

With methods based on risk management, different soil management policies can be established, such as land sustainability management policies for slightly polluted areas and restoration policies for heavily contaminated sites. An assessment of contaminant risks needs to be considered in the context of current and future land use, and development scenarios (e.g., residential, commercial, industrial, agricultural or recreational use). A detailed site-specific environmental risk assessment may be used to develop strategies that yield acceptable health risks, while achieving low level contamination on-site.

7.2.2.2 Attach importance to participation of interest-related parties in soil environment supervision

The support of interest-related parties (namely participation of the most relevant parties) is a key factor in establishing effective soil environment policies. One of main principles in the contaminated site management flow in the USA is the whole-process participation of communities. The principle of "polluters are responsible for harnessing" for the polluted soil is difficult to be implemented sometimes, and it will be an effective solution that all interest-related parties of polluted soil participate in it together. Figure 7-2 for the relationship among all directly interest-related parties in soil environment supervision.

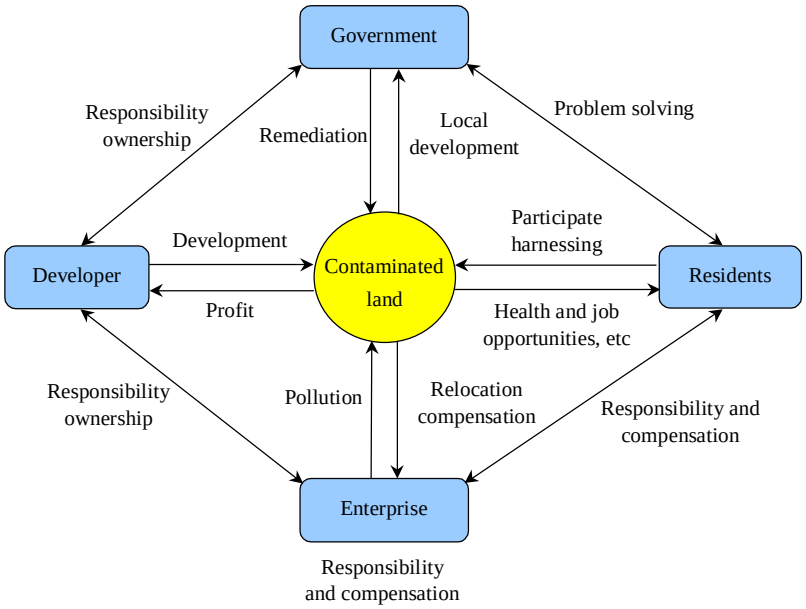

Figure 7-2 The Relationship among All directly Stakeholders

7.2.2.3 Attach importance to soil supervision by local governments

It's shown from experience of Canada that the most effective method is to manage the soil at the local first level, which can make use of capital most effectively. At the same time the diversity of soil and local conditions should be taken into consideration for further optimization of soil environment management costs.

7.2.2.4 Draw up effective financial incentive measures of soil environment supervision

The financial incentive is a determinant in soil environment protection and pollution control as well as a key element for governments at all levels to implement the soil protection strategies. The multi-channel fundraising mode is a determinant in promoting soil control, redevelopment and utilization. Effective financial means include environment taxation, cleaning subsidies, special appropriation, loan guarantee, market licensing and so on. It's shown from experience in developed countries that the challenges caused by soil pollution will not be solved fully unless capital is available and responsible parties are responsible for their behaviours. Box 7-4 for the financial mechanism of Superfund.

Box 7-4 Financial Mechanism of Superfund

The capital sources of Superfund mainly include: the raw material tax on petroleum and 42 kinds of chemical raw materials from 1980; the environment tax collected from the company revenues from 1986; the appropriation from the general finance; the charges collected from companies and individuals responsible for environmental damages relating to disposal of hazardous waste; and others, such as interests and penalties from those companies and individual unwilling to assume relevant environment responsibilities.

In the beginning when Superfund was set up in 1980, its capital sources mainly included the special tax on petroleum and chemical raw materials, plus an appropriation from the general federal finance. The Superfund Amendments and Reauthorization Act of 1986 increased the rate of special taxes for the above petroleum and chemical sectors and also set a new environment tax collected from those companies with an annual revenue not less than US$2 million, plus an appropriation from the general federal finance. The Omnibus Budget Reconciliation Act of 1990 extended the period of Superfund's taxation and treasury appropriation to 1995, with the same tax rate and the appropriation amount from the general finance. Without new authorization after 1995, the new capital sources of Superfund only included the charges collected from potentially responsible parties and the income from interests and penalties.

7.2.3 Soil Environment Protection Standard System

7.2.3.1 A complete standard system for soil environment protection is a guarantee for implementation of policies

The soil quality standards play a vital role in developing soil environmental protection policies. After drawing up special laws and regulations on soil environment protection, generally developed countries will release relevant enforcement rules and standards in accordance with their respective soil environment problems, thus establishing a complete system of laws, regulations and standards on soil environment protection. In the regulatory framework, most developed countries have set up a complete standard system for soil environment protection in accordance with requirements for soil risk management, land usage and protection objectives of acceptors, including screening, target or restoration values of soil pollutants; meanwhile the system often contains guidelines for standard set values plus documents of technical codes like methods for soil survey, monitoring and pollution screening and evaluation, thus jointly providing technical support for identification, management and harnessing of polluted soil/underground water of the sites.

7.2.3.2 Set standards for soil environment quality with the risk-based method

Since the 1980s, Western developed countries have set standards for soil environment quality in accordance with prior risks (such as human health, safety of agricultural products, ecological system and conservation of resources) and in consideration of different use of land, such as housing, industry, agriculture and nature, regarding the problem of soil and underground water pollution of industrial sites remaining from the industrialization period (Box 7-5). According to the designation situation of guideline values for soil quality in the world currently, it has been an international development trend to set guideline values for soil quality to protect ecology and human health with the evaluation method based on exposure risks by means of dividing different land utilization types and in combination with effects of soil ecotoxicology and exposure risks of human health.

Box 7-5 Set Suitable Standards for Soil Environment Quality

In the 1980s the Netherlands set a general soil quality standard, which was (excessively) strict, without being based on land reuse, thus making a mistake, so that a lot of soil wasn't able to be reused and that the quantity of contaminated sites was huge. It's necessary to set applicable soil quality standards and use funds for control of the most polluted soil for harmonious and sustained development between soil environment protection on one hand and economy and society on the other.

Land use is a complex and sensitive issue. It is therefore recommended to calculate the effects of setting soil quality standards. It took the Netherlands a substantial effort to build up (nation-wide) databases on contaminated soils. At present these databases are used to calculate the socio-economic effects of setting soil quality standards.

Too strict soil quality standards will hamper socio-economic processes. Too lenient soil quality standards will miss the objective of soil protection (and improvement). In Canada and the United States, over the last 30 years, governments have committed considerable time and resources to develop soil quality criteria. These criteria are now used by owners, industry, developers and governments to determine whether a site is contaminated, what activities are allowed on the site and if a site should be remediated and to what standard.

7.2.3.3 Set national and local guiding standards for soil quality

A perfect system for soil environment protection standards is a guarantee for enforcement of policies, and the local governments can formulate local standards stricter than the national one. Since the 1990s, a majority of European and American countries have developed from setting a national uniform standard into setting a series of guiding standards for

soil pollution evaluation and restoration centering soil screening values and harnessing target values in accordance with different regions or sites, different requirements for soil environment quality by different utilization functions and protection objectives, and different objectives of soil pollution harnessing and management. The priority in setting and revising soil environment protection standards has transformed from improving the national uniform mode of 'universal limit values' into the mode of 'one set of rules but multiple guiding values in accordance with local conditions'. Both Canada and USA have established guiding standards for soil quality at the federal/national level. The governments at lower levels (such as provincial-level or state-level) are free to establish guidelines or standards at levels which may be more or less stringent than the national values.

Table 7-1 shows the comparison of measures for soil environment supervision between developed countries and China.

Table 7-1 Comparison of Measures for Soil Environment Supervision between Developed Countries and China

	Developed Countries	China
Legislation	Having special laws and codes for soil environment protection and pollution control, such as Superfund Act and Brownfield Act in the USA, Soil Protection Plan in the Netherlands and Soil Pollution Countermeasures Act in Japan	Having no special laws on soil pollution prevention and control
Supervision	Adopting risk-based management modes	Having not implemented risk-based management modes
Standard system	Having a complete standard system for soil environment protection; both Canada and the USA have established national and local guiding standards for soil quality	The standard system for soil environment protection is incomplete; and the whole country adopts the uniform Standard for Soil Environment Quality
Fund guarantee	Multi-channel fundraising mode	Fund sources are limited and not guaranteed

7.3 Soil Environment Protection Policies Recommendations

7.3.1 Develop and Improve China's Systems for Laws and Regulations on Soil Environment Protection and Provide Legal Basis for Soil Environment Supervision

Establish a special law of China on soil environment protection and pollution preven-

tion and control that integrates current laws and regulations on soil pollution prevention and control with experience from the international community, foreign countries and Chinese Taiwan. Such a law should effectively coordinate policies, measures, methods, management experience and enforcement activities that have existed in China for many years. Successful polices, measures, methods, management and enforcement experience need to be incorporated into codes of conduct for people in the field of soil pollution prevention and control activities. In establishing this specific law on China's soil environment protection and pollution control, attention should be paid to integration with China's existing laws to avoid contradictions or conflicts.

7.3.1.1 Set up a cross-departmental workgroup

Set up a special cross-departmental workgroup that has political support, to coordinate and draw up laws, codes and relevant systems about China's soil environment protection and pollution control. The workgroup will focus on all soil protection problems in China.

Define supervision management systems for soil environment protection and pollution control. Of them, the most important points include authority setting and division of its functions and powers, especially division of responsibilities among such departments as environmental protection, agriculture, land resources and water resources, Ministry of Finance, Ministry of Defence, and Ministry of Railways. At the same time it's necessary to define basic rights and duties of all parties in soil environment supervision, basic legal principles and systems for soil environment protection, and basic requirements and measures for prevention of soil pollution and restoration or harnessing of polluted soil. In addition, it is necessary to define how to settle disputes about soil pollution prevention and control as well as legal consequences in violation of laws on soil pollution prevention and control.

7.3.1.2 Attach equal importance to soil pollution prevention and harnessing

The fundamental solution for soil pollution is to control the discharge of pollutants with whole-process clean production and recycling of materials. Take comprehensive account of China's current situation and actual needs of soil pollution prevention and control. It's recommended that the legislation of soil pollution prevention and control of China at the present stage should focus on both soil pollution prevention and control.

7.3.2 In Meeting Environmental Supervision and Control Objectives, Great Importance should be Attached to the Soil Pollution Caused by Industrial Activities Apart from that Caused by Agricultural Pollution

The management policies for China's soil environmental problem-solving and restoration must continue to adhere to the overall objectives of improving soil environmental qual-

ity, guaranteeing of the quality of agricultural products and building a good and habitable environment. Comprehensive control efforts, ecological restoration and project demonstrations at typical polluted soil sites must be undertaken. Successful demonstration projects at agricultural and industrial soil contaminated sites will build knowledge for transfer.

7.3.2.1 Strengthen soil environment quality supervision in basic farmland and major agricultural production areas

It's essential to select those regions with good basic conditions, conforming ecological environment and being suitable for producing green and organic food, set up a group of bases of organic and green food and strengthen supervision and management of soil environment, thus ensuring product safety from sources. The environmental protection authority shall work with other departments concerned to work out measures for supervision of soil environment of places of origin of major agricultural products as well as standards for production soil environment safety of products and relevant technical specifications. Also it's necessary to strengthen supervision of pollution sources having an impact on product quality and strictly control the discharge of pollutants. The municipal sludge and bed mud should not be employed on farmland without treatment, thus ensuring safety of agricultural products and ecology. The environmental protection authority should supervise and check the soil environment quality of green and organic food bases on a regular or irregular basis.

It's essential to establish a network of soil environment quality monitoring for places of origin of agricultural products of key cities in combination with the result of the national soil pollution investigation; to exercise supervision and control by classification and division, and give priority to strengthening soil environment quality management of basic farmland and places of origin of major agricultural products, especially bases listed in 'Vegetable Basket' Program; carry out special investigations on environment pollution problems in places of origin of listed in 'Vegetable Basket' Program to get accurate information on the environment pollution status of such places. The Ministry of Agriculture should tighten use of pesticides and fertilizers, and strengthen inspection and quarantine of products listed in 'Vegetable Basket' Program. The Ministry of Environmental Protection should supervise and manage soil environment and pollution sources having an impact on product quality through strengthening supervision-oriented monitoring. The governments at all levels should include funds required by building of soil environment monitoring capacity and monitoring of soil environment into their financial budgets, and put more funds in monitoring.

7.3.2.2 Attach importance to supervision of the high-risk industrial contaminated sites

In order to address problems of industrial soil pollution impacts on human health, it is necessary to attach great importance to high-risk industrial soil pollution management and

control. This requires a concerted effort to intervene and control the following types of industrial land: contaminated sites caused by relocation of industrial enterprises; contaminated sites caused by stockpiling, sites contaminated by treatment and disposal of toxic and harmful waste; contaminated sites of gas stations or underground storage tanks. A comparison of activities responsible for contaminating soil in Europe and America with those that are active in China should be undertaken to ensure that no types of industrial activity escape scrutiny. It's necessary to establish specifications on monitoring and assessment technologies for soil pollution as soon as possible, and to define relevant provisions on field pollution control and restoration. In accordance with different types of industrial pollution fields, it will be necessary to carry out systematic investigations and monitoring of soil at contaminated sites and establish a soil environment monitoring network and database. This database would help to focus soil pollution investigation within key regions. The database could be used to research and develop efficient and fast restoration technologies of polluted soil including physical, chemical and biological combined restoration technologies.

In addition, attention, prevention and control of radioactive pollution in soil are required. Restoration standards or references and study restoration technologies applicable for harnessing radioactive soil are required.

7.3.3 It is Essential to Strengthen Risk-based Soil Environment Management, Drawing on the Mode Generally Adopted by the International Community

7.3.3.1 Draw up different management countermeasures based on risk management methods with the protection targets of human health, soil ecology and groundwater

The risk-based environmental management of polluted soil as a supervision and control mode is generally adopted by the international community. Such a management means has many advantages. A cost benefit approach is used, which is, to a large extent, applicable for China as a developing country. Over the next 5-10 years, it is necessary to establish technical guide rules or documents for field risk evaluation and management using a risk-based management framework. Soil references and standards for risk evaluation of contaminated sites need to be proposed. Risk evaluation models, evaluation criteria and risk management technologies need to be studied and adopted. Acceptable pollutant levels, ecological effects, health hazards and an environmental control index system must be applied in urban and rural areas of China in order to understand how best to protect people and food supply. Effective control technologies to reduce or resolve risk in accordance with risk evaluation need to be specified. Technical guide rules or documents for risk management to protect the human health and the safety of ecological systems need to be developed in such a way that contrac-

tors can implement remediation work. It is necessary to give restoration priority to those contaminated sites with the biggest risks. Low-exposure and low-risk contaminated sites must be given attention through a low cost, high efficiency management approach that protects health/safety.

7.3.3.2 Attach importance to stakeholder partnerships

In the soil environment supervision, it is necessary to ask opinions of all interest-related parties and establish cooperation among relevant departments, among governments at all levels, between public and private sectors, and between affected citizens and others. The link between liability and accountability must be made.

7.3.4 The Means and Measures for Soil Environmental Supervision Require Reform and Innovation. It is Necessary to Promote the Building of a Soil Environment Standard System and to Encourage Provinces and Cities to Set Local Standards for Soil Environment Quality and Restoration of Polluted Soil in the Coming 5-10 Years

7.3.4.1 Establish the soil environment supervision system suitable for China's actual conditions

Both the state and local governments should follow uniform deployment of initiatives by the Ministry of Environmental Protection to include soil environment supervision and management as an important part of environmental protection. The local governments need to be encouraged to research and establish locally-feasible regulations, policies and measures on soil pollution prevention and control in accordance with local conditions. It is necessary to establish China's own soil environment supervision systems based on advanced experience of foreign countries, including the soil environment quality monitoring and evaluation system, the soil pollution accountability system, the soil pollution prevention and control fund system, the polluted soil control system, the soil pollution harnessing and restoration system, and the soil pollution emergency management system.

Both the state and the local government should bring the soil environment quality monitoring under a routine environmental monitoring system, make soil environment monitoring plans, and provide adequate resources to implement the plans. It's necessary to set up and improve the soil environment monitoring network at three levels: national, provincial and county, and carry out research to establish a system for publishing the state of soil environment quality on a regular basis. It also is necessary to strengthen the building of soil environment protection teams and make emergency plans for soil pollution events. Facing the current situation that the soil environment monitoring management has not been brought under the present routine tasks of environmental monitoring, and that the monitoring au-

thorities, abilities and systems have not been normalized, it's necessary to further increase and set up special authorities for soil environment monitoring. Existing environmental monitoring stations at county, city and provincial levels will need to be strengthened and added to with the help of the special authorities. The soil environment monitoring field needs to be properly equipped and efficiently integrated to provide results at the county, provincial and national levels.

It's necessary to draw up early warning and response mechanisms and measures based on soil environment risk evaluation, safety evaluation and environmental monitoring information to respond to all kinds of pollution (including accumulated pollution and pollution caused by emergencies or other reasons). Moreover, it's necessary to carry out research that can lead to establishment of a technical support system to guarantee effective early warning and emergency response. The early warning systems for soil environment safety mainly includes: a real-time monitoring information system for the state of pollutant discharge in key pollution sources, an early warning system for emergencies, and an early warning system for soil environmental monitoring and safety evaluation in key areas. It's also necessary to establish criteria that will initiate the early warning system.

It's necessary to strengthen the building of soil environment protection publicity and education teams. Plans, ordinances, rules and regulations for soil environment publicity and education need to be developed. Textbooks for publicity and education of soil environment protection must be written to capture learnings and minimize duplication. Archival repositories for soil environment publicity materials and information network sharing platforms need to be established. Professional teams for scientific research, monitoring and management service of soil environment protection need to be nurtured and supported to ensure those qualified can do their job.

7.3.4.2 Establish a registration system for contaminated sites at the point of property transaction

Establish a registration system for contaminated sites at the point of property transaction, and this would be applied when there is buying or selling or a proposal for a change in land use.

The land seller should identify the current owner of land usage rights, activities / operations on the land (related to causing of any possible contamination), extent of existing contamination, owner's declaration of such contamination or no contamination, and a declaration awareness/acknowledgement recognizing their responsibility/liability for any contamination that may have occurred on this piece of property. The land buyer should identify any contamination on the property and declare the awareness of such contamina-

tion and liability from such contamination that might be transferred to the buyer, and declare the Not-Guilty responsibility with all possible due diligence effort before the property transaction.

7.3.4.3 Improve China's soil environment standard system

China's soil environment protection standard system should include five parts: the standards for soil environment protection of agricultural land, the standards for soil environment protection of sites, the standards for soil environment analysis methods, the soil environment standard samples and the basic standards for soil environment.

The standards for soil environment of agricultural land mainly include the standard for soil environment quality, the technical code for soil environment quality assessment, the technical code for soil environment monitoring and the technical code for soil pollution prevention and control of agricultural land. The standards for soil environment of sites mainly include the technical codes or guidelines about the sites' environmental survey, assessment, restoration and monitoring, mainly involving technical provisions on all links in environmental protection of sites. The standards for soil environment analysis methods mainly include the analysis method standards of various pollutants in the soil, like heavy metal pollutants, volatile pollutants, semi-volatile pollutants and permanent organic pollutants, plus technical specifications for pre-treatment methods of relevant soil pollutant samples. The soil environment standard samples mainly include standard samples of various pollutants in the soil, like heavy metal pollutants, volatile pollutants, semi-volatile pollutants and permanent organic pollutants. The basic standards for soil environment mainly include terminology, definitions, symbols, measurement units and other standards in soil environment protection.

Incorporated into all standards is a requirement of due diligence, liability and accountability in order to ensure those responsible undertake their tasks in a manner that reflects the specified standards.

7.3.4.4 Set the national and local guiding standards for soil quality

The current Standard for Soil Environment Quality emphasis is on a uniform national standard. It should be revised in the coming 5-10 years. It's necessary to adopt risk evaluation methods to set standards for soil environment quality of different regions reflecting different soil characteristics and land utilization types. It's necessary to adjust pollutant items stated in the current Standard for Soil Environment Quality to include other pollutant types (including heavy metal and toxic and harmful organic pollutants). The country should establish soil environment protection standard systems, speed up the revision of the national standard for soil environment quality, draw up and improve relevant monitoring and analysis methods for the soil environment, and implement research to set the soil pollution control

standards. The local governments should be encouraged to research and set local or regional soil environment standards in accordance with local conditions that, at a minimum, meet the national standards but exceed them where required.

Proposals on establishing the soil quality standard:

(1) Suggest methods for China's soil pollution ecology and health risk evaluation and establish relevant laws, codes, technical codes and guide rules as soon as possible.

(2) Carry out studies on pollutants' environmental behaviours, biological availability, ecotoxicology tests and dosage-reaction relations in a systematic way to provide theoretical references for determining the soil standard values.

(3) Develop methods and technologies to establish standards at a national level that reflect China's diversified soil types. All provinces, autonomous regions and municipalities should establish their own regional standards. Revise and improve national soil quality standard systems applicable for different land utilization types. Set local soil quality standards in all provinces, autonomous regions and municipalities.

7.3.5 For Soil Pollution Control and Harnessing, the National Environmental Protection Authority Should Carry Out Assessments on Applicability of Remediation Technology of Polluted Soil Sites Through Implementation of Demonstration Projects and Study to Develop A Financial Capital Mechanism for Addressing Soil Remediation

7.3.5.1 The key areas for soil pollution control and harnessing include lands used for agricultural production, abandoned industrial sites with high pollution and risks, hotspot areas and ecology-sensitive areas. Support should be given to build a group of key demonstration projects of harnessing and restoration

The priority for implementation action should be given to supporting basins and regions with a history of sites harming public health, safety and the habitable environment. Special focus should be given to sites that have contributed to poor quality of agricultural products. In rural areas, the priority should be given to major production bases of grain, agricultural products and export-oriented agricultural products. Restoration of polluted soil and ecological control needs to be in accordance with resolving soil environment problems having an impact on quality of agricultural products or food.

In urban areas, the priority should be given to industrial sites after relocation or closedown of high-pollution and high-risk enterprises (such as pesticide plants, chemical plants, coke-oven plants and landfill of hazardous waste). Comprehensive control and soil restoration of contaminated sites need to be undertaken as a demonstration to show how public

safety and the environment can be protected. In an urban situation, many people can be affected. It's necessary to focus on hotspot areas for demonstration projects. Areas of cancer, areas of endemic diseases and frequently occurring areas of environmental pollution will be a priority. In the coming 5-10 years, it's necessary to establish screening index systems for different restoration technologies with such pollutant targets as heavy metal, petroleum, pesticides and permanent and volatile toxic organic substances. Also, it is necessary to promote the building of a group of national and local key labs for soil pollution prevention and control, or technical centers for soil restoration engineering.

7.3.5.2 The local governments are the principle responsible agents in implementing soil pollution prevention and control projects, and such projects should be mainly funded by the local governments, while the central government's financial fund mainly serves as a guide to encourage the participation of private capital

According to restoration practice of polluted soil sites in different regions at present, the fund raising for restoration is an important bottleneck problem. In the future 5-10 years, it's necessary to find a reasonable mechanism for raising capital for restoration projects. The capital sources should include pollution taxes levied from polluting enterprises, contributions from developers of polluted plots, government grants, funds gathered from responsible parties, penalties from companies and individuals evading their relevant environment responsibilities, funds raised from local communities and residents, public donations, interests of funds.

The projects for prevention and control of soil pollution should be mainly funded by the local governments while the central government's financial fund should mainly serve as a guide to encourage the participation of private capital. The central government should arrange a certain proportion of specific funds from its financial budgets for prevention and control of soil pollution, and ensure that such funds will increase year by year; and also the local governments should arrange a certain amount of funds for prevention and control of soil pollution from their budgets. Besides, the central government should give fund support for local prevention and control of soil pollution, as appropriate.

7.3.6 For Soil Environment Supervision, It is Necessary to Strengthen Technical Support and Make Breakthroughs in Scientific and Technological Obstacles Affecting the Effective Progress of China's Soil Environment Supervision

7.3.6.1 Make lists of pollutants requiring prior control in different regions and different producing areas of agricultural products

Facing the challenge of various kinds of environmental pollution sources and pollutants

affecting agricultural products, the Ministry of Environmental Protection should cooperate with agriculture and health ministries to screen and make lists of pollutants needing control and management. Land used for agricultural production must be tested to ensure pollutants do not enter the food supply. The environmental quality assessment indices for agricultural products should be selected and determined in accordance with the state of pollution sources, characteristics of agricultural production, origin location and status quo of pollution of agricultural products. Relevant standards and evaluation methods should be set to provide guidelines for environment supervision.

7.3.6.2 Establish soil record and information management systems of contaminated sites

Carry out systematic investigations on contaminated sites, especially those industrial contaminated sites currently utilized or abandoned in cities. An audit of pollutant categories in soil and underground water, pollution scope, comparison with background or original plant site data should be undertaken. A soil record and information management review of environmental measures taken for control and remediation should be recorded and compiled for overall government management purposes through a database.

7.3.6.3 Establish screening systems for polluted soil restoration technologies and develop technologies and equipment for polluted soil restoration

Soil restoration technologies for contaminated sites should be developed. Guides need to be prepared for soil restoration technologies at contaminated sites. Polices on technologies and their applicability for soil protection and control must be developed. The building of a group of national key labs for soil pollution prevention and control and technical centers for soil restoration must be developed. National soil analysis and testing methods and standard samples as well as equipment for soil restoration of contaminated sites should be made available for use by the expert teams.

In the future 5-10 years, the priority for restoration and harnessing of polluted soil should be given to implementing demonstration projects. For contaminated sites that are a priority for development, R&D of rapid physical-chemical restoration technologies to improve restoration efficiency and lower the restoration cost need to be pursued. For agricultural soil (including sewage irrigation areas), efforts should be made in developing biological remediation and stabilization technologies. Safe, low-cost and environment-friendly technologies for the purpose of land restoration to safeguard safety of agricultural products and ecology will have to be identified in order for measures to be practical.

7.3.6.4 Establish mechanisms for sharing soil environment data in China

It’s necessary to study mechanisms of sharing soil environment data in China based on scientific data sharing management mechanisms in developed countries, including systems

for policies and codes, confidentiality management mechanisms, public sharing mechanisms, organization guarantee of data sharing and so on. The use of environmental due diligence information collected during investment transactions should be explored as a means of building the Country's environmental database.

Appendix Ⅰ Progress on Environment and Development Policies in China (2009-2010) and CCICED Policy Recommendations Impact

CCICED Chinese Chief Advisor & Support Team

Introduction

China Council for International Co-operation on Environment and Development (CCICED), a top policy advisory body approved by the Chinese government, is entrusted with the task of proposing policy recommendations in the area of environment and development for the reference of decision makers. At its annual general meeting, members home and abroad proceed from CCICED basic research findings, discuss policy-related issues and formulate its policy recommendations which are subsequently submitted relevant government agencies. CCICED members and partners are very interested in the impact of the recommendations on policy practice in the area of environment and development. Therefore, since 2008, CCICED secretariat entrusted the chief advisory panel to track down major developments and policy formulation and readjustment in China's environment and development area, in an attempt to assess the direct or indirect impact of CCICED policy recommendations on policy formulation, and finalize a written report.

This report aims to describe achievements China made in the area of environment and development, and provide a real policy context so that members could make their own judgments as to the practical impact of policy recommendations. By relating policy practice to policy recommendations, members could see clearly what policy recommendations were adopted by the Government, what recommendations would lose ground in current policy context, and what suggestions will facilitate the overall development of environment and

development in China in the long run without showing any immediate impact. In this manner, members could readjust policy recommendations for effectiveness and consistency.

As is known to us, formulation and readjustment of major policies by all governments across the world is a comprehensive decision making process in light of national reality. It's hard to attribute the formulation of a particular policy to the recommendation or suggestion of a single agency or organization. Complexity of policy development process makes it difficult to assess the relevance of a particular policy adopted to CCICED recommendations last year. This report does not seek to assess CCICED recommendations' impact. Rather, it leaves the decision to the readers to make about the impact of the recommendations by comparing the policy practices happened in China with the recommendations.

This report is the third of a series of consecutive reports from 2008. This report is divided into two parts. The first part summarizes the adjustments in some of the important policies in the area of environment and development in China during the one year period of time after the annual meeting of China Council for International Cooperation on Environment and Development (CCICED) held in the November of 2009. The areas covered are mainly those that are highly related to the policy recommendations from CCICED. The second part is the major policy recommendations from CCICED in 2009. The information contained in this report represents the expert recommendations and is used for reference for the domestic and foreign committee members and various parties.

Part I: Current Status of Major Policies of Environments and Development of China

1 General Situations of Environment and Development

2010 was among China's most difficult years of the decade in economic terms. China fared relatively well while the world suffered from economic depression. GDP of China reached 335 billion *yuan* and an 8.7 percent increase from 2008. In the first two quarters of 2010, China accelerated a conversion of economic development modes and an adjustment of its economic structure. Gross domestic product (GDP) grew 11.1 percent from the same period a year ago.

(1) Energy-saving and emission reduction has made significant progress. In 2009, the energy consumption per unit GDP of our country is 1.077 tons of coal equivalent/ten thousand *yuan* and 3.61% decrease from 2008. The last year of " the 11th Five Year Plan" (2010) also is critical to whether the index of energy-saving and emission reduction can be accom-

plished. The emission is accumulatively reduced by 14.38% in the first 4 years of "the 11th Five Year Plan" compared to 1.25% in 2010, from which we can see that it is hard to accomplish the objectives of energy-saving and emission reductions.

In 2009, newly-added urban sewage treatment capacity per day reached up to 13 300 000 tons in our country, which overfulfilled the objective (10 000 000 tons) determined at the beginning of the year. The daily treatment capacity for urban sewage treatment factories reached up to 86 640 000 m^3 at the end of the year and urban sewage treatment efficiency reached up to 72.3%, which rises by 2.1 percent. The installed capacities of newly-added fuel coal sulphur removal sets were 0.102 billion kW. In the whole year in our country, which overfulfilled the target (50 000 000 kW.) determined at the beginning of the year.

In 2009, total emissions of chemical oxygen demand (COD) were 12 775 000 tons and total emissions of sulfur dioxides were 22 144 000 tons, separately reduced by 9.66% and 13.14% compared with 2005. The progress of emission reduction of sulfur dioxide has outrun the objective of emission reduction determined for "the 11th Five Year Plan". Up to now, the objective of COD also has been achieved.

(2) Clean energies significantly increase**.** In August of 2010, it was pointed out in *Global Trends in Sustainable Energy Investment 2010* issued by United Nations Environment Programme (UNEP) and *Renewable Global Status Report in 2010* issued by Renewable Energy Policy Network that China has overtaken America in investments on clean energies in 2009. In 2009, the investments of public and private sectors on key clean energies in China have been increased by 53%, the power generation capacities of renewable energies have been increased by 37 billion Watts and the newly-added capacities are higher than any other countries in the world. Thus, China has become the largest market for the installed capacity of wind-driven power with newly-added installed capacity of 13 750 000 kW occupying one third of the newly-added installed capacity of wind-driven power in the world.

(3) The elimination of backward production capacity was enhanced. In 2009, with policies of structural emission reduction, such as "keep and promote the large and hold or close down the small", etc., the installed capacities of small thermal power stations closed down in China were 26 170 000 kW and backward production capacities of ironmaking, steel-making, coking coals and cements having been eliminated separately were 21 130 000 tons, 16 910 000 tons, 18 090 000 tons and 74 160 000 tons and totally 1 200 enterprises dealing in paper-making, chemicals, alcohol and monosodium glutamate have been closed down. In 2010, small thermal power generation units of 10 600 000 kW have been closed down. During the period of "the 11th Five Year Plan", the installed capacities of the small thermal pow-

er generation units to be closed down shall be over 70 000 000 kW in China. If the same quantity of electric charge to be generated by large power generation units, it shall save raw coals of 81 000 000 tons and separately reduce emission of sulfur dioxide and carbon dioxide by 1 400 000 tons and 0.164 billion tons each year.

(4) Solid achievements on protection of biological diversity. It is the international biological diversity year determined by UN in 2010. According to the data issued by the Ministry of Environmental Protection of China, total 85% of terrestrial ecosystems, 47% of natural wetlands, 20% of natural forests, most of natural areas, 65% of higher aquatic plants and most of rare and endangered wild animals and plant species resources protected by our country are effectively protected.

(5) Environmental quality has been improved more or less**.** In the last half year of 2010, the general water quality of surface water was remarkably improved in our country. Class Ⅰ-Ⅲ water quality of state-controlled sections is 49.3% and 1.3 percentage higher than the same period in last year; the average concentration of indexes of permanganate is 5.1mg/L and 0.2mg/L lower than the same period in last year. Compared with the same period in 2005, the ratio of Class Ⅰ-Ⅲ water quality of state-controlled sections increase by 17.2 percentages, Class Ⅴ bad water quality decreased by 11.2 percentages and the average concentration of permanganate indexes decreased from 8.0mg/L to 5.1mg/L. The water quality of the seven water systems has been improving. Ratio of Class Ⅰ-Ⅲ water quality is 56.8% and 1.0% higher than the same period in last year while Class Ⅴ bad water quality is 19.2% and 2.9% lower than the same period in last year, where the main stream of Changjiang and Yellow River, tributary of Zhujiang and Sanxia water reservoir is of good quality and the water bodies of main stream of Zhujiang, tributary of Changjiang and main water lines of the east water line of South-to-North Water Diversion Project are kept well.

The air quality of 113 key environmental protection cities is generally kept well, the ratio of average days of good air quality is 91.0% and the ratio of average days of good air quality for 105 cities is higher than 80%.

In 2009, under the influences of international financial crisis and economic depression of the world, the growth rate of the economics of China abruptly declined and thus the economic policies of our government were concentrating on “Maintaining Growth”. With entry into 2010, the influence of financial crisis gradually becomes weak, the economic of the world gradually picks up, and thus Chinese government timely adjusted the economic policies from “Maintaining Growth” in 2009 to “Promoting Transformation” in 2010, greatly promotes adjustment of industrial structures and updates and develops green industries. Accordingly, the strength of energy-saving and environment protection is further enhanced.

In the *Report on the Work of the Government* issued in March of 2010, Premier Wen Jiabao pointed out that we should energetically promote economics into the development track of "Innovation-driven, Endogenous Growth" and the transformation of economic development modes. Cultivate strategic industries with growth potential including new energies and energy-saving and environment protection so as to realize a new technological revolution and industry revolution, race to control the economic and technological points, make arrangements for energy-saving and emission reduction works in 2010 and be ready to accomplish the hard and long time task of energy-saving and emission reduction task of "11th Five Year Plan". He also pointed out: 1. Focusing on industry, transportation and building, vigorously promote energy-saving and improve efficiency of energies. 2. Strengthen environment protection, actively promote treatment of key drainage basins and areas, treatment of urban sewage waste, treatment of agricultural diffused pollution and overall comprehensive regulation on heavy metal pollution, etc., and quicken construction of all coal-fired units and put Flue gas desulphurization (FGD) facilities into operation. 3. Actively develop cycling economy and energy-saving and environment protection industry. 4. Actively respond to climate changes. Strengthen the construction of adaptation and mitigation of climate changes. Vigorously develop low-carbon technologies, promote high-efficient and energy-saving technologies, actively develop new energies and renewable energies and strengthen the construction of smart grids. Quicken the progress of greening motherland and increase carbon sequestration in forestry. Take efforts to establish the industry system and consumption mode characterized in low-carbon emission, actively participate in international cooperation in responding to the climate changes and thus the world can make achievements in dealing with climatic changes.

2 Progression of Important Environment and Development Policies Related with Policies and Suggestions since Last Year

2.1 Develop green economics and promote green transformation of economics development mode

At the annual General Meeting of China Council for International Cooperation on Environment and Development in 2009, as a key concept put forward in the policies and suggestions for Chinese policies by the General Meeting, Green Economy was gradually accepted by leaders of Chinese Government. They stressed the necessity to develop green economics at different sites and also to consciously drive the transformation of Chinese economic development modes driven by this concept. At the end of 2009, Premier Wen said during a special interview of Xinhua News Agency that economic crisis each time shall brew

a technological revolution; however, the key to the economic crisis is human's wisdom and the power of sciences and technologies. In order to face the economic crisis, Chinese government has been ready for culturing new economic growth areas for the next round of technological revolution. The key for this round of technological revolution is to promote innovation of environment protection technologies and develop green economics and low-carbon economics.

At the Third Session of the 11th National People's Congress and the third session of the 11th National Committee of the CPPCC called in March of this year, the hottest key words include "low-carbon economy" and "green economy" and members of the two committees put forward large quantities of proposals accordingly. The Chairman of the Standing Committee of the National People's Congress proposed that the government "shall strengthen legislation of green economy and low-carbon economy in response to climate change." Qinglin Jia, the chairman of the Chinese People's Political Consultative Conference, also pointed out that we should "promote energy-saving and emission reduction, develop the circular economy and low-carbon economy so as to face climate change."

In May of this year, Vice-Premier Li Keqiang restated suggestions on development of "green economy" and execution of "green and new policies" in terms of the policies and suggestions determined at the 2009 Annual General Meeting of CCICED and systematically described ideas on the development of green economics in China when he spoke at the Green economy and international cooperation on climate change meeting. He considered that the development of green economy presently has become a key trend in the world. At the time when the conflicts between economic development and resources and environments are appearing seriously, it does not only achieve energy-saving and emission reduction, but also can fully take advantages of resources, enlarge market demands, provide new employment opportunities and is a key combination between environment protection and development of economics. It is an objective requirement and inevitable choice for China with 1.3 billion people to break through bottleneck of energies and resources and achieve peaceful development and modernization.

Vice-Premier Li Keqiang put forward three suggestions on development of green economy and adaptation to climatic changes: 1) China shall quicken its efforts to transform the economic development mode and actively promote the development of green economy. Pay more attention to cultivate new growth points, such as new energies and energy-saving and environment protection industry, etc., further address promotion of energy-saving and efficiency-increasing efforts in all areas, such as production, communication, distribution, consumption and construction, etc., and pay more attention to protect ecological environ-

ments. With further reform, to establish and improve the system of green development, construct green industry system and thus form a green development mode. 2) Firmly set up ecological civilization concepts and promote positively green consumption patterns. Pay attention to “Can People Live in Harmony with Nature”, include saving culture and ethics of environment into public order and good custom for the society and take the resources carrying capacity and ecological environment capacity as important conditions of economic activities. Guide the public to consciously select consumption modes for saving, environment protection and low-carbon emission, and to make efforts to establish a resource-saving and environment-friendly society. 3) Improve the mechanism of economic globalization and form an environment beneficial to the development of green economy. The international communities should establish and execute trade policies encouraging green development and oppose all kinds of trade protectionism. The developed countries should help the developing countries to culture green economy and support the sustainable development of newly emerging economies.

Clearly, suggestions on policies put forward by CCICED, such as “develop green economy to promote transformation of economic development modes”, “develop energy-saving and environment protection green industries”, “make green industries as key parts of new growth points and strategically newly-emerging industries of China economy”, “advocate sustainable consumption”, “strengthen cooperation and jointly promote the development of green economy” and “oppose trade protectionism, enlarge and promote the transformation of resource and energies-saving and environment and climate-friendly technologies”, etc., have been considered by the decision-making circles and also have influences on the direction of decision-making.

Starting in 2010, the Government of China issued a series of policies to promote transformation of economic development and these measures provide a way forward for the development of green economy of China. The *report on the implementation of the 2009 plan for national economic and social development and on the 2010 draft plan for national economic and social development* points out that efforts should be made to drive the transformation of economic development modes and adjustment of the economic structure, the improvement of economic development quality and benefits, the strengthening of sustainable development, and the achievement of sound and fast development of economy. Eliminate backward production capacities and strengthen energy-saving and emission reduction as well as environment protection. In May of 2010, in order to further fulfill the general arrangement for adjustment of economic structure and transformation of development mode, the State Council approved *Measures to deepen and restructure economic reform* issued by the

National Development and Reform Commission. These measures define the key points of economic reform of 2010, make a series of arrangements of systems and departmental responsibilities for the transformation of economical development modes, and put forward requirements for deepening resource product prices and reform of environment protection charges.

In view of their respective functions, all ministries and commissions successively issued a series of new measures to promote the green transformation of industry structures. For example, in March of 2010, the State Administration of Industry and Commerce issued opinions on "thoroughly applying scientific concept of development and actively promoting quickened transformation of economical development modes". This opinion puts forward some measures for promoting the transformation of economic development modes and development of green economy, including: entry into strategic newly-emerging industries by encouraging technologies with self-owned intellectual property rights evaluated for investments and actively guiding all kinds of social capitals with investment by shareholders' equity; actively guide consumers to consciously reject high energy consumption and high pollution items with expensive packaging, and advocate green living and consumption mode characterized by low-carbon emissions.

In order to promote the transformation of consumption mode of residents, *Opinion on Multistep Household Electricity Pricing System (Draft)* issued in October of 2010 set out the preliminary plans of multistep electricity pricing. The draft mentioned two proposals: the price shall be increased if monthly household electricity consumption separately exceed 110 and 140kWh. The electricity pricing shall be increased by 3 levels. The residential tariff for households shall not be less than 0.2 *yuan* per kWh for the highest level. The Ministry of Environmental Protection has started to study and establish an ecological civilization construction evaluation index system and policies, and is promoting the transformation of economic development and economic structural adjustment by strict environmental measures.

On January 1, 2009, the Circular Economy Promotion Law was formally put into force, which indicates that the development of circular economy has been formally included as part of the rule of law. In opinions and suggestions of the 2009 CCICED AGM, the development of circular economy is one of the key points of promotion of green economy. In May of 2010, the National Development and Reform Commission issued the *Notice on Model Pilot for Distribution to the Objective of Energy-saving and Emission Reduction of "the 11th Five Year Plan"*, which requires taking the development of circular economy as a key measure to promote energy-saving and emission reduction. With regard to the system of development of circular economy, the Chinese Government successively made a series of arrangements, and

started planning of circular economy and construction of pilot models. In May of 2010, the Ministry of Commerce issued *Guiding Opinions of the Ministry of Commerce of the People's Republic of China on Further Pushing Forward the Industry Development of Renewable Resource Recovery*, which promotes the principle of "Government-oriented, Market Operation and Social Participation" to establish a renewable resource recovery system, try to establish a perfect renewable resource recovery network covering urban and rural areas and many kinds of items, standardize approximately 50 regional terminal markets so that the recovery rate of major types of renewable resources could reach over 80% and thus the resource recovery could be industrialized. In order to further promote comprehensive utilization of resources, improve utilization rate of resources and develop the circular economy. In July of 2010, China issued *The Outline of Technical Policy of Comprehensive Utilization of Resources of the People's Republic of China*, which lists 3 kinds of comprehensive utilization of resources technologies: 1) Technologies for comprehensive utilization and proper utilization of interlinked and associated minerals during exploitation of mineral resources. 2) Technologies for recovering and proper utilizing waste residues, waste water (liquids), waste gases, remaining heat and remaining pressures generated during the production. 3) Technologies for recovering and reusing all kinds of wastes generated from social production and consumption process. Also, this Outline specifies value-added and corporate income tax preferences for these technologies. On December 24, 2009, State Council formally approved and applied *Overall Planning of Circular Economy in Gansu Province*, which requires trying to establish Gansu Province as a National Demonstration Area of Circular Economy. This is the first regional circular economy development approved by our country, achieves significant breakthrough from theory to the practice and is a landmark event during the course that the circular economy is increased up to national development strategy. Before or after it, the National Development and Reform Commission successively approved overall planning of circular economy development and model pilot fulfillment proposals of Shanxi Province, Henan Province and Tianjin, etc..

It is a key point of the proposal on development of green economy issued by General Meeting of China Council for International Cooperation on Environment and Development through development of ecological and low-carbon agriculture and ecological system services management to promote the development of green economy in rural areas. It definitely specifies in *Opinions on Strengthening Urban & Rural Development to Further Consolidate Agricultural and Rural Development Foundation* (No.1, Zhongfa (2010)) that "consolidate ecological safety barrier", "prepare planning of protection and utilization of forestry lands, start up forestry operation engineering, strengthen ecological service function of forestry,

improve overall production capacities of forestry lands and vigorously increase Carbon Sequestration in Forestry" and strengthen treatment of widespread pollution and develop circular agricultural and ecological agriculture".

Over the last year, the National Forestry Department and Agricultural Department have undertaken a number of actions. The National Bureau of Forestry issued *Notice on Model Pilot of Carbon Sequestration for Forestation* and thus formally started up "Carbon Sequestration for Forestation". "Carbon Sequestration for Forestation" mainly aims at exploring measurement and monitoring methods of carbon sequestration, taking into account Chinese characteristics, while complying with international rules, providing technical support and a scientific basis for carbon sequestration of different kinds of trees under different situations, and giving a solid foundation to the measurement, reports and verification of carbon sequestration of national forestry. They also guide enterprises to voluntarily contribute money to plant trees for carbon sequestration, to participate in actions against climate change. As well they promote social responsibilities to enterprises and explore reform of investment and financing systems where social capitals flow to forest planting for public benefits. During the model pilot period, "Forestation for Carbon Sequestration" shall adopt combination between social contributions and national allowances for key projects of forestry.

Agricultural departments also have been driving studies and model pilots of high-efficiency and ecological energy, and low-carbon agriculture. Department of Agriculture and Shandong Province jointly established a high-efficiency ecological agriculture model pilot at Delta of Yellow River to promote construction of high-efficiency ecological plant production, high-efficient ecological animal husbandry, high-efficiency ecological fishing, export-oriented agriculture and scientific and technological support capacities with regard to intensive utilization of resources, circular and high-efficiency development of industries, environment protection and ecological civilization construction. In 2010, the concept of "Low Carbon Agriculture" was increasingly included in agenda of decision-making circles. Department of Agriculture has been exploring effective measures guaranteeing security of foods and against climatic changes, successively wrote *Low-carbon—Agricultural Action against Climatic Changes*, organized a series of national level forums, discussed all kinds of adverse influences on our agricultural production caused by global climatic changes and seek to support the planning of "National Twelfth Five Year Plan".

With regards to advocacy of sustainable consumption and low-carbon living, China shall continuously carry out government procurement of environmental labeling products. At present, total purchase lists for 6 stages have been issued. The World Exposition, Shanghai China 2010. Inherits and carries forward the inheritance of the Beijing Green Olympics by

creating a green and low-carbon World Exposition. Under the three big subjects of "low-carbon, harmony and sustainable city", Shanghai outlines an embryonic form for a new generation of cities. Shanghai issued *Environmental Report EXPO 2010 Shanghai China*, which describes the process of establishment of environment-friendly city and practice of green EXPO separately from 3 levels, such as improvement of environment quality, green practice of EXPO and participation of the public. In order to improve public participation, EXPO 2010 Shanghai China also issued low-carbon public transportation cards to encourage the public to take public transportation modes and to offset carbon emission caused by visits to EXPO.

2.2 Vigorously develop low-carbon economy to meet the challenge of climate change

China expects to continuously take an active stance towards participation in international negotiations on climatic changes. In October of 2010, China successfully hosted the October 2010 Climate Change Conference in Tianjin, which is the first international climate change conference undertaken within China under the UN framework convention. Before the Copenhagen conference in December of 2009, the objective of emission reductions in China until 2020 was set, with an intensity ratio of carbon dioxide per GDP in China that shall be reduced by 40%-50% by comparison to 2005. This ratio is to be included in medium and long term planning of the national economy and social development as a mandatory index and accordingly prepare domestic statistical base, monitoring and criteria for evaluation. This is a solid promise made by the Chinese government in fully considering the Chinese situation and represents good faith on the part of China towards climate change action, and an active attitude intended to stimulate international climate change negotiations. On December 18, 2009, Premier Wen Jiabao restated once again the promise of the Chinese Government for reduction of carbon emissions. The policy recommendations at the 2009 AGM of CCICED, suggested that the Chinese government "should establish a quantitative index for definite low-carbon economy development according to the general requirements that carbon emission shall be significantly reduced until 2020 by comparison to 2005, try to guarantee the carbon emission per GDP is reduced by 4%-5% per year and break down the objective according to different regions and industry features." This recommendation generally is in line with the final promise of Chinese government.

Model pilots of low-carbon economy and cities have spread like wildfire. Except for some model pilots jointly carried out some local government and foreign institutes or governments at an earlier time, the Chinese government has started deployment of model pilots of low-carbon cities and economy at a national level and is trying to give a foundation for global warming emission statistics and management system during "the 12th Five Year Plan"

through the model pilots.

In December of 2009, the Ministry of Environmental Protection issued a *Notice on the Development of a Low Carbon Economy in National Pilot Eco-industrial Parks*, and the development of low-carbon economy has to be included in the construction of parks during the construction and development of national pilot eco-industrial parks since the start of 2010. It requires that the principles of circular economy, low carbon economic concept and ecological industry should be followed during the declaration, construction and acceptance of national pilot eco-industrial parks, with continuously improved utilization rate of energy and energy structures through industry optimization, technical innovation and management updates on the basis of low energy consumption, low emission and low pollution. Taking into account the characteristics of each park and starting from low-carbon production, products and living, should actively explore effective approaches of carbon emission reduction of the parks and industrial zones through model pilots of national pilot eco-industrial parks.

In August of 2010, National Development and Reform Commission issued *the notice of the development of low carbon and low carbon city pilot*, giving intent to carry out pilots in five provinces of Guangdong, Liaoning, Hubei, Shaanxi and Yunnan, and eight cities of Tianjin, Chongqing, Shenzhen, Xiamen, Hangzhou, Nanchang, Guiyang and Baoding. The model pilot includes: preparation of a development plan of low-carbon model pilot, preparation of policies supporting low-carbon and green development, acceleration of the effort to establish industrial systems characterized by low-carbon emissions, with greenhouse gases emission data and management system and an active advocacy of low-carbon and green living mode and consumption mode.

It is an important channel for development of low-carbon economy in China to save energy and to increase energy efficiency and this also is a significant contribution of China to mitigation of global climate change. Policy recommendations of CCICED fully confirms the significance of energy-saving and improvement of energy efficiency to development of low-carbon economy and suggests that “starting from promotion of energy-saving and improvement of energy efficiency continuously optimize energy structures and develop low-carbon energies and significantly improve production capacities of carbon”. “The 11th Five Year Plan” specified a constraint index that the energy consumption shall be reduced by approximate 20%, if such an objective can be achieved by the end of the year, it means that approximate 0.6 billion tons of coal equivalent are saved and a total of 1.5 billion tons of carbon dioxide are reduced during the past five years. In order to drive energy-saving and improve energy efficiency and to achieve the objective of energy consumption determined during “the 11th Five Year Plan”, The Chinese government issued a series of measures last

year and some of them are mandatory.

The key to the optimization of industry structure and achievement of energy-saving and reduction of emission is to quicken to elimination of backward production capacities. In 2010, State Department successively issued some documents, including *Notice of the State Council on Further Strengthening the Elimination of Backward Production Capacities* issued in February and *Circular of the State Council of the People's Republic of China on Further Strengthening the Efforts to Meet the Purpose of "the 11th Five Year Planning" Energy Saving and Emission Reduction* issued in May. The State Council requires the closing down of a total of 10 000 000 kW small thermal power generating units, plus the elimination of 25 000 000 tons of backward iron-making production capacities, 6 000 000 tons of steel-making production capacities, 50 000 000 tons of cements, 330 000 tons of electrolytic aluminium, 6 000 000 loaded containers of sheet glass and 530 000 tons of paper. All provincial governments should delegate the task to cities, counties and related enterprises and declare a list of enterprises eliminating backward production capacities. Thus, our country also should strengthen verification on backward production capacities and strictly control investment projects arranged by our country, and execute the "Regional Restricted Approval System". As to those not accomplishing elimination of backward production capacities within a limited period, it will be necessary to legally withdraw pollutant discharge permits, production permits and safety production permits. The investment management department shall not approve and verify new projects; while Land Resources Management Branches shall not approve newly-added lands and relevant departments shall legally close down power and water supplies to those with backward production capacities.

As to specific industries, the State Council issued *Opinions on Further Strengthening Energy-saving and Emission Reduction & Quickening Adjustment of Iron and Steel Industry Structure Adjustment* in June of 2010, indicating that the iron and steel industry has the most potential for energy-saving and emission reduction and plays a key role in the energy-saving and emission reduction area. Except those projects approved by our country for carrying out preliminary works, no iron and steel projects that will increase production capacities will be approved and kept in files prior to the end of 2011.

Additionally, in order to further strengthen energy-saving and emission reduction of all industries, all departments and commissions also issued a series of regulations within their respective functions. SASAC issued *Interim Supervision and Management Measures for the Energy-saving and Emission Reduction of Central Enterprises* to urge central enterprises to assume their social responsibilities; the Ministry of Industry and Information Technology issued *Guiding Proposals on Strengthening Energy Saving and Emission Reduction in Me-*

dium and Small-sized Enterprises, which requires medium and small scale enterprises to eliminate backward processing equipments. Also, the Ministry of Industry and Information Technology issued a *Notice on Special Supervision on Fulfillment of Energy Consumption Standard Per Unit Product and Elimination of High Energy Consumption and Backward Electromechanical Equipments (Products)*. Nine supervision teams consisting of Ministry of Industry and Information Technology and Standardization Administration of The People's Republic of China, related industry associations and local energy-saving supervisors to supervise fulfillment of energy consumption standard per unit, and elimination of backward electromechanical equipments of all provinces, autonomous regions and municipalities directly under the Central Government. In May of 2010, the General Office of State Electricity Regulatory Commission issued a *Notice of the State Council on Further Strengthening the Energy-saving and Emission Reduction Supervision of Electricity Industry*, which requires actively taking measures to resolve outstanding issues arising from the energy-saving and emission reduction of electricity industry; the General Office of Ministry of Agriculture issued the *Notice on Notice on Further Energy-saving and Emission Reduction of Mechanization of agriculture*, which requires strengthening energy-saving and emission reduction of mechanization of agriculture and making significant contributions to the energy-saving and emission reduction objectives determined during "the 11th Five Year Plan".

In order to promote generalization and application of energy-saving technologies and products and drive the industry development, Chinese government issued a series of economical, technological and management measures, such as financial allowance, management innovation, encouraging and guiding civil investments, etc.. In May of 2010, the State Council issued *Several Opinions of the State Council on Encouraging and Guiding the Healthy Development of Private Investment*, which encourages and guides non-state owned enterprises to develop circular economy, green economy and invest in constructions of potential newly-emerging industries, such as energy-saving and emission reduction projects, water-saving and consumption reduction, new resources, environment protection and overall utilization of resources, etc.. Thus, it requires eliminating and modifying legal policies not beneficial to the development of civil investments, practically protecting legal benefits of civil investments and culture and maintaining investment environments of equal competition; innovating and flexibly using many kinds of financial tools and strengthening financial supports to civil investments. In April of 2010, the General Office of the State Council transmitted *Advice on Speeding up the Implementation of Energy Management Contract to Promote Energy Saving Service Industry Development* issued by National Development and Reform Commission and put forward policies and measures improving and promoting the

development of energy-saving service industry.

One of the opinions of CCICED submitted to Chinese government for establishing practical low-carbon economical policies and systems is to "explore and establish voluntary carbon emission trade system, promote carbon financing and introduction of technologies and drive the development of low-carbon economy through the market systems". According to what officials of the National Development and Reform Commission said at the United Nations Climate Change Conference in Tianjin, China shall soon issue Management Measures of China Greenhouse Gases for Voluntary Emission Reduction Trade Activities (provisional) to encourage and support some capable regions and industries within China to explore carbon emission trade, standardize voluntary emission reduction of carbon trade market, and provide practical market experiences for fulfillment of forceful emission reduction market of China in future. This shall vigorously promotes the execution of domestic carbon emission trade in China and also provide support to China for achieving the objective of carbon emission in 2020.

In order to develop low-carbon economy and optimize energy structure, presently Chinese government is preparing *Planning of Newly Emerging Industry Development* and it is expected that the final draft shall be issued by the end of 2010. As reported, in order to guarantee that the ratio of non-petrochemical energy in primary energy consumption can reach up to 15% in 2020, it is scheduled in *Planning of Newly-emerging Energies Industry* that the accumulated added investments of our country is expected to be up to 5 000 billion *yuan* during the planning period (2011-2020). It is reported such investment includes national investments and the commercial social investments that will be stimulated. However, according to the specific segments, the investments on renewable resources except nuclear power and hydroelectricity, shall reach up to 2 000 billion *yuan* to 3 000 billion *yuan*, where wind power approximately occupies 1 500 billion *yuan* and investment on solar energy can reach up to 200 billion to 300 billion *yuan*. Medium and Long Term Development Planning of National Nuclear Power is also adjusted and the middle and long term objective is 800 billion kW. While the nuclear power is developed, China is increasingly strengthening nuclear safety and regulation. As President Hu Jintao pointed out at the Nuclear Security Summit in April of 2010, nuclear safety is an issue concerning nuclear energy and economic sustainable development, social stability and public safety as well as international peace. It complies with common benefits requirements of all countries to strengthen safety of nuclear power and thus we should work hard together with each other. Perfect nuclear safety laws and supervision systems have been established in China, effective measures are taken to guarantee safety of nuclear power facilities and better records of nuclear safety have been

kept.

In order to guide the energy industries and guarantee achievement of energy-saving and emission reduction, the government also has strengthened institutional capacities, structures, and examination, evaluation and accountability. On January 22, 2010, the State Council decided to establish the State Energy Resources Commission and Premier Wen heads the Commission. The State Energy Resources Commission is responsible for studying and preparing national resource development strategies, reviewing major issues arising from energy security and development and accomplishes overall coordination of domestic energy development and international cooperation on energy. With establishment of this Commission, it effectively improves capacities of our country in development and utilization of new energies and reduction of carbon emission. In order to achieve the objective of energy-saving and emission reduction, The Central Government strengthens examination and accountability system and declared the examination result of provinces and some enterprises. On June 21, 2010, National Development and Reform Commission declared the evaluation and examination results of responsibilities for energy-saving objective of all provinces, autonomous regions and municipalities directly under the Central Government in 2009, where Guizhou Province and Xinjiang did not accomplish the objective. On June 25, 2010, the National Development and Reform Commission declared the assessment and evaluation results of energy saving target responsibilities of 901 enterprises, where total 28 enterprises cannot accomplish the annual energy-saving objective. As for those enterprises not accomplishing the objective, they are required: 1, to put forward measures for rectification and improvement within one month after the results are declared, report such measures to local provincial level energy-saving authority and accomplish rectification and improvement within the specified period; 2, not to apply for measures supporting superiors of “annual awards, award honorary titles and national inspection exempted are not granted”; and 3, to suspend authorizing and examining/approving newly-established high energy consumption investment projects within the same year and the newly-added lands for industries.

2.3 Reforming and perfecting the economic policies, and improving the energy efficiency and the environmental management level

The leaders of the Chinese Government have expressed on many occasions the need to promote environmental protection by means combining law, administration and economic mechanisms. Along with the perfection of rule of law and market economy, more and more attention has been paid to the economic means. In the policy proposals of CCICED in 2009, there is a special policy proposal for “reforming and perfecting the economic policies, and improving the energy efficiency and the environmental management level”, and the relevant

suggestions are raised respectively for reform on price of energy resources, implementation of environmental tax, enhancement of green credit policy and perfection of liability insurance for environmental pollution. In 2010, the comprehensive economic administration authority, and the financial policy and regulatory authority of China have successively promulgated intensively a series of policies to actively promote the implementation of green economic policy, and some measures in the policy proposal have been implemented to different degrees. Many measures still remain at the level of policy directives; however, many policies and measures have already been fulfilled and implemented, such as the system of stepped prices of water and electricity and the support through green credit to projects of energy conservation and emission reduction, and the limitations placed on projects of "high pollution, high consumption, and high emission and resource dependence". Excessive production capacity elimination efforts have already been initiated; the pilot program is being considered for environmental tax; and the pilot program of system of environmental liability insurance is being introduced smoothly.

The Opinions on Key Work of Deepening Reform of Economic System in 2010 requires deepening the reform of prices of resource products, of electric charge, water tariffs, and oil products, and reform of the charge system for environmental protection. They specifically include: adjusting the classification and structure of electric sale prices, simplify the classification and structure of electric charges, promote the system of stepped prices of electric consumption of residents, and perfect the mechanism of pricing of power generation by renewable resources and cost sharing. Gradually smoothen out the price relationship between natural gas and renewable resources. Continue to consummate the pricing mechanism of oil products. Steadily promote the reform on water tariffs, implement the system of raising the price for water consumption of residents where it is feasible to do so, and promote comprehensive reform of agricultural water saving and agricultural water prices. Comprehensively promote the system of charges on urban sewage, garbage and medical wastes, make research on establishing the system of deposit for treatment of dangerous wastes, formulate and issue the guidelines for pilot efforts concerning waste discharge transactions and expand the scope of pilots, and bring to full fruition the system of use and management of imposition of waste discharge charges.

The *Opinions on Key Work of Deepening Reform of Economic System in 2010* also raises requirements in regard to the reform of environment and resource taxes, and requires issuing a plan for reform of resource taxes, gradually promote the reform on house property taxes, perfect the system of excise tax, and make further studies on the scheme of imposing environmental taxes. Currently, under the joint efforts of the Ministry of Environmental

Protection, the Ministry of Finance and the State Administration of Taxation, the scheme of collection of environmental tax is already completed and reported to the State Council, and the provinces of Hubei, Hunan, Jiangxi and Gansu have applied to the State Council to be the pilot spots for collecting environmental tax. Actually, a substantive stride has been made in resource tax reform with a pilot project launched in Xinjiang since July 1st, 2010. Covering the two major resources, oil and natural gas, on which *advalorem* duties are levied with a rate of 5%.

The preferential policies of electric charge and taxation are cancelled for the enterprise with high consumption of energy. In May 2010, the National Development & Reform Commission, the State Electricity Regulatory Commission and the State Energy Bureau jointly issued the "*Notice in Regard to Issues of Sorting out Preferential Electric Charge on Enterprises of High Energy Consumption, etc*.", and decided to cancel the measure of preferential electric charge for the enterprises of high energy consumption. Hereby, the state completely cancels the measure of preferential electric charge implemented locally in 22 provinces and municipalities where the preferential electric charge was implemented for the enterprises with high energy consumption, and all enterprises with high energy consumption started to implement the new policy of differential electric charge. According to the statistics, the preferential price cancelled this time amounts in total to more than 1.5 billion *yuan*. For partial products of high pollution and high energy consumption, the Ministry of Finance and the State Administration of Taxation issued the "*Notice on Canceling Export Rebates for Partial Commodities*" that regulates that, from July 15, 2010, China will cancel the export rebates to partial commodities of 406 tariff numbers of steel and non-ferrous metal processing.

The green credit policy is further enhanced, and the role of financial institutions in energy conservation and environmental protection is further highlighted. The green credit guides the behavior of investors and enterprises by limiting the flow of funds towards the industries of high pollution and high energy consumption and the industries with excessive production capacity, and enhancing the money support to the emerging industries and key industries. On December 22, 2009, the People's Bank of China, the Bank Regulatory Commission, the Securities Regulatory Commission, and the Insurance Regulatory Commission issued the "*Guideline for Further Fulfilling Financial Service and Support to Adjustment and Revitalization of Key Industries and Restraining Excess of Production Capacity of Partial Industries*" that requires the financial regulatory organs to strengthen the communication, coordination and linked action, enhance the pre-warning and monitoring of credit structure and credit risks in the governing areas, and for the projects without approval or ratification according to the procedure, the financial institutions in banking industry should not provide

the credit support of any form. At the same time, the approval procedure for bond issuance and financing from capital market should be tightened. The guideline also expressly holds that it should implement the "green credit", actively support the technical renovation and the elimination of backward production capacity by enterprises, further increase the financial support to the projects of energy conservation and ecological and environmental protection, and support the development of low-carbon economy. Encourage the financial institutions in banking industry to develop diversified low-carbon financial innovation products, and enhance the support to the enterprises and projects that comply with the state requirements on energy conservation and emission reduction and environmental protection. Explore the establishment and consummation of identification system of environmental protection classification of clients, support the development of cyclic economy, and set tighter limitation on the financial support to enterprises and projects of high energy consumption, high pollution and resource dependence. In April and May of 2010, the "*Notice on Opinion in Regard to Supporting Development of Circular Economy and Policies and Measures for Investment and Financing*" and the "*Opinion on Further Fulfilling Financing Service in Supporting Energy Conservation and Emission Reduction and Elimination of Backward Production Capacity*" are issued by the relative authorities, and they respectively require the financial institutions to enhance the support of investment and financing policies to the development of cyclic economy, promote the formation of larger scale of circular economy, further enhance and improve the credit management, and set tighter control on the credit for supporting energy conservation and emission reduction and elimination of backward production capacity.

The environmental liability insurance is further steadily promoted. The Ministry of Environmental Protection and the China Insurance Regulatory Commission have strengthened the building of capacity of environmental liability insurance by the form of holding the training classes of liability insurance for environmental pollution. On June 5, 2010, 66 enterprises with high risks in Suzhou in the industries of chemistry and dyeing signed the contract of liability insurance of environmental pollution with Pacific Property Insurance, PICC Property & Casualty, Samsung Property & Casualty and China Continent Property & Casualty, the insured amount is 132 million *yuan*, and it is the largest project of liability insurance of environmental protection currently in the country.

2.4 Solving problems of energy and environment prominent in urban development

For the problems of energy and environment in the development of urbanization, the CCICED makes multiple suggestions from the angles of exploring the new urbanization route, modes of urban life and consumption, energy conservation of urban buildings, and

planning of traffic development. In the past year, some problems in the course of urbanization of China became more prominent. The problems of excessively quick rise of house prices, great increase of quantity of urban automobiles and traffic jams, and the elevation of energy consumption caused because of these factors afflict many big cities. The central and local governments have successively adopted a series of measures in response, and these measures, to a large extent, are consistent with the 2009 policy proposals of CCICED.

In February 2010, the All-China Women's Federation, the Civilization Building Office of Central Government and the National Development & Reform Commission jointly initiated the "Deepening Residential Community Action of Energy Conservation and Emission Reduction, and Carrying out Theme Activity of 'Low-carbon Household – Fashionable Life'" to carry out; a series of low-carbon activities among massive women and households, propagate and popularize the low-carbon knowledge, promote the broad households to adopt the low-carbon living style featuring in low energy, low consumption, low expenditure and low cost, and forming the life concept and consumption mode of saving energy resources and protecting ecology and environment.

In the construction field, the Ministry of Housing and Urban-Rural Development actively promotes the energy conservation and emission reduction of public buildings, establishes the target of cutting down 5% of energy consumption indicators of public institutions in 2010 on the basis of 2009, and requires that in towns throughout the whole country, the proportion of new buildings that implement the compulsory standard of energy conservation is over 95%; fulfill 50 million square meters in renovation of heating metering and energy saving for the existing residential buildings in the northern region with heating provision in 2010, and fulfill the renovation work of 150 million square meters in the period of "Eleventh Five Year Plan". For promoting energy conservation, the Ministry of Housing and Urban-Rural Development also requires that it should actively promote and use the contracted energy management mode to implement the operation and renovation of energy conservation.

Chongqing, Inner Mongolia and Jiangsu should fulfill the pilot work of building of provincial dynamic energy consumption monitoring platform, and the regions with condition should make research on establishing the standard of limits of energy consumption of public buildings. In February 2010, the "Opinion on Further Promoting Renovation of Heating Metering" required to enhance the urban heating management, improve the mechanism of heating metering monitoring of the new buildings, further expand the energy-saving management of heating system, support the energy-saving renovation of heating pipelines and heat sources to reduce the energy consumption, and implement the metering management of

heating system. In August 2010, the "Standard of Efficiency of Residential Heating Boilers (Exposure Draft)" was published, and it sets the different requirements on efficiency of coal boilers, and gas or oil boilers.

In face of the increasing rise of housing price, the central government and the local policies have adopted a series of measures, but the trend of rise still cannot be checked. Therefore, in September 2010, the state issued a series of most rigorous policies since the regulation and control of real estate in order to check the irrational housing demand and opportunistic practice, including: Set limits on the number of houses purchased by a residential family; strictly implement the system of accountability, and require an interview with those who fail to implement the policy fully or are ineffectual in work, investigate the responsibility; consummate a policy of differential housing credit, and require the commercial banks suspend the loan to residential families for purchasing the third set or above of houses; adjust the preferential policy related to contract tax and personal income tax, strengthen the supervision and examination of collection of land VAT, and emphatically make calculations and check on land VAT of real estate development projects with price obviously higher than the price level of surrounding houses; accelerate the pilot work of reform on housing property tax, and expand it gradually to the whole country; increase the effective supply of houses, particularly the construction of common commercial houses of medium and small dwelling sizes and low-income houses; and investigate and punish the acts of speculation and drive up of price.

It can be seen that these real estate policies in the policy proposal are related to the urban construction and resources and environment, and are highly in accord with the policy proposals of CCICED such as "Set limit on per capita building occupancy in the city", and "Implement the property tax as quickly as possible to reduce the irrational market demand for buildings through market mechanism", etc..

In the traffic field, for promoting the generalization of energy-saving and new-energy automobiles, the relative governmental departments also issued a series of policies. In May 2010, the Ministry of Finance, the National Development and Reform Commission, and the Ministry of Industry and Information Technology issued the "Implementing Regulations of Generalization of Energy-saving Automobiles (Passenger Cars of 1.6L or Below) of 'Project of Benefiting People by Energy-saving Products'" to provide a one-time fixed subsidy to purchase of energy-saving automobiles by consumers, the subsidization standard is 3 000 *yuan*/vehicle, and it is cashed to buyers by the producers in sale. On May 31, 2010, the Ministry of Finance, the Ministry of Science and technology, the Ministry of Industry and Information Technology, and the National Development and Reform Commission issued the "No-

tice on Carrying out Pilot Program of Subsidization to Personal Purchase of New-energy Automobiles" to provide subsidy as per 3 000 *yuan*/kWh to new-energy automobiles that meet the supporting conditions, the highest subsidy to plug-in hybrid passenger cars is 50 000 *yuan*/ vehicle, and the highest subsidy to pure electric passenger vehicles is 60 000 *yuan*/ vehicle.

In addition, the State has further expanded energy conservation in the field of public service and the demonstration and generalization of new-energy automobiles, and on the basis of existing 13 pilot cities, increased the number of such cities by 7, with Tianjin, Haikou, Zhengzhou, Xiamen, Suzhou Tangshan and Guangzhou as the pilot cities. In accordance with the "Science and Technology of Clean Energy in Development of China in 2010" issued by the Ministry of Science and Technology in October, by the end of 2010, China will generalize the use of 20 000 new-energy vehicles in the field of public traffic. By 2015, the quantity of new-energy automobiles in China will be over one million vehicles, and by 2020, the market scale of new-energy automobiles will be up to the level of ten million vehicles.

2.5 Preparation of green "Twelfth Five Year" Plan

Currently, China is formulating the "Twelfth Five Year" Development Plan, and will formally approve and implement it in March 2011. In a timely way, the "Policy Proposals" of CCICED of 2009 proactively point out that: "The formulation of 'Twelfth Five Year' Plan should give prominence to the enhancement of China's capacity in sustainable development, and take the green economy including low-carbon economy as the important element of the plan. Vigorously promote the conversion of economy towards 'green' approaches, and put environmental protection and elevation of energy efficiency on a more prominent strategic position so as to lay a solid foundation for China to accelerate the change of development mode, take the route of a new type of industrialization and urbanization, adapt the rural areas to climate change and protect the ecological system to be adapted to the new cycle of adjustment of economic structure in the world featuring in the green economy."

The intermediate evaluation of fulfillment of "Eleventh Five Year" Plan has been basically completed. The result demonstrates that the implementation of "Eleventh Five Year" Plan for environmental protection meets the schedule for the first time, some indicators have been realized above the quota, the main plan target is expected to be fulfilled according to the schedule, and it is the Five Year Plan for environmental protection implemented best in the history of our country. China will formulate the "Twelfth Five Year" Plan on the basis of comprehensively summarizing the "Eleventh Five Year" experience. According to the report, on the basis of emission reduction experience in the "Eleventh Five Year" period, the "Twelfth Five Year" Plan may increase the pollutant factors that implement the total volume

control, and expand main pollutants from two items to four items, i.e., chemical oxygen demand, ammonia nitrogen, sulfur dioxide and nitric oxide. In decomposition of the task of emission reduction, the target of emission reduction will still be decomposed to various local governments and enterprises, and will continue to follow the stricter target examination. And in the future, it will not only examine the fulfillment of figures, but also will examine the improvement of environmental quality.

Although the "Twelfth Five Year" Plan has not officially come out, According to the disclosure of Hu Angang, Professor of School of Public Administration of Tsinghua University and Director of Center for China Study of Tsinghua University, who has participated in preparation of this plan draft: "The 'Twelfth Five Year' Plan will be officially implemented in next March, the green plan indicators take up 51% of 47 major indicators of this plan, this plan will become the first green development plan in China, become the historical starting point of green modernization of China, and China will turn from the largest 'black cat' in the world into the largest 'green cat' in the world".

2.6 Enhancing rural energy and environment management, and promoting rural environmental protection

The No. 1 Document of Central CPC Committee in 2010 "Some Opinions of Central CPC Committee and the State Council in Regard to Enhancing Combined Planning of Urban and Rural Areas to Further Solidify Foundation of Agricultural and Rural Development" sets focus once again on the issue of rural areas and agriculture, reflecting the attention of the Central Committee to this issue. The document points out some new requirements and work direction for rural energy and environmental protection, including "Support the rural areas to develop and utilize the new energies, and promote the recycling and clean utilization of agricultural and forest wastes", "Construct safe, energy-saving and environmental-friendly housing", "Implement the policy of promoting management by awards to steadily promote the comprehensive management of rural environment", and "Carry out the pilot program of rural drainage and river dredging, realize treatment of garbage and wastewater, and improve the living environment in rural areas", etc.. In these ways the environmental protection authority and the agricultural authority have formulated corresponding policies of environmental protection and energy for rural areas.

According to the requirement of the Ministry of Environmental Protection, 2010 will further materialize the policy and measure of "promoting management by awards", and enhance the investment in environmental protection in rural areas. For the regions with concentrated environmental problems, implement the comprehensive management of linked areas, and construct the facilities of concentrated pollution control; for the villages with dis-

persed dwelling, poor economic condition, or in the remote regions, generalize the wastewater treatment mode of distributed type, low cost and easy management; encourage the service of rural sewage and garbage treatment facilities to extend to cover the surrounding villages and towns in order to realize the sharing and joint use of infrastructure by urban and rural areas. Carry out the pilot program of reduction on discharge of sewage of rural market towns and pollutants of livestock and poultry husbandry up to scale. Establish and consummate the accountability system for comprehensive management target of rural environment.

The Ministry of Agriculture requires to "truly strengthen the ecological and environmental protection in rural areas, and promote the sustainable development of agriculture", and this includes:

First, accelerate the development of clean energies in rural areas: Increase the construction of marsh gas (methane) projects in rural areas, and speed up and promote the construction of marsh gas projects in breeding zones and up-to-scale breeding farms. Increase the construction of marsh gas service system, enhance the technical innovation of marsh gas, maintenance management and supporting service, organize training related to marsh gas, and elevate the service level of marsh gas management and protection and the rate of marsh gas utilization. Accelerate the promotion of comprehensive utilization of crop straws, and accelerate the transformation of fertilizer, feedstock and new energy of crop straws. Moderately develop the non-crop energy plants, and take the route of development of agricultural biomass energy industry with Chinese features. Increase the development and utilization of renewable energies, such as solar energy, in rural areas.

Second, promote the agricultural and rural energy conservation and emission reduction: Take the conservation of fertilizer, pesticide, water and energy as the breakthrough, accelerate the popularization of technologies of agricultural and rural energy conservation and emission reduction, and improve the utilization efficiency of resources. Mightily popularize the technologies that save cost and increase efficiency such as scientific fertilization and scientific use of pesticides, etc., improve the utilization ratio of products used, and reduce the agricultural production cost. Vigorously develop the technology and equipment of agricultural machines and fishing machines that save fuel, electricity and coal, upgrade and eliminate the agricultural machines and fishing boats of high energy consumption, and accelerate the technical renovation for energy conservation and emission reduction of township enterprises. Continue to implement the projects of rural cleanness and the management of village environment. Carry out the demonstration of comprehensive control technology for agricultural surface pollutions in the key regions of "three rivers and three lakes", region of Three Gorges reservoir, and along the line of south water to north. Implement the monitoring

on environment of production areas of agricultural products, and strengthen the safety management at production areas of agricultural areas.

It is obvious that in the past year, some policies in regard to rural and agricultural environmental protection and energy development as well as the low-carbon agriculture (Refer to the part of "Developing green economy, and promoting green transformation of mode of economic development") issued by the Chinese Government echo the policy proposals of CCICED in regard to developing the renewable energies in rural areas, and enhancing the rural environmental protection. CCICED particularly points out in the policy proposals, "In response to the climate change, pay attention to the protection of biological diversity, and save the information of biological diversity of domestic and foreign gene banks", and this year is the year of biological diversity of UN, and the Chinese Government therefore published the "Chinese Strategy and Action Plan for Protection of Biological Diversity (2011-2030)", which lists the agricultural biological diversity and improvement of ability in response to climate change and protection of biological diversity as the fields of priority, and advances the relative action plan, such as "Establish the action plan for protection of biological diversity and response to climate change", "Evaluate the influence of biofuel production on biological diversity", and "Change the local production and nature-loving mode through popularizing the applied technologies of household marsh gas, ecological agriculture, ecological tourism, rotation of pastures, building of artificially sown pastures, drylot feeding, and confinement feeding, etc., and implement the demonstrating project of livelihood substitution in the northwest ecologically vulnerable regions".

CCICED advised that "The voluntary carbon transaction mechanism of the state and the provision of subsidy for reduction of pollutants and emission of greenhouse gas by poverty farmers are effective methods for promoting the low-carbon agriculture, and will also help the realization of target of eliminating poverty". Although the relevant policies and measures have not been issued currently at the State level, some local governments, such as Xinjiang and Sichuan, have already cooperated with the international organizations to carry out the pilot work, and have made prominent achievements.

2.7 Environmental Governance Progress: legislation, judicial administration and public participation of environment and development in China

CCICED always attaches importance to the improvement of environmental governance in China, and its policy proposals in the past years have included policy proposals related to enhancing the level of legislation, judicial administration and public participation. The improvement of management structure is of important significance in forming the scientific policy for environment and development to timely respond to the new problems of environ-

ment and development, and to assure the basis for comprehensive fulfillment and implementation of the policies. In the past year, the great progress either in legislation, judicial administration or public participation, and the management structure and ability of China for environment and development were further improved and elevated.

(1) Legislation for resources, energy and environment From November 2009 to September 2010, only the environmental protection authority has completed the formulation and amendment of 61 national environmental standards, and current national environmental standards are up to 1 200. The law system of China for environment and resources has been further improved.

From November 2009 to present, the Standing Committee of the National People's Congress has constituted the "Law on Island Protection", the "Law on Petroleum and Natural Gas Pipelines", the "Law on Torts" (The "Responsibilities of environmental torts" are regulated in the special chapter), and amended the "Law on Renewable Energies". In accordance with the "Plan of Standing Committee of the National People's Congress of Legislation Work in 2010", the environmental laws currently under the review include the "Law on Soil and Water Conservation" (Amendment), the "Law on Natural Preservation Areas", the "Law on Forest" (Amendment) and the "Law on Land Administration", and the laws ready for review include the "Law on Air pollution Prevention" (Amendment) and the "Law on Energy".

The State Council has formulated the "Statute of Safety Administration of Transport of Radioactive Products", the "Statute of Administration on Substances Consuming Ozone Layer", and the "Statute of Protection of Fossils".

The authorities of environmental protection department, etc.. have formulated and amended the "New Method for Environmental Administration of Chemical Substances", the "Method for Environmental Administrative Punishments", the "Method for Environmental Safety Administration on Import and Export of Microbial Agents for Application to Environmental Protection", the "Method for Filing Administration of Local Environmental Quality Standards and Pollutants Discharge Standards", the Method for Safety License Administration of Transport of Radioactive Products" and the "Provisional Method for Administration of Emergency Plan for Contingent Environmental Incidents".

The Development and Reform Commission has formulated the "Provisional Method for Evaluation and Examination of Energy Conservation of Projects of Fixed Assets Investment" and established the "energy conservation evaluation" system similar to the "environmental impact evaluation"; the State-owned Assets Supervision and Administration Commission has formulated the "Provisional Method for Supervision and Administration of

Energy Conservation and Emission Reduction of Central Enterprises".

For enhancing the energy administration, regulating the development and utilization of traditional energies and being adapted to the development of new energies, the energy resources authority has initiated a series procedures for law amendment and new lawmaking, including the amendment on the "Law on Coal", and the formulation of the "Statute of Administration of Nuclear Power" and the "Statute of Administration of Hydroelectric Development".

(2) Judicial administration promoting environmental protection On December 9, 2009, the Supreme People's Court promulgated the "Notice on Seriously Fulfilling the Spirit of Meeting of Economic Work of the Central Committee and Providing Strong Judicial Guarantee for Realizing the Economic Development Target in the Next Year" to point out that it should properly judge and enforce cases related to energy conservation, enterprise bankruptcy, and restructuring and system reform occurred in the aspects of strengthening macro-control and adjusting the economic structure, etc., and provide the good judicial service for winning the full victory in response to the impact of international financial crisis, and maintaining the smooth and quicker development of economy. At the beginning of 2010, the "Some Opinions in Regard to Fulfilling Criminal Policy of Severity Tempered with Mercy" of the Supreme People's Court pointed out that in a period at present and in the future, it should deal according to law severely with various serious crimes against environment and resources, such as serious environmental pollution, illegal mining, and unlawful felling of trees, to maintain the economic order of the country, and protect the life, health and safety of broad masses.

On June 29, 2010, the Supreme People's Court issued the "Some Opinions in Regard to Providing Judicial Guarantee and Service for Accelerating Change of Economic Development Mode". It points out "It should accept the cases concerning disputes of environmental pollution, damage and compensation filed by the environmental protection administrative departments on behalf of the state, and severely cracks down all acts against environment", and this means to open a door for public interest litigation related to environment. In addition, the Supreme People's Court also expresses that the court that has more cases of disputes of environmental protection can establish the court of environmental protection to implement the professional judgment on environmental protection cases, and can elevate the level of judicial administration for environmental protection.

(3) Information disclosure and public participation Under the active efforts of different sectors, since 2010, China has made some new progress in the respect of environmental information disclosure and public participation.

The degree of information disclosure by the Chinese Government is increased: On January 20, 2010, the General Office of the State Council issued the "Opinion on Realizing Disclosure of Governmental Information through Application". In the process of accepting the application for disclosing the governmental information, for the governmental information that need or can be widely known by the public, while giving the answer to the applicant, the administrative organ should take the initiative to make disclosure on the government website, and avoid as much as possible that the public governmental information is only disclosed to individual applicant so as to reduce the repeated application for the same governmental information, save the administrative cost, and improve the work efficiency.

Besides the government should in a timely fashion release the relevant information as the information disclosure entity. The relevant regulation came out this year to set new requirements on the disclosure of environmental information by the enterprises causing pollutant discharges. In July 2010, there was the incident of polluting Dingjiang River of Fujian by the listed company Zijin Mining Group, and it caused serious economic loss. The Shanghang County Government of Fujian disclosed the accident information as late as 9 days after the pollution incident happened, and this caused strong criticism from the media.

For guaranteeing the right of the public to be informed, on September 14, 2010, the Ministry of Environmental Protection issued the "Guideline of Environmental Information Disclosure by Listed Companies (Exposure Draft)" to require that the listed companies in such 16 industries of heavy pollution as thermal power, steel, cement, and electrolytic aluminum, etc.. should publish an annual environmental report, and regularly disclose the environmental information related to discharge of pollutants, abidance by environmental law, and environmental management, etc.. The listed company having a contingent environmental incident should issue the interim environmental report within one day after the incident to disclose the time, location, and major polluting substances and quantity of environmental incident, the environmental impact and casualty (if any) of the incident, and the emergency treatment measures adopted, etc..

In addition, the Ministry of Environmental Protection issued the "Notice on Further Regulating System of Regular Publication of List of Production Enterprises Noncompliant with Environmental Protection" to promote the disclosure of information on regulatory violations by enterprises, and require the environmental protection departments of different levels to take the initiative to disclose the list of production enterprises noncompliant with environmental protection in case of discovering such environmental unlawful acts as non-compliance with standard and pollutants discharge over the total volume during the daily supervision and examination of pollutant discharging enterprises in their administrative

regions. The environmental protection departments of different levels can also disclose according to the need of work the relative information by the forms that are convenient for the public to know such as newspaper, broadcast, television and news release meeting, etc..

In the field of public interest litigation, the local legislation has made the new breakthrough. The “Ordinance of Guiyang City for Promoting Building of Ecological Civilization” adopted on January 8, 2010 regulates that for the environmental public interests, the procuratorial organs, authorities of environment and resource administration, environmental public service organizations, and supervisors of ecological environment and planned construction can file a civil lawsuit against acts of environmental pollution and destroying resources according to laws that require the violator to assume the responsibility for stopping the infringement, removing the obstacle, eliminating the risk, restoring the original state, and eliminating the ill effect, etc.. The complainant can file an administrative lawsuit according to law against the specific administrative act and administrative nonfeasance in relation to environment and resources, and require the relative administrative organ to perform the administrative duty favorable to protecting environment and preventing pollution. This ordinance symbolizes that the lawsuits of environmental public interests have a specified code to follow at least in Guiyang City. This ordinance is the first local code with stipulation of lawsuits of environmental public interests in China.

The disclosure of some important information to the public in accordance with the relative system of disclosure of governmental information is of important significance in protecting the right of the public to know the environmental information and increasing the depth of public participation. In 2010, the information important or good for participation of the public in environmental supervision disclosed by the governmental departments mainly includes: (a) “Bulletin of First Census of National Pollution Sources”: It shows clearly for the first time the pollution state of industrial sources, agricultural sources, family sources and concentrated pollution management facilities, and provides the scientific basis for the formulation of “the Twelfth Five Year” Plan in relation to environmental protection of our country. (b) On May 14, 2010, the General Office of Ministry of Environmental Protection issued the “Notice on Fulfilling Commitment to Environmental Check and Rectification for Listing within Time Limit”, and published the list of listed companies that failed to complete rectification on time and have the new environmental problems. (c) For further clarifying the environmental key monitoring targets and truly fulfilling the such environmental supervision and administration as online monitoring of the enterprises under the focal supervision of the state, the General Office of Ministry of Environmental Protection published the “List of Enterprises under Focal Supervision by the State in 2010”. (d) In March 2010, the Ministry of

Environmental Protection issued the "Bulletin about State of Environmental Quality of Major River Basins and Key Cities of Environmental Protection in 2009" to disclose in detail the state of water environmental quality of major river basins in 2009 and the state of ambient air quality of key cities in 2009.

3 Closing Remarks

2009 is the most difficult year for Chinese economy and 2010, although its developmental situation is better than last year, the economy is still in a rather complicated situation. From an international view, the world economy takes on signs of recovery, but the foundation is still fragile as the financial risks have not yet eliminated. In China's domestic situation, the foundation for economic turnaround has been further consolidated and the market confidence is increasing as well. However, there are outstanding contradictions and problems existing in the economic and social development as the economic growth lack internal promotion, self-innovation ability is still weak and there are obvious contradictions of overcapacity in some industries, which leads to increasing difficulty in the industrial restructure. Such problems impose pressure not only on the Chinese economy but also on energy conservation and environmental protection efforts in China.

The GDP per unit in the first half of 2010 rose by 0.09% compared year on year and sounded an alarm for the energy conservation and emission reduction this year. Exactly as judged by the central government, the energy conservation and emission reduction is a fort-assaulting and lasting war and therefore shall be never treated lightly at any time. Additionally, a series of unexpected environmental events and accumulative pollution events also calls on the realization of Chinese government and Chinese people that China has entered a high-incident period of environmental pollution and it's urgent for the government to take more rigorous and effective means to deal with. Chinese government is taking an iron fist to achieve the goals of energy conservation and sustainable development. Despite numerous difficulties, and based on the experience of reform and opening up, any goal, as long as the Chinese government makes decision to achieve it, almost always can be achieved. And thus it's not beyond our expectation to fully complete and even to surpass the goals of energy conservation and emission reduction as well as to achieve a green turnaround of industrial structure for sustainable development under "the 11th Five Year Plan".

Looking back on the Chinese government policy for environment and development, we shall specially pay attention to signs of development of some important policies:

(1) To promote industrial turnaround through environmental protection will be a long-term policy. Since the "11th Five Year Plan", we can clearly see that under the unified

deployment of the CPC central committee and the state council, more and more sectors have applied the authority within the scope of its functions in elimination of backward productivity and guidance of green economy. The “green turnaround” is not only the matter of the environmental department but also the common view and actions that all the governmental departments shall take. Governmental departments, whether legislative, executive or judicial organs, are make their decisions and policies toward or under “green transformation”. The Chinese government has solemnly promised the world its goal of emission reduction by 2020. It can be expected that at least for the next 10 years, the Chinese government will stick to the current policies, forcing the industrial structure into green turnaround by virtue of environmental protection indicators. And after 10 years, China may have finished the green turnaround and entered the new historical period of virtuously-circled economical and environmental development.

(2) The voice and environmental administration ability of the environmental department is on rise. On one hand, under the pressure of current environmental situation and international community, the government and the public have attached great importance to environmental protection. And the work of environmental department has been offered with robust support from the government and the public. On the other hand, the environmental departments at all levels from the central to the local take fully initiatives to use favorable external conditions and put efforts into enhancement of law enforcement capabilities and institutional innovation, which further win widespread praise and support. It can be predicted that with improvement of planning and environmental evaluation systems, increasing roles of environmental protection in the macro control and enforcement of environmental laws, the voice and environmental administration ability of the environmental department will continue to be improved in the future.

(3) The status of market-based instruments continues to go up in China’s environmental management and administration approach. The government has realized that environmental administration through market-based instruments may be more effective and at less cost than through direct executive means using command and control management. In the past year the green credit and environmental pollution liability insurance has been further developed and the elimination of backward production capacity and guidance of green economy through taxation and price levers are being carried out, and the environmental tax is also to start pilot initiatives. The economic policies such as finance and tax leverage have directly to deal with production and operation of enterprises and, if applied properly, they can maximize the control effect. As the market economy is gradually improved, the status of economic policies will have a higher profile within environmental administration.

(4) Disclosure of information and awareness and ability of public participation is on the rise. In the long run, disclosure and public participation is the right fundamental motivation to improve the environmental management performance. With the gradual improvement of economic living standards and strengthening of law conception, and the passion of the public participation in environmental affairs is soaring, so obvious mistakes existing in the environmental decision-making may easily lead to strong public opposition. This situation will encourage the decision-making sectors to start the public participation procedure as early as possible and so as to make the decision-making more democratic and more scientific. Since disclosure of information plays an important role in guarantee of the pubic right to know, supervising the government and sewage disposal enterprises as well as enhancing effectiveness of public participation. In the past few years disclosure of information and public participation in the environmental field has stepped into the forefront in China. And the environmental department has set down a series of rules to ensure disclosure of information and public participation, which will become an inexhaustible drive to promote environmental protection in China.

(5) China begins to involve more and more environmental obligations as a big country. As indicated by Prime Minister Wen Jiabao at the Copenhagen Conference, the Chinese government sets the goal to reduce greenhouse gas, which is a voluntary action according to the situation of China. It comes from the responsibility for Chinese people and the human species worldwide, without any additional conditions and not linked to any country's emission reduction goals. We'll keep the promise and act resolutely. As one of the biggest energy-consuming and carbon dioxide-emission country, China's influence on the global environment is crucial. As a responsible big country, China voluntarily undertakes the obligation to reduce emission, which is not only to perform the international obligation, but also the way for us to achieve sustainable development.

In the past year, many policies and suggestions of the China Council for International Cooperation on Environment and Development (CCICED) have been embodied in the Chinese government's polices under enforcement. It can be seen that the CCICED has more and more profound insight and understanding of China's policies on environment and development. The CCICED should not only focus on the long-term trend of China's environment and development, but also consider the latest policy progress made in China and the new problems the government faces. The Government of China has to think over the significance of China's environment and development progress from the view of the environmental protection and development as well as from the international and the domestic perspectives. Additionally, the CCICED's ideas and propositions have caused attention of the central lea-

dership and governmental departments.

Part II: Policy Recommendations to the Government of China (November of 2009, Concise Version)

The Third Annual General Meeting of the 4th Phase of the China Council for International Cooperation on Environment and Development (CCICED) is taking place from 11-13 November 2009 in Beijing with the theme of "Energy, Environment and Development". Based on these studies and further inputs at the AGM, seven policy recommendations are presented to the State Council. More detailed information on many of the recommendations is available in the individual Task Force reports.

In the recommendations, the CCICED members warmly recognize the 60th anniversary of the People's Republic of China and strongly encourage China to continue promoting its strategic transformation of environment and development, in order to achieve and sustain green prosperity as the basis of China's future development. CCICED members recognize that now is the key time to design an environment and development strategy for the 12th Five Year Plan. It is a critical testing period for China's sustained energy-saving and emission reduction efforts, and an important time to incorporate green economy including low carbon economy into the national development plan. Otherwise, China will be at risk of losing the achievements gained during the 11th Five Year Plan and of losing new growth opportunities. CCICED also warns China government of a future in which it is necessary to address multiple crises involving the economy, energy, environment and climate change, and possibly other matters.

1 Develop a Green Economy and Speed Up Green Transformation of Economic Development

From the perspectives of scientific development, ecological civilization and strategic consideration for long-term global competitiveness, China should consider green economy as important approaches to promote transformation of its economic development mode, and should develop a national strategy for green economic development as soon as possible. While striving for Low Carbon Economy that will address many energy and environment concerns, China should also take actions in the following areas to promote green economy:

(1) Strengthen the promotion of Circular Economy to increase resource efficiency. Circular Economy practices support green economy development by creating new wealth and resources from waste, via the "Reduce, Reuse and Recycle" principles. China has many successful pilot demonstrations and substantial commercial experiences. Yet most sectors are

far from being eco-efficient in either use of energy or environmental resources when judged by international benchmarks. China should fully enforce its Circular Economy Promotion Law that became effective this year, establish and improve relevant policy and regulations, and strengthen the capacity for broadly promoting circular economy.

(2) Increase R&D investment for advanced green technology, develop green industries and foster new green growth opportunities. China should substantially increase its investment in R&D and industries for renewable energy, clean energy, energy-saving, environmental industries, urban public transport, building energy, ecosystem protection and restoration, environmental infrastructure and waste recycling, and make green growth as a key part of China's industrial and economic development strategies.

(3) Strengthen industrial restructuring to promote eco-reform of traditional industries. China should seize this historic time of economic recovery as an opportunity to incorporate environmental considerations into its transformation of traditional industries and industrial restructuring. This could be done through stringent environmental admission standards and permits to operate, pollution emission standards and management instruments, and by speeding up green transformation of all major industrial sectors. In particular, in its revitalization plans for key industries China should further increase requirements for environmental protection, resource and energy efficiency; accelerate the elimination of environmentally-inefficient production capacity; and strengthen the green transformation of industrial structure.

(4) Develop rural green economy through environmental improvement of mainstream farming methods; introducing ecological and organic farming, low-carbon farming; and by improved management of ecosystem services. In the development of green economy strategy and practice, China should pursue integrated rural and urban green development and avoid deepening rural and urban differences. Green economy development in rural areas should integrate low carbon pursuit into traditional ecological farming and organic farming, strengthen the management of land utilization, ecosystem services and biodiversity conservation, promote rural economic development and create jobs while reducing pollution discharge and greenhouse gas emissions.

(5) Advocate sustainable consumption and low-carbon lifestyle, enhance the role of the public and NGOs in green economic development. Recognizing the significant role of citizens and their consumption patterns in promoting green economy, it is important to raise public awareness for individual consumers and households, commercial enterprises, and industries–through resource-saving, low carbon, and environmental protection messages and action. Messages should emphasize modest levels of individual and household consumption

that take into account embedded energy, high efficiency and low carbon; and certification regarding sustainability, low carbon criteria, and environmentally-sound production for both goods and services. China should promote green procurement by government agencies at all levels, strengthen its legal basis, disclose relevant information, and encourage the role of NGOs in the communication and technical aspects of green consumption, and in green economy development. China should continue its 2008 "Green Olympics" experience. The 2010 Shanghai Expo, with its "Better City Better Life" theme and with more than 70 million visitors expected, offers an unprecedented opportunity to promote a low carbon lifestyle and build low carbon cities.

(6) Strengthen international cooperation and promote green economic development. The development of green economy needs to be built upon fair, equitable, orderly and free global trade practices, taking steps to avoid anti-trade protectionism, and expanding the number and value of environment and climate-friendly technology transfer arrangements. With enhanced overall capacity and increased sustainable development practical experience, China should play an increasingly important role in promoting global green development and in dealing with environmental challenges.

2 Develop Low Carbon Economy with Consideration of Both International and National Contexts

Based on both the international and national contexts, China should develop a national Low Carbon Economic Development Plan as soon as possible including strategic objectives, specific tasks and measures. Low carbon pilot demonstrations should be initiated within key industrial sectors and within selected urban and rural locations. Low Carbon Economy lifestyles and opportunities should be promoted widely to China's citizens.

(1) Identify the strategic objectives of Low Carbon Economy. LCE in China should start with promotion of energy saving and energy efficiency, optimization of energy structure, development of low carbon energy and increase of carbon productivity. According to the overall objective of significant reductions of carbon intensity by 2020 over the 2005 baseline, China should establish a clear quantified target for low carbon economic development and strive for at least an annual 4%-5% reduction of carbon emission per GDP. The national target will need to be disaggregated on the basis of regional and sectoral characteristics.

(2) Develop and implement operational policy mechanisms. (a) implement continued reform of energy pricing; (b) increase investment oriented towards a low carbon economy; (c) consider introduction of a carbon tax when the time is right; (d) study and establish

a voluntary carbon emission trading system to promote low carbon finance, technology transfer, and low carbon economy development through market mechanisms; (e) promote low carbon technology innovation and application within China's industrial base and pay special attention to the training of professionals; (f) incorporate low carbon development into urban and rural planning, and into planning for all major transportation systems including road, rail, air and sea shipping; (g) initiate LCE pilot efforts; and (h) improve the energy statistical system by introducing carbon emission statistics.

(3) Optimize energy structure and develop low carbon energy sources. China should pay close attention to development of strategic objectives for intensive, clean and high-efficient use of coal. Depending on costs of carbon capture and storage, as well as emission reduction, the proportion of coal in total energy consumption can be gradually lowered from the current 70% to 55%, 50% and less than 33% in 2020, 2030, and 2050 respectively. China also should vigorously develop low carbon energy sources, and promote the commercialization of solar photovoltaic power generation, in order to achieve a full-scale, industrialized and commercialized low carbon energy mix by 2020. Since safety is the ultimate condition of nuclear development, China should substantially enhance the capacity building of nuclear power plant safety supervision, thus ensuring safe, consistent and healthy development of nuclear power plants.

(4) Establish an industrial system featuring low carbon emissions. Speed up industrial restructuring and upgrading; increase comprehensive utilization of resources and promote lower energy consumption and emissions; promote application of advanced mature technologies and develop advanced low carbon technology to increase energy efficiency; build up a support system for low carbon technology innovation, and improve the legal framework and other enabling mechanisms.

(5) Analyze the possible impacts on China's trade and economy of a climate change "border adjustment tax" and consider how implementation of low carbon economy initiatives might ease this threat.

3 Implement a National Strategy for Sustainable Use of Coal

While ensuring national energy security and environmental protection, China should develop and implement a strategy for safe, highly-efficient and clean national coal exploitation and utilization in order to provide a long-term, stable energy foundation for green economic development.

(1) Further emphasize the strategic role of coal in the national mid-to long-term energy strategy, and speed up the development of a new national coal strategy focused

on sustainable use of coal.

(2) Improve governance of the Chinese coal value chain. The Chinese government should strengthen responsibilities and mandate of relevant agencies, improve coordination mechanisms to improve sustainability of the Chinese coal industry.

(3) Promote green mining. (a) Concurrent mining and reclamation, particularly in the areas rich in both coal resources and food production; (b) minimization of mined-land subsidence and improvement of management; (c) water resource conservation and aquifer protection; (d) environmentally sound mining waste utilization and treatment; (e) improved risk management and ecosystem protection; and (f) safe mine closure and site restoration. China should broadly implement a payment system for coal mining rights, and fully collect the one-time charge for this right; speed up the reform of coal mine resource tax policy; changing from a specific tax to a compound tax, or move to a totally ad valorem tax levy, and increase the levy limit; establish an ecological compensation system for coal mining, and implement a damage restoration deposit system for environmental management. The "one ballot veto" rule should be strictly applied. The implementation of strategic environmental assessment needs to be strengthened in all coal mining areas.

(4) Develop a sound strategy for coal-fired power generation, with intensive, highly-efficient and clean use of coal. China should control growth rates of coal use to stay within environmentally sound and safe limits, and gradually reduce the proportion of coal in total energy consumption. Efforts should be accelerated for the development and adoption of advanced coal-fired power generation technology (e.g., ultra-supercritical and IGCC) to reduce coal consumption in power generation and to increase conversion efficiency to the highest international standards; promote technology and management for combined power, heat and cooling systems to increase the comprehensive utilization of coal resources in urban areas; optimize generator capacity structure to minimize efficiency loss during operation; promote price linkage of coal and electricity to regulate future power and coal supply/demand at the national level.

(5) Improve and enforce standards associated with processing and use of coal.

(6) In heavily polluting situations, and based on the requirement of total emission control, establish pilot efforts for regional controls on total coal consumption, and strengthen pollution supervision for coal-fired power plants.

(7) Encourage technical innovation and promote technologies related to the sustainable use of coal. Actively promote technologies related to green mining and clean coal technologies. Develop CO_2 capture, utilization and storage (CCUS) technology suitable to China's situation and needs. Strengthen international cooperation for joint development of

technologies and for transfer of technologies; and develop demonstration technology suitable to China's situation of widespread coal availability and use.

4 Take more Innovative Approaches to Address the Key Energy and Environment Issues in Urban Development

China should thoroughly assess its urbanization policies of the past 30 years, and identify an overall strategy for a new road of urbanization based on lower energy growth and carbon emissions, and on overall higher environmental and social quality of life. The new urbanization road should focus on improvements to the key areas of rapid energy consumption increase such as urban buildings and construction, transport and livelihood energy demands, urban consumer behavior and lifestyle, urban climate change awareness, and strengthened policies to facilitate sustainable urban development throughout China.

(1) Revise the current urban energy statistics system and establish a dedicated urban energy consumption statistics system with emphasis on energy consumption, especially the potential of energy saving from daily life activities as the key focus of urban energy saving.

(2) Reduce the scale and rate of urban construction and improve building qualities. In the future, per capita floor space (home, public building and commercial building combined) should not exceed 40 m^2. It is recommended that the governments at various levels should tighten up the approval of new projects and establish strict control of total allowable construction volumes. In addition, it is also recommended that a property tax system should be implemented soon to manage irrational demand within the housing market. It also is important to establish sound demolition and management decrees for existing buildings.

(3) Explore a new road for urbanization by designating low carbon cities. Cities need a more compact mode for urban development. This should be incorporated into urban planning throughout the country. China should properly increase density of population within its cities, develop city groups, city belt or city functional groups on the basis on mega-cities or central cities, and optimize distribution of specialized functions; identify urbanization strategy focusing on large cities; speed up development and implementation of national city/township system plans and land use plans; conduct pilot projects on low carbon and low pollution cities with lower energy consumption.

(4) Develop energy efficiency policy for urban construction, promote energy-saving technology and standards, and construct "low energy and carbon buildings". China should gradually establish building energy efficiency standards for different regions

and different types of buildings and, on this basis evaluate the energy consumption of buildings, decide on subsidies, support for individual technologies, and renovation for existing high energy consumption buildings; encourage developers and consumers to develop and purchase "low energy" and "low carbon buildings" through fiscal policy incentives; initiate low energy and carbon building pilot efforts; strengthen urban energy consumption supervision and audits; adopt certification for energy-saving products; improve efficiency of urban heat supply; and encourage utilization of new energy sources.

(5) Deepen reform of district heating networks in northern China and significantly reduce heating energy consumption.

(6) Make mass transportation and non-motorized transportation (NMT) a national strategic priority. A number of steps are recommended: intensify development of urban public transport, and increase share of public transport and control of unlimited growth of private cars; speed up rail transport and inter-city high-speed railway (cities with more than 2 million population should be encouraged to develop urban rail transport); promote vehicle fuel efficiency through mandatory fuel efficiency standards, and develop low carbon vehicles such as hybrid vehicle, electric vehicles; plan, construct and improve bicycle and walking pathways; develop enabling legislation and improve funding mechanisms, including a dedicated public transportation fund, to guarantee public transportation as a matter of the highest priority.

5 Strengthen Policies for Energy and Environment in Rural Development Including Greater Attention to Climate Change Adaptation

The Chinese government should integrate rural energy and environmental issues into the strategic task of Building the New Countryside, strengthen management and adopt comprehensive strategies, develop clean and renewable energy sources in the rural areas and establish a comprehensive rural renewable energy service system and develop low-carbon and highly efficient agriculture; and pay attention to the policy measures on climate change adaptation for rural areas.

(1) Increase the role of rural energy development in the national energy strategy and national climate strategy. China should speed up the upgrading of rural electrical grids and increase efficiency of rural energy use; strengthen the development of energy-saving technology and new energy technology/products suitable for various rural regions; determine how to establish national rural energy financing mechanisms to promote sustainable energy construction in rural areas; improve rural renewable energy development plans and relevant regulations; develop rural biomass energy subject to local conditions; incorporate rural bio-

mass facility, especially large or medium-scale methane facility, into national rural infrastructure plans; and meanwhile, strengthen rural environmental improvement to reduce health risks such as those associated with burning of coal for cooking and heating in homes.

(2) Adopt integrated measures to stimulate the development of clean and renewable energy sources.

(3) Optimize land use to increase carbon sequestration potential and support the development of high quality low carbon, low pollution agriculture; introduce a new rural carbon sequestration compensation mechanism, with provision for fiscal transfers and possibly for international financial transfer mechanisms. National voluntary carbon trading mechanisms, and payments to impoverished farmers for reducing pollutants and GHG emissions are a cost-effective way to promote low pollution and low carbon practices while also contributing to the goal of alleviating poverty.

(4) Improve the capacity of farmers and rural regions to adapt to climate change.

(5) Enhance the statistical analysis of rural energy use. Authorities need to strengthen their statistical analysis of rural energy end-use by both households and producers.

6 Reform and Improve Economic Instrument Policies for Increasing the Capacity of Energy Efficiency and for Environmental Management

China should consider setting a substantial increase in energy productivity as a national target; reform and improve policies of pricing, energy and environment-related taxation and Green Credit; and establish an insurance system for environmental damage and pollution liability.

(1) Increase energy price as a long-term incentive to improve energy productivity. Energy pricing needs to be linked carefully with environmental tax reform in order to maximize its potential for energy and environment benefits, for example in the case of a carbon tax.

(2) Implement environmental tax system reform with a focus on improving existing environmental taxes and establishing new ones. China should speed up the implementation of environmental tax system reform. Wastewater, air pollutants, solid waste and CO_2 should be among the first items addressed by environmental taxes.

(3) Improve and strengthen Green Credit policy and fully utilize the role of financial institutions in environmental protection and energy-saving. China should strengthen the use of Green Credit to regulate investment and industrial behaviors, speed up the promulgation of robust policy for Green Credit to limit high energy consumption and high pollution projects; carry out market reform for energy-saving and emission reduction fund man-

agement and use; establish a national guarantee mechanism for energy-saving and emission reduction credits, and provide interest subsidies for key projects; direct and standardize Chinese enterprises' overseas investment through Green Credit policies; develop Green Credit policies to support medium and small-scale enterprises in their efforts for environmentally-sound business development and practices; and establish an open and transparent mechanism for Green Credit implementation supervision and information disclosure.

(4) Establish and improve environmental pollution responsibility insurance regulations and policy system.

7 Develop a Green 12th Five Year National Economy and Social Development Plan

Preparations for the 12th Five Year Plan should give attention to strengthening China's capacity for sustainable development including incorporation of green economy including Low Carbon Economy as a key element of the Plan; promotion of green growth and future prosperity based on transformative environmental protection, energy efficiency and innovation as strategic priorities.

(1) Continue the mandatory targets for environmental protection and energy efficiency. Based on the 11th Five Year Plan experience, China should continue to adopt mandatory targets for energy-saving and emission reduction as important tools to protect environment and increase energy efficiency; expand emission reduction to other pollutants, such as NO_x and heavy metals with major impact on environment and human health, and further raise the fuel economy standards of vehicles; develop carbon intensity indicators per unit of GDP as mandatory targets to control GHG emission.

(2) Incorporate the green economy concept in the 12th Five Year Plan as a means to achieve sustainable development objectives.

(3) Strengthen and improve energy and environmental technical innovation and supporting system, increase national investment in R&D, enhance safety supervision of nuclear power plants. A national new energy research institution should be established with the intention of making it open to universities, business and other research organizations in order to create common platforms of energy technology, energy conservation and environmental protection.

(4) Place major energy, environment and green economy policies into overall fiscal and economic reform. China should improve the overall design and pilot implementation of key environmental taxes as a sound base of a fiscal system that can benefit resource and energy conservation and environmental protection in the 12th Five Year Plan period. China should initiate the research and pilot activities that will provide the funding channel for for-

est, grassland, and agricultural land improvements for rural carbon sequestration. China should speed up the implementation of property taxes to regulate the rapid increase of urban buildings and to encourage an urban sustainable consumption mode.

(5) Improve information statistics on energy and environment performance. Development of an improved basis for calculating carbon footprints is needed within various industrial sectors, communities, and for individuals and households.

(6) Improve management mechanisms of 12th Five Year Plan and implement EIA for plans at various levels. After the promulgation of the "Planning EIA Decree", in order to ensure green development, China needs to conduct EIA on major development plans, sector development plan, regional and local development plans that potentially pose a major impact on the environment.

Appendix Ⅱ Name List of Council Members

Mr. Li Keqiang	Vice Premier, State Council **Chairperson of the Council**
Mr. Zhou Shengxian	Minister, Ministry of Environmental Protection **Executive Vice Chairperson of the Council**
Ms. Margaret Biggs	President, Canadian International Development Agency **Executive Vice Chairperson of the Council**
Mr. Xie Zhenhua	Vice Chairman, National Development and Reform Commission **Vice Chairperson of the Council**
Mr. Klaus Töpfer	Former Executive Director, United Nations Environment Programme **Vice Chairperson of the Council**
Mr. Børge Brende	Secretary General, Norwegian Red Cross **Vice Chairperson of the Council**
Mr. Zhu Guangyao	**Secretary General of the Council**
Ms. Wang Jirong	Vice Chairwoman, Environment Protection and Resources Conservation Committee, National People's Congress
Ms. Jiang Zehui	Vice Chairwoman, Committee of Population, Resources and Environment, National Committee of the Chinese People's Political Consultative Conference
Mr. Wu Hailong	Assistant Minister, Ministry of Foreign Affairs
Mr. Zhang Shaochun	Vice Minister, Ministry of Finance
Mr. Li Ganjie	Vice Minister, Ministry of Environmental Protection
Mr. Yi Xiaozhun	Vice Minister, Ministry of Commerce
Mr. Ning Jizhe	Vice Minister, Research Office, State Council
Mr. Ding Zhongli	Vice President, Chinese Academy of Sciences (CAS); Academician of CAS

Mr. Shen Guofang	Professor, Former Vice President of Chinese Academy of Engineering (CAE); Academician of CAE; Chinese Chief Advisor of the Council
Mr. Liu Shijin	Vice President, Development Research Center, the State Council
Mr. Feng Zhijun	Professor, Counsellor of the State Council
Mr. Li Xingshan	Professor, Former Academician Dean, Central Party School of the Communist Party of China
Mr. Zhou Dadi	Senior Research Fellow and Former President, Energy Research Institute, NDRC
Mr. Lu Yaoru	Professor, Chinese Academy of Geological Sciences, Ministry of Territory and Resources; Academician of CAE
Mr. Zou Deci	Professor and Senior Urban Planner, China Academy of Urban Planning and Design, Ministry of Construction; Academician of CAE
Mr. Zhou Wei	Professor and President, Research Institute of Highway, Ministry of Transport
Mr. Wang Hao	Professor and Director, Department of Water Resources, China Institute of Water Resources and Hydropower Research, Ministry of Water Resources; Academician of CAE
Mr. Ren Tianzhi	Professor and Deputy Director, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Ministry of Agriculture
Mr. Wang Wenxing	Professor and Senior Advisor, Chinese Research Academy of Environmental Sciences; Academician of CAE
Mr. Niu Wenyuan	Professor and Chief Scientist, Institute of Policy and Management, Chinese Academy of Sciences
Mr. Ma Xiangcong	Senior Research Fellow, Institute of Law, Chinese Academy of Social Sciences
Mr. Ding Yihui	Professor and Senior Advisor, China Meteorological Administration; Academician of CAE
Mr. Hao Jiming	Professor and Dean, Department of Environmental Science and Engineering, Tsinghua University; Academician of CAE
Ms. Sarah Liao Sau Tung	Senior Advisor to the Vice-Chancellor of the University of Hong Kong on Environmental and Sustainability Matters;

	Former Secretary to the Environment, Transport and Works of the Hong Kong Special Administrative Region Government
Mr. Roger Beale	Senior Associate, the Allen Consulting Group, Australia; Former Portfolio Secretary, the Department of Environment and Heritage, Australia
Mr. Corrado Clini	Director General of Sustainable Development and Research Department, Ministry for the Environment, Land and Sea, Italy
Mr. Gordon Conway	Professor of International Development Centre for Environmental Policy, Imperial College, London, UK
Mr. Daniel J. Dudek	Chief Economist, Environmental Defense Fund, USA
Mr. John Forgách	Chairman of the Board, the Equator LLC in New York; Brazil
Mr. Arthur Hanson	Distinguished Fellow and Former President, International Institute for Sustainable Development, Canada; International Chief Advisor of the Council
Mr. Stephen B. Heintz	President, Rockefeller Brothers Fund
Mr. James Leape	Director General, World Wildlife Fund
Ms. Julia Marton-Lefevre	Director General, International Union for Conservation of Nature
Mr. Lars-Erik Liljelund	Executive Director of Mistra, Sweden
Mr. Lim Haw Kuang	Executive Chairman, Shell Companies in China
Mr. Timo Makela	Director, International Affairs, DG for Environment, European Commission
Mr. Dirk Messner	Director, German Development Institute
Mr. Mark Moody-Stuart	Chairman, Hermes Equity Ownership Services, UK
Mr. Mohammed Valli Moosa	Chairman of Lereko Investments and Sun International Ltd., South Africa; Former Minister, Ministry of Environmental Affairs and Tourism of the Republic of South Africa
Mr. R.K. Pachauri	Director General, the Energy and Resources Institute, India Chair of UN Intergovernmental Panel on Climate Change
Mr. Achim Steiner	Executive Director, United Nations Environment Programme
Mr. Björn Roland Stigson	President, World Business Council for Sustainable Development
Mr. Hau Sing Tse	Senior Vice President, Canadian International Development Agency, Canada
Ms. Laurence Tubiana	Director, Institute of Sustainable Development and Interna-

	tional Relations, France
Mr. Hans van der Vlist	Vice Minister, Ministry of Housing, Spatial Planning and the Environment, the Netherlands
Mr. Kandeh K. Yumkella	Director General, United Nations Industrial Development Organization