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

[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

Mechanism (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

---

[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

---

[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

---

[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

frightening 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 reforestation, grasslands conservation and the institution of new environmental management approaches such as functional ecological zoning in some coastal waters, restoration of wetlands, 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, including 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]

---

[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

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

UNEP-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

---

[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.

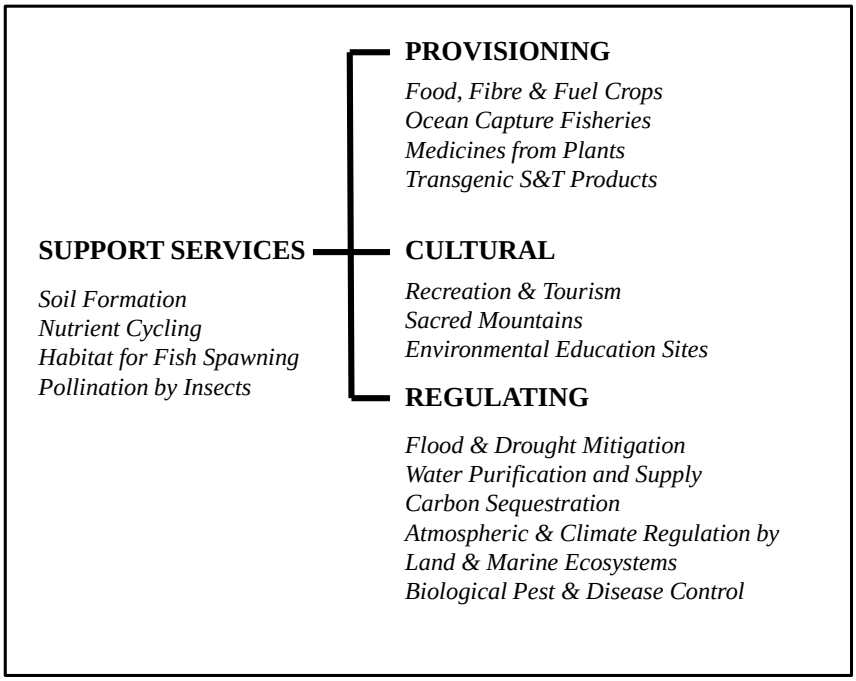

Figure 2-1 Types and Examples of Ecological Services

Source: Adapted from Millennium Ecosystem Assessment and other studies.

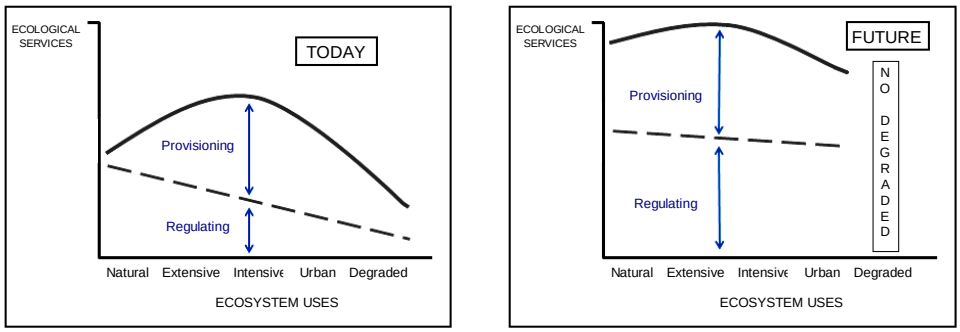

Figure 2-2 Ecological Provisioning and Regulating Services for China – Today and in the Future

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 for-

mation 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.

---

[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

[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

China. 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 Po-

[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

yang 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

---

[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

---

[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 condi-

tions 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.