Chapter 3 Ecosystem Service and Management Strategy in China

3.1 Introduction

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

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

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

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

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

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

and benefit from their experience.

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

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

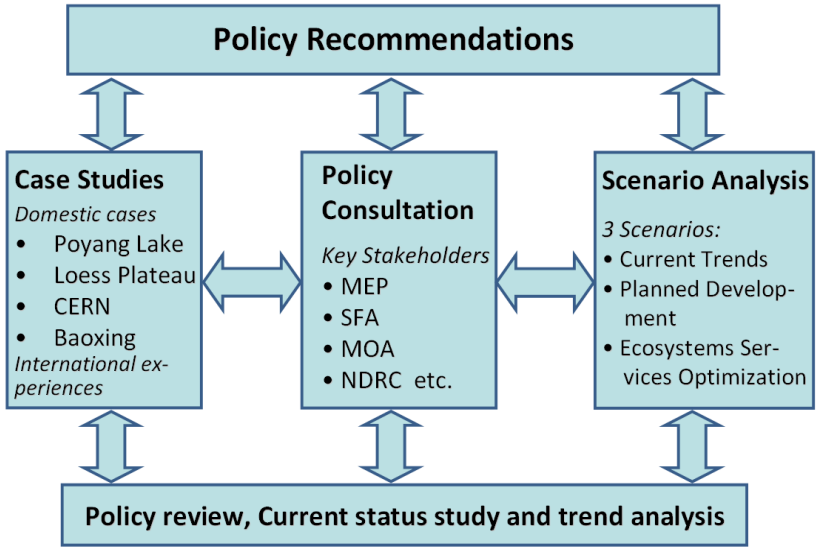

Figure 3-1 Methodology of the Task Force on Ecosystem Service and Ecosystem Management Strategy

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

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

3.2 Concept of Ecosystem Services and Ecosystem Management

3.2.1 Definition and Importance of Ecosystem Services

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

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

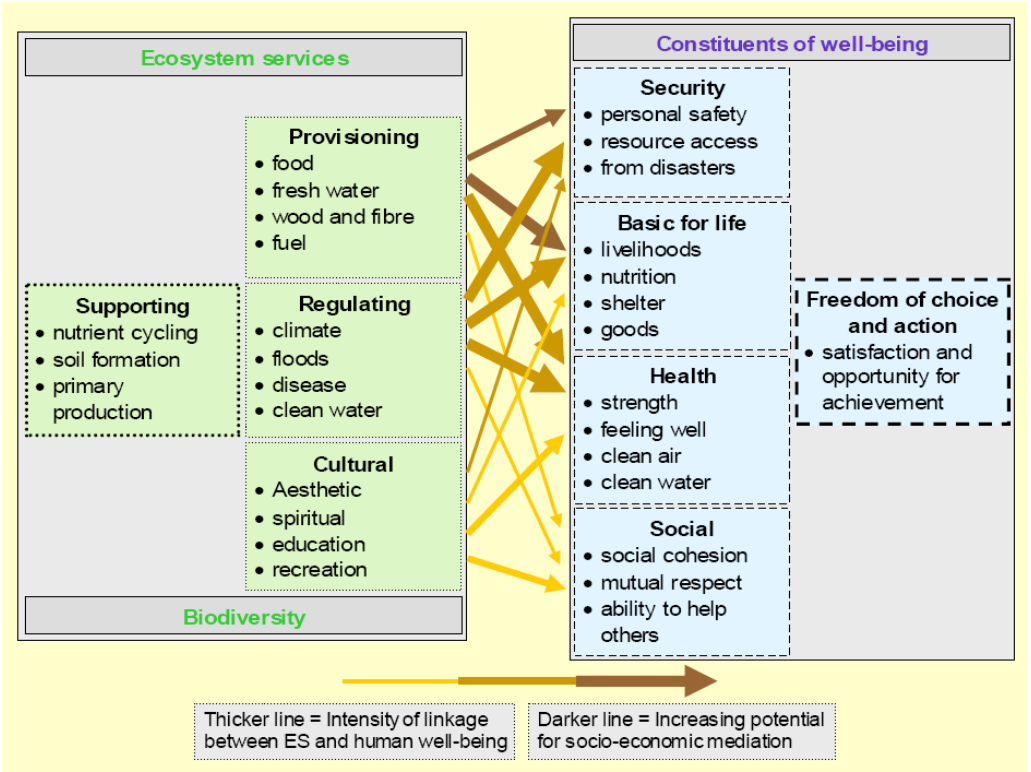

Figure 3-2 Biodiversity Underpins the Generation of All Ecosystem Services, and These Services are of Fundamental Importance for Human Well-Being[2]

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

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

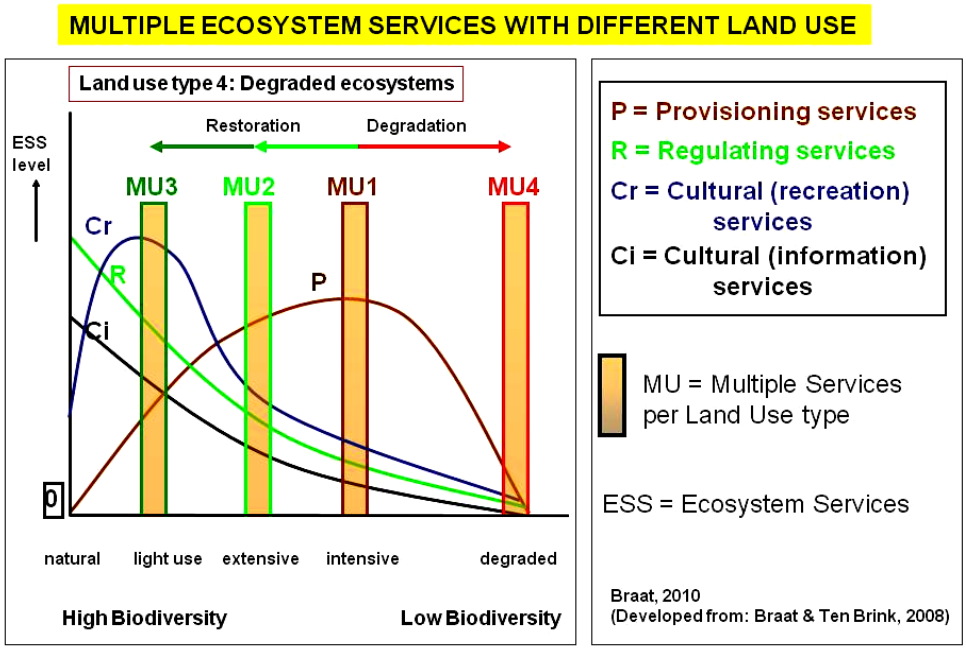

Figure 3-3 Restoration Steps or Degradation Use of Intensive Lands Leads to Different Levels of the Mix of Ecosystem Services in Other Land Use Types

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

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

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

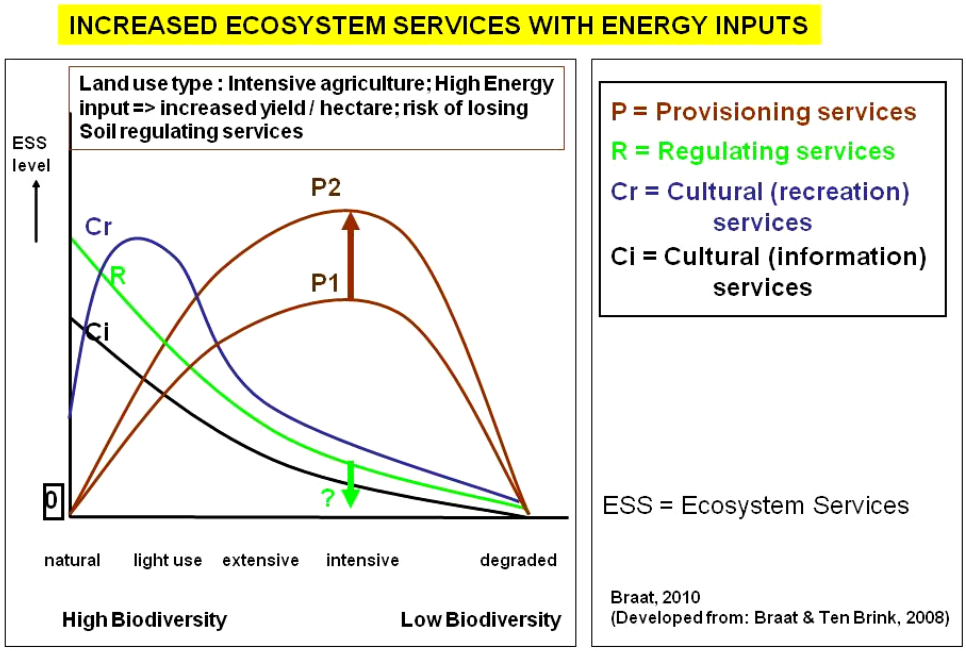

Figure 3-4 Increased Yield of Ecosystem Services per Hectare (P1 to P2) Requires Some Kind of Extra Energy Input but Risks of Degradation of Regulating Services

3.2.2 Definition and Importance of Ecosystem Management

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

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

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

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

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

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

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

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

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

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

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

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

3.3 Status of Major Ecosystems and Ecosystem Management

3.3.1 Status and Trends of Major Ecosystems and Services

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

3.3.1.1 Forest ecosystems

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

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

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

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

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

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

the evaluated forest ecosystem services so far.[9]

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

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

3.3.1.2 Grassland ecosystems

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

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

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

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

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

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

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

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

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

3.3.1.3 Wetland ecosystems

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

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

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

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

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

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

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

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

3.3.2 Institutional System of National Ecosystem Management

3.3.2.1 Management system and cooperation mechanism

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

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

3.3.2.2 Analysis of the legal system of ecosystem management

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

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

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

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

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

Box 3-1 Examples of Legal Conflicts between Different Laws

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

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

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

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

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

3.3.3 Outputs of National Ecological Programs

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

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

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

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

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

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

3.4 Scenario Analysis

3.4.1 Introduction

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

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

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

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

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

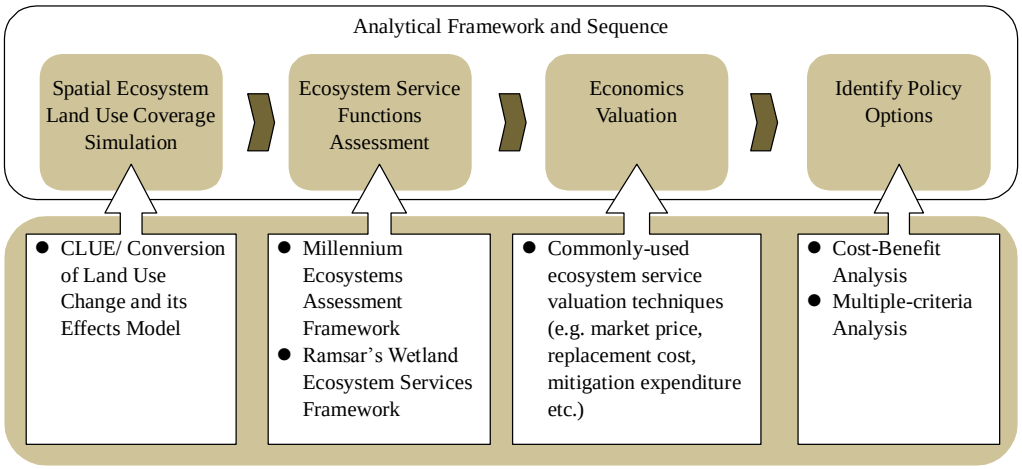

Figure 3-5 Analytical Framework and Sequence

The three scenarios were used for analysis:

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

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

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

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

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

3.4.2 Assessment Methodology

3.4.2.1 Land use change assessment

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

3.4.2.2 Ecosystem service assessment

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

3.4.2.3 Future demands-supplies and economics

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

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

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

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

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

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

3.4.3 Major Results

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

3.4.3.1 Future scenarios: BAU vs. Planned

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

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

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

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

[29] National Land Resources Bulletin.

and 16%.

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

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

3.4.3.2 Ecosystem services optimization – the Optimum Scenario

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

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

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

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

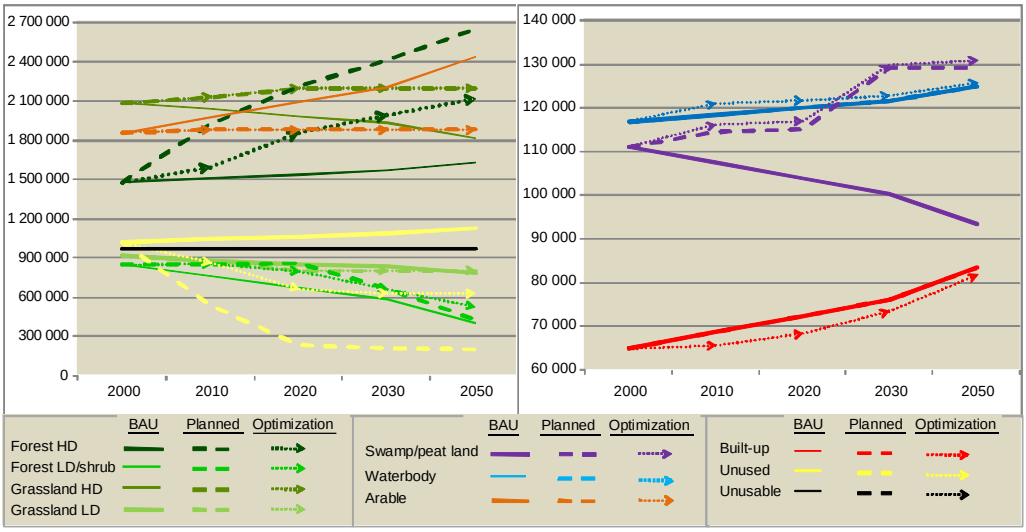

Figure 3-6 Land Use Change in the BAU, Planned and Optimum Scenarios

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

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

3.4.3.3 Ecosystem service assessment (ESS), demands and valuation

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

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

for outdoor recreational activity.

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

Table 3-1 China Ecosystem Services Values

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

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

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

The potential domestic supplies of specific ecosystem provisioning services (grassland

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

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

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

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

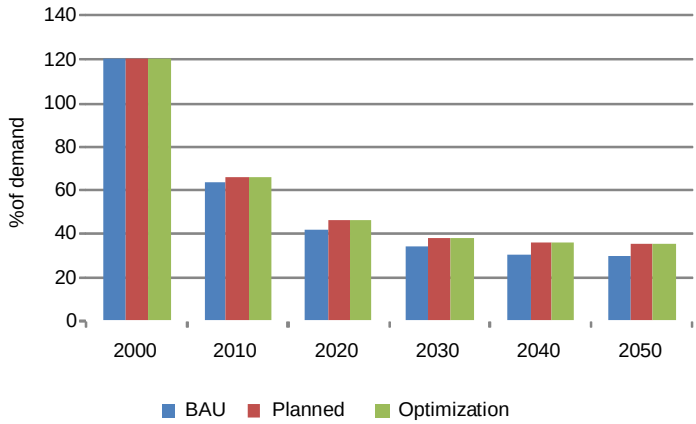

Figure 3-7 Grassland Carrying Capacity Provision, as Share of Demand

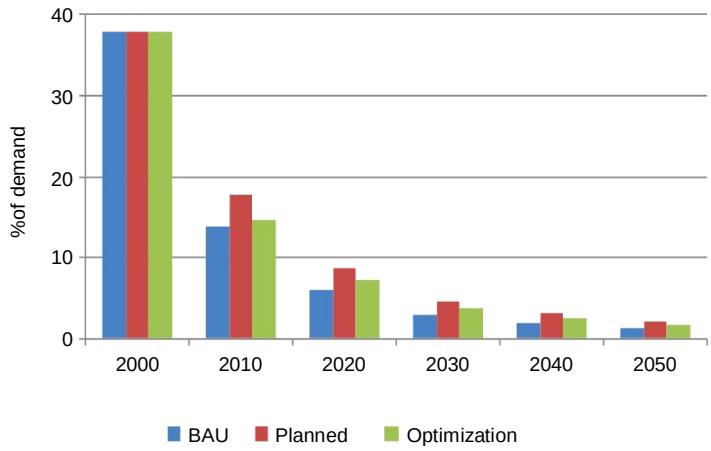

Figure 3-8 Forest Product Increment Provision as Share of Demand

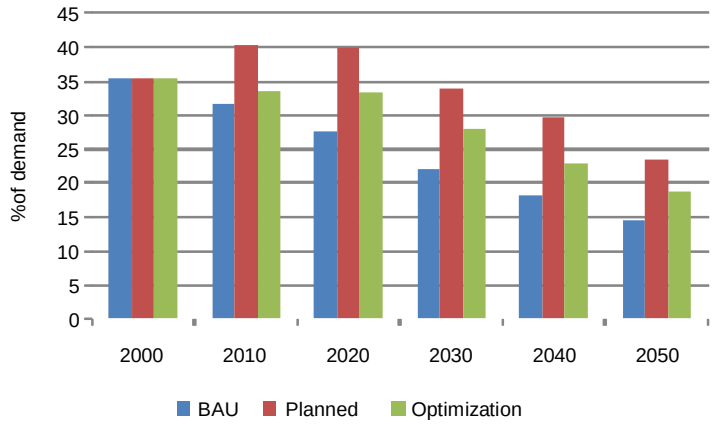

Figure 3-9 Forest Tourism Services as Share of Domestic Demand

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

3.4.4 Summary

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

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

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

3.5 Chinese Case Studies and International Experiences

3.5.1 Selection of Chinese Case Studies

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

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

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

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

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

3.5.2 Case Study of Poyang Lake

3.5.2.1 Lessons learned in ecosystem management

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

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

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

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

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

3.5.2.2 Policy implications

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

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

3.5.3 Case Study of Loess Plateau

3.5.3.1 Lessons learned in ecosystem management

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

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

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

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

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

3.5.3.2 Policy implications

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

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

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

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

3.5.4 Case Study of CERN

3.5.4.1 Experiences and lessons learned from CERN

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

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

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

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

3.5.4.2 Policy implications

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

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

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

3.5.5 Case Study in Baoxing County

3.5.5.1 Lessons learned for ecosystem management

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

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

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

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

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

3.5.5.2 Policy implications

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

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

3.5.6 Lessons Learned from International Experience

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

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

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

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

(2) Reforming subsidies that harm ecosystems;

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

(4) Adding value through expanding protected areas;

(5) Investing in ecological infrastructure;

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

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

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

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

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

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

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

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

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

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

[37] Natural Capital Project

jects should receive more funds.

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

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

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

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

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

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

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

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

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

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

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

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

3.6 Major Findings

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

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

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

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

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

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

c) The ongoing decline in wetland ecosystems.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

d) Mechanisms for solving conflicts.

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

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

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

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

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

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

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

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

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

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

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

3.7 Policy Recommendations

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

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

[43] Central Government Bulletin, 2007

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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