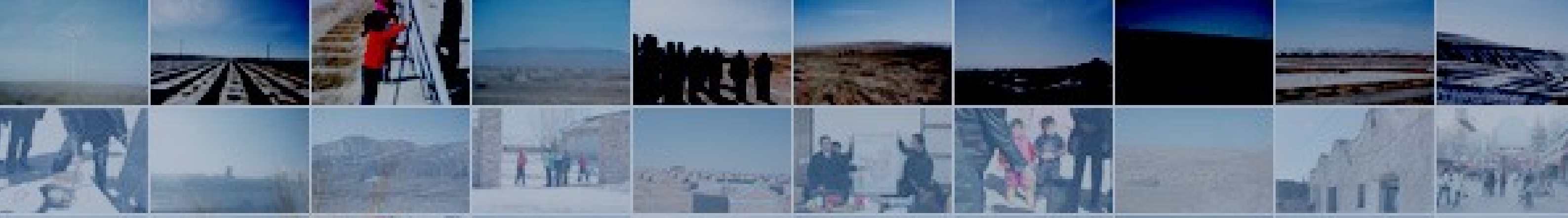

China Ecosystem Services and Poverty Alleviation Situation Analysis and Research Strategy

Final Report
(Annex)

Submitted to:
NERC, ESRC and DFID

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Chinese Academy of Agricultural Sciences (CAAS)
CAB International
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Stanford University - The Natural Capital Project
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Ningxia Centre for Environment and Poverty Alleviation
Ningxia Development and Reform Commission

Contents

Annex1

Project methodology

The ESPA Programme tries to boost the potential of poor people to improve the state of ecosystems and profit from such activities rather than contribute to their destruction and slip deeper into poverty. Their actions as local agents for sustainable development have the potential to benefit not only themselves but support the survival of modern society.

1 INITIAL ANALYSIS AND RESEARCH THEMES

The ***initial workshop*** in London provides an opportunity for the China ESPA consortium to present its capacity and project development strategy. The workshop further focuses on the expectations and needs of the donor consortium NERC, ESRC and DFID ('must haves'). The donors stress that the Situation Analysis (SA) commissioned in this first bid, is

- not intended to do new research, but
- to consult on the status of institutional involvement, ongoing activities and knowledge in the field of ecosystem management and poverty alleviation, and
- to determine the gaps in scientific knowledge and institutional capacity that need to be addressed by a full ESPA research and capacity building project
- to identify priority areas and conceptual support for the development of such project under the premise of maximizing its impact
- to investigate also ecosystem services other than provisioning services, such as regulating (e.g. climate, water), supporting (e.g. energy and material flows), and cultural (e.g. spiritual, recreational benefits), despite project team strengths in provisioning services, especially in the agricultural sector.
- to provide evidence that better management of ecosystem services is important to the poor, also in the form of case studies, to support arguments, why investment in research for better ecosystem management provides a better return than other poverty alleviation approaches (DFID – major donor).

1.1 Project inception workshop

It serves various objectives, most importantly to:

- create awareness about the topic and point out potential benefits for China
- receive an initial feed-back and inputs from stakeholders
- build understanding by developing a conceptual framework of ecosystem services and linkages with human well-being or poverty
- discuss project co-ordination, work strategies, identify sources of information

Potential advisory committee members, stakeholders, media, donor representatives and project partners attend the workshop, an inaugurative discussion forum for the topic of ecosystems and poverty alleviation in China. The second part of the workshop, attended primarily by project partners is dedicated to project conceptualization and management. A preliminary draft of the final report, the main output of the Situation Analysis is developed.

1.2 Establishment of Advisory Committee and Definition of Methodology

The role of the project Advisory Committee (AC), a group of voluntary, interested, actively supportive and critical stakeholders, who have been invited by the project team considering their key roles and authoritative level of expertise is to:

- provide advice on information sources,
- review interim project findings, and
- lend support and credibility for the final results within the wider academic, NGO and policy communities of China.

1.3 Initial stakeholder meetings

The work with the Advisory Committee is complemented by contacts to a more diversified and larger group, ideally representing the whole stakeholder community from primary producers to biodiversity conservationists, regional planners, and political decision makers. The objective of this work package is to:

- get further feed-back on the project approach (methodology)
- serve as a source of relevant information
- provide a wider forum for the discussion of findings and dissemination of results
- identify additional stakeholders and information needs at the national and focus region level (e.g. Ningxia)

Stakeholders are subdivided into government, research and NGO categories. Their statements are sought in the form of interviews (e.g. by phone) or semi-structured questionnaires. An important result would be to gather critical and constructive opinions and further sources of information to complement the literature search.

1.4 Comprehensive literature search

The comprehensive CAB Abstracts form the core element of the literature search. Work by CAB information specialists is complemented by separate searches of the scientists involved in the production of work packages. Key words and key word combinations are proposed by team members covering a range of topics including ecosystems, different kinds of ecosystem services, especially those relevant to the poor, direct and indirect drivers of change and threats to ecosystems at various levels, and other issues.

1.5 Design and setting-up of project website

Comprehensive information sharing within an international project and the need for dissemination among a wider community of stakeholders is accomplished in the form of a project website (http://www.espachina.org/wpackage.asp). Literature search results and project documents are deposited on the web server, which provides access to the public and restricted access to the project team.

1.6 Ongoing management of project information

The ongoing management of information is largely accomplished by circulating important information or documents among the team, by updating and maintaining the website. Work package leaders are writing monthly reports that are submitted to the donors and shared among the project team. Meetings are held to address specific issues, discuss work progress and gaps, etc. Such meetings and their minutes also function as information share mechanisms.

1.7 Poverty mapping and profiling

This work package (WP) assembles poverty indicators that describe and quantify the status and trends of poverty in China (e.g. NBS poverty standard) and compiles the information in the form of maps. These are overlaid with geographical information on ecosystems (WP 1.9) to test the findings of the Millennium Assessment (MA) that poverty coincides with lack of ecosystem services, for example in regions of fragile or vulnerable ecology. This is contrasted with other possible causes of poverty. CAAS has access to information covering the 592 poorest national poverty counties, whereas this is not the case for the provincial poverty counties. A more detailed analysis can be conducted for the Ningxia focus region, covering, for example information on how poverty is distributed among different groups of ecosystem users.

1.8 Review of climate change scenarios, ecosystem services and poverty impacts

The team dealing with this work package presents an overview of existing climate change models and their effects on selected ecosystem services considering issues of uncertainty and reliability. Regional information on observations and trends of climate change from China's National Climate Change Program are matched with ecosystem categories identified under WP 1.9, particularly those which are also regions of high levels of poverty (WP 1.7). Apart from revealing more information about climate change as driver of ecosystem alteration, this WP seeks evidence showing in what regions the change processes impact most strongly on poor ecosystem users. Terrestrial ecosystem services, water resources and biodiversity are receiving most attention in the analysis of climate change impacts.

1.9 Mapping of ecosystems and assessment of service supply

This section is targeting to:

- produce a systematic and concise description of the main ecosystems of China and current knowledge of the supply of supporting, regulating, provisioning and cultural ecosystem services.
- provide a more detailed analysis of ecosystem properties and services for the Ningxia region and the Upper Yangtze region.
- assess the state of knowledge for determining the potential to improve the supply of services through ecosystem management; focusing on the services most likely to alleviate poverty.

The resulting recommendations may include balancing critical priority choices between ecosystem restoration of degraded ecosystems and sustainable management of yet well-functioning systems under threat of future degradation. Essentially the work package leads to an identification of priority ecosystems for improved management and research gaps for scientific support of sustainable management system optimization.

1.10 Identification of institutional structures and policies affecting land use and ecosystems

Objectives:

- To identify the policies which are drivers of ecosystem change
- To categorise the institutions and processes in China governing land use and water use
- To suggest the entry points for research on poverty alleviation

Ecosystem-related constraints that have a strong relevance with regard to poverty are identified and the impact on ecosystem users is measured with livelihood or poverty indicators. Some general recommendations with regard to tackling limitations in land and water for better ecosystem management and poverty alleviation and how this could be supported at the institutional and policy level are provided.

1.11 Assessment of effects of agriculture on ecosystems

A central issue to be addressed is the elaboration of quantifiable factors or 'indicators', for example population density, carrying capacity, rainfall characteristics, poverty (which often conditions the over-exploitation of natural resources), that can help assess qualitative or quantitative changes and find key elements that lead to agro-ecosystem enrichment or deterioration. A portrait of the main ecosystem impacts by agricultural practices at the national scale is complemented by a more detailed study of the conditions in parts of Ningxia Hui autonomous region.

1.12 Poverty reduction policies review and characterization of routes out of poverty

In this work package, the policies for poverty reduction in China and routes out of poverty (education, business, migration) are summarized. Emphasis is laid on activities, which impact on the use of ecosystems and demand for their services. Implicitly this also allows for some comparison of ecosystem management for poverty alleviation and other poverty alleviation strategies.

1.13 Review of ecosystem valuation and its potential

Experiences and potentials of how applied ecosystem valuation models (PES, etc.) may also be used as an instrument for poverty alleviation, deserves special attention. Such discussion picks up results from other work packages, for example by focusing on ecosystems with a high natural rehabilitation potential that have at the same time been identified as being part of or including high poverty areas. The team also screens the potential of future research on the subject of ecosystem valuation in China.

1.14 Analysis of ecosystems and poverty linkages and priority areas

This package largely elaborates on the findings of previous WP's. The work team extracts the information on those ecosystems which coincide with poverty areas and have a good potential for strengthening ecosystem services that are most relevant to the poor. Focusing on agricultural ecosystem and policies, this section assesses the extent to which such services are under threat from direct or indirect drivers of change, ranging from overexploitation and inappropriate management to climate, demographic or economic factors. Ways of augmenting the supply of ecosystem services for poor people by appropriate management and the right policies are discussed using positive experiences or case studies for reference. The role of research to fill knowledge gaps as a precondition for circumspective policies is investigated.

1.15 Synthesis document of initial findings and research issues. Workshop to review & approve document and plan next stages

A synthesis document of the initial findings is composed using material from the work packages as input for the preliminary report. The report structure is agreed during the midterm workshop, which serves as a platform for discussion and reflection on the work done so far by the project team with stakeholder support.

2 CONSULTATION ON FINDINGS, RESEARCH & CAPACITY NEEDS

2.1 Review of analyses and proposals by stakeholders

The Advisory Committee and other stakeholders are asked to comment on the preliminary report and propose changes. Getting more information about the concrete outcomes of the project may motivate the readers not only to share their critical views, but also to provide more evidence or substance to the report in the form of additional, more accurate information or recommendations. The response from the stakeholder community is evaluated and feeds back into the report.

2.2 Assessment of the knowledge and skills needs of researchers, policy makers and agencies for ecosystem management for poverty reduction.

To accomplish the tasks of this work package, semi-structured interviews are send out to a range of scientists and policy makers to consult them regarding their research and capacity needs. This contains questions relating to the interviewees perceptions of what the ideal preconditions are for doing research on ecosystem management for poverty alleviation. Other questions are related to their own situation and self-perceived needs for further skills and capacity building on the subject.

2.3 Regional workshop

Building on the results of the preliminary report and the stakeholder feedback, the regional workshop is convened in Ningxia Hui Autonomous region. While this comprises the opportunity to look at the problems associated with ecosystem management for poverty alleviation in more detail and with participation of local stakeholders, including representatives of the ultimate target group of poor ecosystem users, it also gives a chance to:

- review and develop the national and regional challenges to ecosystem service delivery for poverty reduction already identified.

- prioritise these challenges according to already established criteria (WP 15)
- suggest information and research topics and related capacity needs to overcoming the challenges.

Outcomes and recommendations from the workshop are incorporated into the relevant sections of the final report.

2.4 Draft recommendations for research needs

According to their areas of expertise, the project partners evaluate and summarize the material compiled so far on research, knowledge and capacity needs associated with ecosystem management for poverty alleviation. This is synthesized and compiled in the form of a concise separate report.

3 FINAL ANALYSIS & CAPACITY-BUILDING STRATEGY

3.1Deepening of analysis of poverty-ecosystem services linkages

The objective of work package is to further develop the draft situation analysis produced in Work Package 1.15 in response to areas of weakness or of particular importance, as identified at the end of Stage 1 and from the consultations in Stage 2. The results will be shared with the ESPA programme which may recommend areas and actions for further investigation feasible within the reach of available resources.

3.2Proposal for strategies to meet skills and knowledge capacity needs of researchers, policymakers and government

Based on the results form work packages 2.2. and 2.4, strategies are proposed to meet skills and knowledge capacity needs of researcher and policy makers. In particular, this section is targeted to:

- review current research strategies to meet policy and information needs (including if there is a 'critical mass' of researchers in relevant fields)
- analyse best practice to support the uptake of research and to disseminate findings
- review existing and planned capacity-building efforts for target research institutions
- discuss current skills and knowledge levels; and
- identify strategies for efficiently meeting needs (training, exchanges, etc.).

4 CONCLUSIONS AND FINAL PRODUCTS

4.1Final workshop to ratify findings with Advisory Committee and ESPA Programme

The workshop envisages the participation by all the project partners, members of the Advisory Committee, ESPA Programme representatives and key stakeholders. Project analysis results and proposals from Work Packages 3.1 and 3.2 are presented and reviewed together by all participants. Feedback, most importantly from the Advisory Committee and ESPA Programme representatives is collected to improve and refine the final report.

4.2 Submission of final report and inclusion of feedback

The final draft of the ESPA Situation Analysis and Research and Capacity Proposal is submitted to the ESPA Programme for review. Comments and suggestions are incorporated into the final draft with concerted efforts of all project partners within a short period to accomplish the timely delivery of the final report, which is intended to guide the development of a 5 year ESPA programme by the British Government in support of research and capacity needs in China and other parts of the developing world.

Annex2

Introduction to the conceptual framework of this report

The conceptual framework for this study was developed from the conceptual framework of the Millennium Ecosystem Assessment (FigureAN2.1). The purpose of the MA was to assess the consequences of ecosystem change for human well-being, and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contribution to human well-being. The ESPA programme aims to go beyond an assessment of ecosystem services and their linkages to poverty, to also identify the challenges for sustainable management of ecosystems to maximise poverty reduction. The conceptual framework developed for this report has distinguished the ecosystem as a separate component of the analysis, with the supporting services as defined by the MA renamed as ecosystem processes. The functioning of these ecosystem processes and the consequent flow of services is dependent upon the intrinsic properties of the ecosystem (e.g. soil type, climate), and its integrity or modification by human actions.

Ecosystem management can be considered as the application of 'tools' to modify the functioning of the ecosystem, to obtain particular services or benefits. A classification of six types of tools for managing ecosystem processes has been proposed by Savory (1999), consisting of fire, rest, grazing, animal impact, technology and living organisms. Rest as a tool is the prevention of major physical disturbance to plants and soils, such as the use of exclosures on grasslands. Grazing is the eating of vegetation by animals, whilst animal impact refers to all the things grazing animals do beside eat, such as dunging, urinating and trampling. Examples of using living organisms a tool for ecosystem management include using trees for afforestation, biological pest control with insects and micro-organisms, and planting of leguminous crops as green manure.

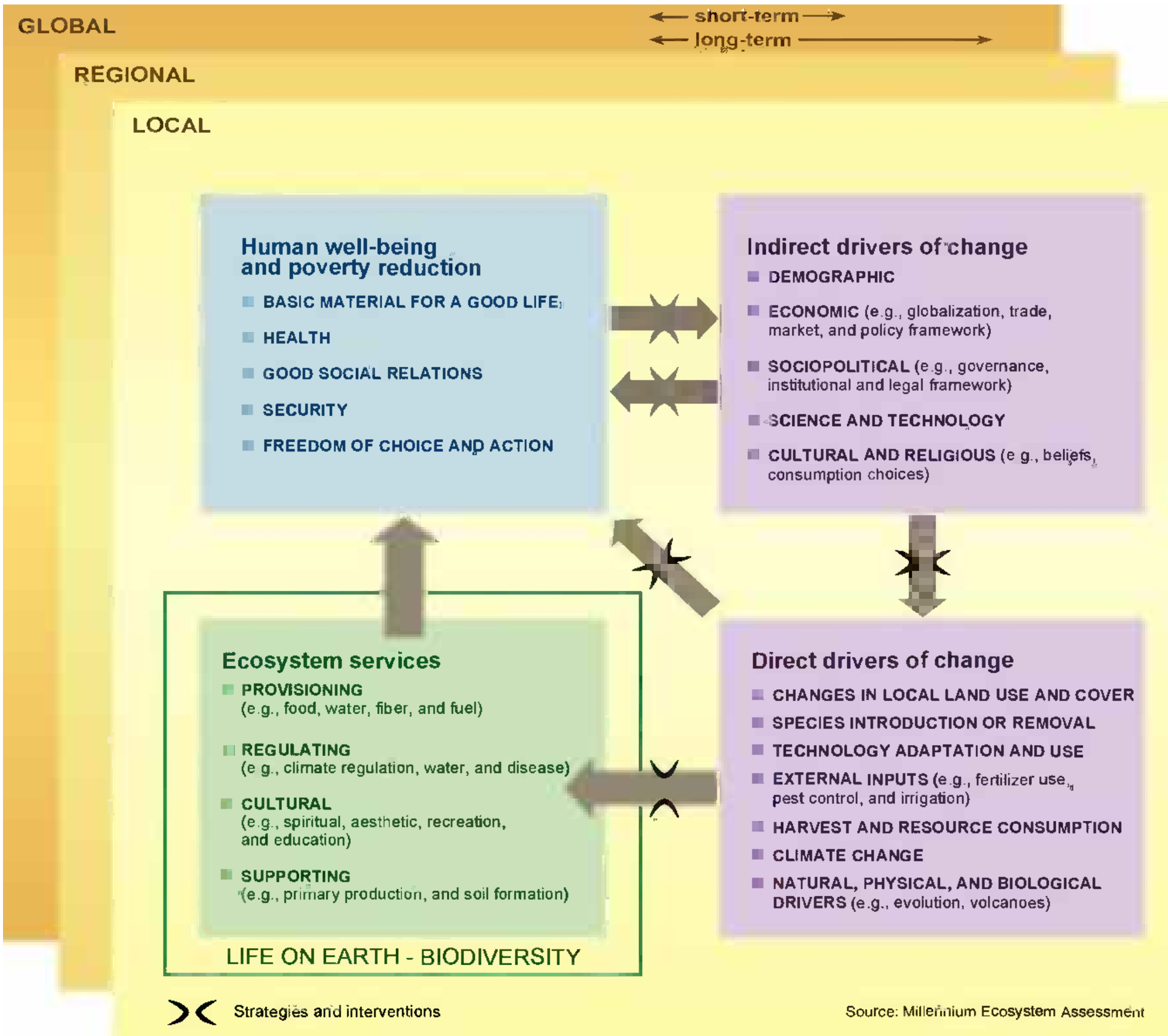
The response of a particular ecosystem to these tools varies according to its intrinsic properties and its degree of modification, and so is case specific. For example, ecosystems in wet tropical climates respond very differently to the use of fire to clear vegetation compared to dry and high mountain ecosystems. A forest ecosystem that has been modified by logging will respond differently to a fire compared to a forest in a natural state.

In China, perhaps more than in any other country, modification of ecosystems is conducted at not only the scale of the actions of millions of farmers and herders, but also through large-scale government projects to change land and water use. Examples include the Sloping Lands Conversion Programme, the Three Gorges Dam, and the South to North water transfer project. As these programmes have such a large impact on China's ecosystems and population that they have been identified in this project's conceptual framework as a particular focus.

Decision-making concerning ecosystems and their supply of services for human well-being is considered through the processes of government policies and programmes and through the decisions of households and the commercial sector. For all of these scales and mechanisms of decision-making, the modification of ecosystems for particular services will be influenced by the objectives and values of the decision-maker. For example, is economic growth or maximising cash income the only objective, or are other goals such as increasing soil fertility or cultural values considered. Decisions about ecosystem management are also greatly affected by the information and skills available to understand the situation, and to design and carry out actions. Such information and skills could include the effects of agricultural or forestry practices on the hydrological cycle and on soil erosion or formation. Decision-making options will also be determined by the assets available to carry out actions, such as financial resources, social and labour assets, and machinery and technology.

Change in ecosystems and their supply of services is driven not only by the conscious management decisions of farmers, business and government, but also by the unintended impacts from pollution, climate change and alien invasive species. These unintended direct drivers of ecosystem change are distinguished in the conceptual framework.

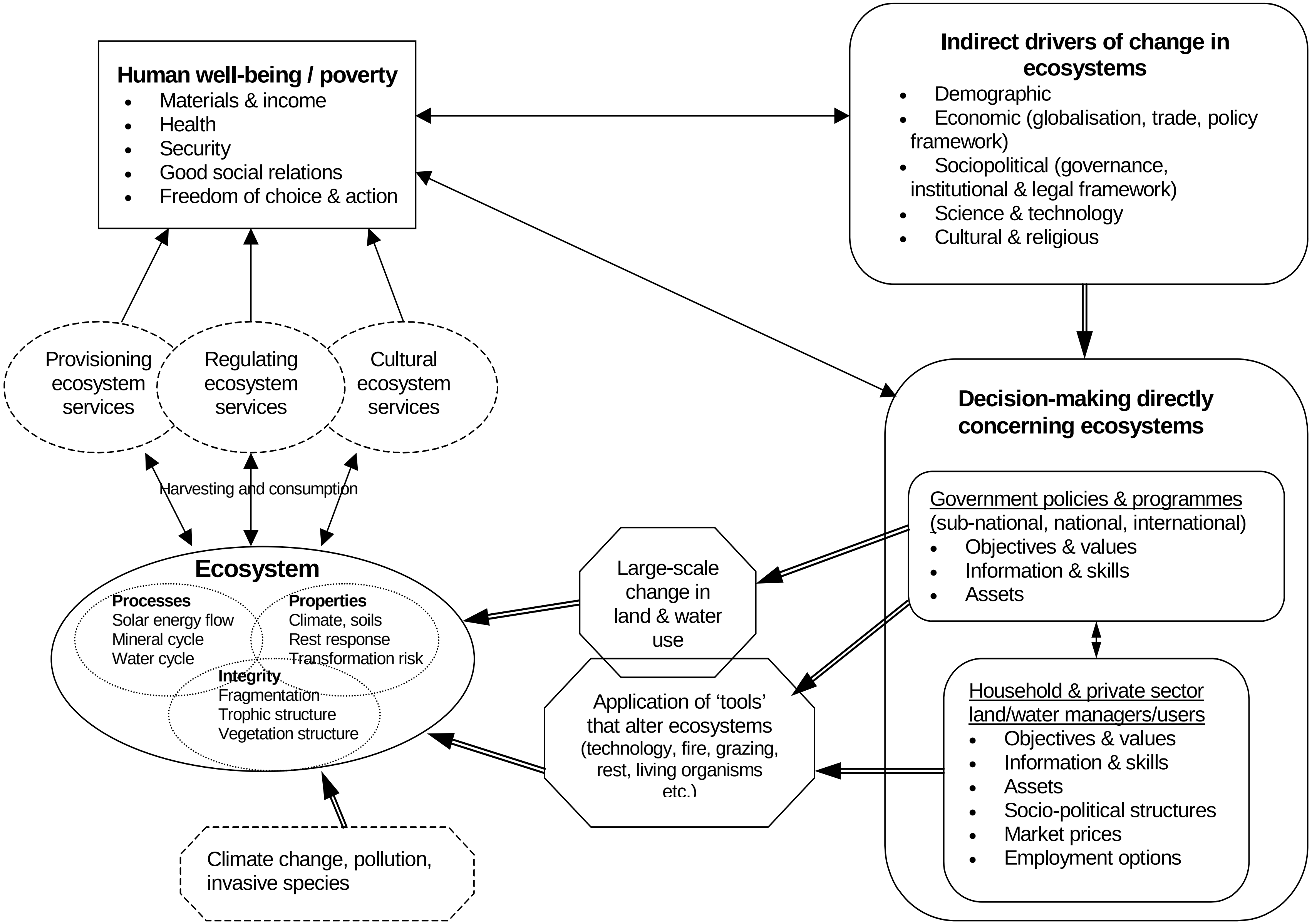
This study follows the conceptual framework of the MA in identifying the categories of indirect drivers of ecosystem change as demographic, economic, socio-political, science and technology, and cultural and religious. The priorities and potential for science and technology to improve ecosystem management for poverty reduction is the particular focus of this study.



FigureAN2.1 Conceptual framework of the Millennium Ecosystem Assessment (MA, 2005)

Conceptual Framework for analysis of sustainable management of ecosystems to maximise poverty alleviation

ESPA China Project version 1.1



Annex3

Concepts of Ecosystem Services and Management in relation to Poverty

Box – Key Definitions

Ecosystem - An ecosystem consists of a dynamic set of living organisms (plants, animals and micro-organisms) all interacting among themselves and with the environment in which they live (soil, climate, water and light). Humans are an integral part of ecosystems. An ecosystem rarely has precise boundaries - it can be defined to be as small as a pond or a dead tree, or as large as an ocean basin – but ecosystems are usually defined in terms of the dominant vegetation or topography.

Ecosystem Services - The benefits people obtain from ecosystems. The Millennium Ecosystem Assessment (MA) defined four categories of ecosystem services: provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as soil formation, photosynthesis and nutrient cycling that maintain the conditions for life on Earth. The human species, while buffered against environmental changes by culture and technology, is fundamentally dependent on the flow of ecosystem services (MA, 2005).

Ecosystem Management - Modification of land and/or water bodies to obtain particular benefits whilst seeking to maintain the supply of these benefits (ecosystem services).
Ecosystem management can be towards one or more aims, such as:

- food production,
- timber supply,
- fuel supply,
- scenic landscape maintenance,
- conservation of valued species (e.g. Giant Panda, medicinal plants),
- water supply or purification or regulation,
- atmospheric carbon sequestration.

Ecosystem Use (or exploitation) is extraction of benefits from ecosystems without consideration of the maintenance of the supply of these ecosystem services.

Human Well-being / Poverty – Human well-being has multiple constituents, including basic material for a good life, freedom of choice and action, health, good social relations, and security. Well-being is at the opposite end of a continuum from poverty, which has been defined as a "pronounced deprivation of well-being". The constituents of well-being, as experienced and perceived by people, are situation dependent, reflecting local geography, culture, and ecological circumstances (MA, 2005).

The concept of different categories of ecosystem services (ES) also allows analysis of trade-offs and synergies between services. For example, increasing the production of food by converting a forest to cropland is likely to decrease the supply of other provisioning ES such as timber and clean water, reduce the flood regulation properties of the ecosystem, and alter cultural services such as spiritual, recreational and tourism values. Trade-offs and synergies in ES reflect the different spatial and temporal scales over which ecosystem processes occur. For example, food production is a localised ES and changes on a weekly basis, water regulation is regional and changes on a monthly or seasonal basis, and climate regulation may take place at a global scale over decades. Trade-offs in the flows of ES also need to consider who are the beneficiaries or loser of changes in ES, especially regarding the poor.

Ecosystem rest response- Different ecosystems vary in their response to being rested or disturbed by people or large animals. Some ecosystem types respond to rest with a diversification of the ecosystem processes, with more complex and increased solar energy flow, mineral and water cycling, and biodiversity dynamics. Diversification of the ecosystem processes results in an increased supply of ecosystem services. Other ecosystem types respond to rest by a simplification of the ecosystem processes, which eventually results in desertification. The tendency of an ecosystem to have a simplifying or diversifying rest response is indicated by the percentage of the year when organic decomposition occurs. Where temperature and humidity permit organic decomposition throughout the year an ecosystem will have a diversification rest response. If organic decomposition is possible for less than half of the year the ecosystem processes will tend to simplify under rest. Therefore, the ecosystems tend to have a simplifying rest response in the Loess Plateau, Grassland Zone, Arid area in Northwest China and Qinghai-Tibet Plateau, and tend to have a diversifying rest response in the Karst area in Southwest China, and the Plain zone and Mountainous area in South China.

Transformation Risk - Different ecosystems have a low or a high risk of being transformed to a different state by human actions. For example, the Loess Plateau grasslands are a high risk ecosystem for potential transformation to bare soil by agricultural practices. When such a transformation occurs, a threshold is crossed in the functioning in the ecosystem processes and the supply of services which may not be easily reversed. Another example is when a lake becomes so eutrophic from nitrogen fertiliser run-off that it cannot sustain fish populations.

Linking ecosystem management and poverty reduction

Many human activities that alter the natural environment can be considered as types of ecosystem management. For example, agriculture with an objective to maintain soil fertility is a type of ecosystem management. Activities that can be described as ecosystem management vary considerably in their significance for poverty reduction, as well as in the timescale of their impacts. Examples of such linkages are presented in TableAN3.1.

TableAN3.1 Ecosystem management activities and linkages to poverty reduction

Ecosystem management activity	*Poverty reduction significance*	*Timescale of poverty impacts*
Cropping, livestock production, aquaculture	High positive for food and income.	1- 3 years
Water catchment management, e.g. afforestation, to reduce floods and increase water supplies.	Medium – high negative for local people's if displaced from land without adequate compensation. Medium positive for downstream people if flood damage reduced and water supplies increased.	1 – 50 years
Timber harvest and afforestation	Medium positive if a source of employment or payments for ecosystem services. Medium negative if sources of non-timber forest products lost or water supplies and flood regulation reduced.	1 – 20 years
Soil and vegetation restoration on degraded lands	High positive or negative, depending on whether access is maintained to the land.	1- 10 years.
River flow control for irrigation, hydropower, flood control, etc.	High positive if agriculture production and security are increased.	1 – 5 years
Use of rivers, wetlands and estuaries as sinks for treatment of pollutants	Medium – high negative, as a risk to health and harvesting of wild products.	1 – 10 years.
Management of land and/or water bodies for harvesting of wild products, e.g. meat, construction materials, vegetables, fungi, medicines, etc.	Low - medium positive, as often only seasonal or low-scale production.	1- 3 years.

Protected areas for biodiversity conservation and/or tourism.	Medium – high negative for local people if displaced from land without compensation, or loss of access to ecosystem. Low – medium positive if local people increase incomes from tourism or sustainable harvest of products.	1 – 50 years
Public parks and sacred sites	Low positive, for cultural and regulating ecosystem services.	1 – 50 years

Annex4

Ningxia Case Study

The Ningxia Hui Autonomous Region (hereafter referred as Ningxia) is located at the upper and middle reaches of the Yellow River in the eastern part of northwest China. Made up of 22 counties in 5 municipalities, Ningxia has a population of 6.04 million by the end of 2006, of whom 3.84 million (63.2%) are in the rural area.

1 General Situation of Ningxia

1.1 Poverty in Ningxia

In 2006, the population of Ningxia had 65,000 people (3%) categorised under absolute poverty and 293,000 people (13.5%) under low income. These poverty-stricken people were mostly distributed in the desertified areas in the central district and the loess hills in the south. They were located in eight national poverty counties, namely. Xiji, Yuanzhou, Longde, Jingyuan and Pengyang in Guyuan Municipality; Yanchi and Tongxin in Wuzhong Municipality；and Haiyuan in Zhongwei Municipality. Together, these counties are spread over 38,900 sq km or 58.6% of Ningxia and have 2.56 million people which represents 42.6% of Ningxia's population.

1.2 Ecosystem in Ningxia

There are many different types of ecosystems in Ningxia; the main ones being forests, grasslands, deserts, wetlands, farmlands and the urban areas. Mainly because of the arid and semi-arid climatic conditions, desert grasslands and steppes have emerged has the major ecological types. The grassland ecosystem alone covers about half of Ningxia.

In terms of geomorphic types and economic development, Ningxia can be divided into 3 main ecological zones, namely the Yellow River Irrigated District (YERID) in the plains of the north, the dry and desert districts (DDD) in the central part, and the mountainous and loess hilly districts (MLHD) in the south. In MLHD, the annual precipitation varies from 400 to 600 mm, 60% of which is concentrated from July to September and mostly as heavy rain. Thus, rainstorms and floods have posed as serious problems, with more than 90% of the land suffering from water erosion and soil loss. In contrast, DDD has very limited precipitation of less than 300 mm/year and suffers from intensive evaporation and land desertification with plenty of sunshine. Because of the extreme dryness, about 88% of the land has suffered from erosion, making it the most difficult place in Ningxia for ecological construction and poverty reduction. However, being relatively flat and near to the Yellow River, it is highly suitable for implementation of lift irrigation. In Ningxia, YERID is the most important place for agricultural production. With development of irrigation for agriculture of more than 2000 years, over 400,000 ha of productive farmlands are now in existence. Although the farmlands constitute only a third of Ningxia's total farmlands, its grain production and agricultural output value is above two-thirds that of Ningxia and its GDP about nine-tenth Ningxia's total.

1.3 Relationship between poverty and ecosystems.

In general, the distribution of poverty matches well the ecological fragile regions. Poor people are mostly distributed in the desertified areas in DDD and MLHD, where the former has 83.4% desertification and the latter 80% of soil erosion. In these areas, the ecological environment is naturally fragile, with low functionality in water source and conservation, sand fixation and soil conservation, windbreak, regulation of micro-climate and the biodiversity. The ecological balance is very sensitive to the impacts of human activities, resulting in increasing conflicts between the bearing capacity of the ecological environment and the demands for economic-social development. Presently, local economic development has lagged and the population is becoming poorer due to limited supporting ecosystem services. In these areas, the poor depend very much on the natural environment, even though the latter is very harsh, and thus frequently runs into deep cycles of poverty and unending environmental deterioration.

The date, the Ningxia government has implemented many programmes and measures to reduce poverty through ecosystem management, examples of which, among others, have included the Slopping Land Conversion Programme, Free-Grazing Ban Policy, Ecological Migration, Water Storage Infrastructure

Construction, and Terracing The Mountain Areas. As a result, Ningxia has made great achievement, such as increasing the forest coverage from 8.4% to 9.8%; increasing grass production by 30%, and decreasing desertification land by 0.23 million ha. The natural grassland coverage rate increased from 20% to 60%, while the desert grassland area reduced by 25,400 ha, and the flow sandy-land decreased by 30.2%. Sand storms have decreased 5 times by 2005 and their intensity weakened by 50%. By 2006, about 2.36 million people (55% of Ningxia's rural total) had solved the problem of access to clean drinking water. And by 2007, Ningxia had built 24 resettlements and 45,330 ha of farmland at YERID and had implemented lift irrigation schemes in favour of 353,000 re-settlers.

2 Challenges and research needs on ecosystem management for poverty reduction in Ningxia.

2.1 The challenges

2.1.1 Lack of capacity to effectively manage ecosystems for poverty reduction.

In general, Ningxia is an ecologically arid and semi-arid region with fragile ecosystems and low productivity. Annual precipitation is only 400 mm on average with water deficiency a major constraint for ecosystem functioning and processes. Consequently, the supply of ecosystem services is limited and the region impoverished. Water scarcity has close relationship with inactive soil microorganisms and low production of organic matter, hence the cycling of minerals and energy in the ecosystem is slow and the ecosystem structure very simple. Loss of vegetation cover and wind and water erosion further reduce the availability of minerals and the retention of any rainfall in the ecosystem to support plant growth or to recharge the ground water. The severe drought in 2004 has remarkable effects in aggravating poverty, especially with most rivers in the poverty regions drying up and 2.2 million people suffering from shortage of drinking water and massive loss in crop production. In general, the diminishing functions of the ecosystems, declining soil fertility and low and unstable crop production have worsened poverty. Off-farm income has been low and farmers have little capacity against natural disasters, which cause farmers to fall back into poverty. All these have posed a major challenge to find ways to develop appropriate strategies to manage the fragile ecosystems in Ningxia so as to overcome the poverty of people there.

2.1.2 Information gaps on the dynamics of ecosystems and effective use of water resources.

The development of effective strategies for ecosystem management requires up-to-date information on the dynamics of ecosystems, especially the spatio-temporal changes of available water resources in the poverty regions. Also, other local information relevant to Ningxia is lacking, particularly that concerning the supply of ecosystem services relating to regulating, supporting and cultural functions of ecosystems. Since proper understanding of all these is crucial for developing the needed strategies to manage ecosystems for poverty reduction, their lack in information has posed a major challenge.

2.1.3 Lack of mechanism to involve multi-stakeholders in ecosystem management and poverty reduction.

Besides having good information dissemination, it is crucial to also have effective exchanges and communication among the stakeholder agencies and individuals who are involved with ecosystem management, such as farmers, local scientists and experts from government organizations, academic institutions and the private agencies, NGOs and the international agencies. Presently, there is lack of the mechanism to involve all these multi-stakeholders and this poses a major challenge for effective management of the ecosystems towards poverty reduction. Development of such a mechanism is urgently needed in Ningxia where poverty has long been an intractable social-economic problem for sustainable development.

2.2 Research needs

2.2.1 Optimizing water allocation among the regions in Ningxia

The per capita water resources in Ningxia is about 1:11 of the national average level and there is big water deficit between water supply and demand. Thus, to increase efficient water use is one of the most important strategic measures to resolve this issue and research priority should be accorded to it. Examples would include water-saving irrigation technology in YRID, diverting water for irrigation in the central arid area, and water retention in the southern Loess hill area. One other important aspect is to establish a highly efficient integrated system of utilizing water resources, which also combines biological techniques into engineering infrastructures that take into consideration the water demand and supply management.

2.2.2 Increasing farmland productivity and population carrying capacity

Different approaches are necessary to address the poverty issues for the different sub-regions in Ningxia because of specific conditions of the sub-regions and their different priority needs. For regions away from river sources and where the farmers are very poor, the research needs would primarily be to increase farmland productivity through sound provisioning ecosystem services. However, for those which are in the Yellow River Irrigation Area, the research needs are different. In such areas, the research would be finding ways to ensure the farmlands are well protected from erosion and damage by floods (e.g. through construction of high quality protective barriers) as well as practices that do not pollute the river ecosystem in the vicinity.

2.2.3 Sustainable management of poverty communities following 'ecological migration'.

There are about 300,000 absolute poor people living in the remote mountain area who experience great difficulties to survive because of limited natural resources and the effects of frequent natural disasters. Traditional poverty alleviation approaches do not work in this fragile area with harsh conditions. So called 'ecological migration' or transmigration is found to be a practical and effective way to relieve them of the environment pressure and poverty. However, such massive re-settlement of poor people from the poverty stricken areas to more productive lands needs to have many associated requirements in place to achieve success. Some potential measures may include developing or improving irrigation facilities, watershed management through afforestation, confined livestock raising, grassland reseeding, building catchment dams, tree planting for windbreaks, and other supporting off-farm employment. To confirm their values, it is necessary to conduct research on them and to determine suitable options for implementing the 'ecological migration', including developing appropriate management approach to sustain the 'ecological migration' and protecting the ecosystems in the areas of re-settlement.

2.2.4 Develop supporting technologies for agricultural diversification and production.

Although Ningxia is facing shortages of resources and possesses fragile ecosystems, it however has great potential for diversification of its agricultural production. At least more than 20 kinds of regional industries are believed possible, such as production of wolfberry, forage, potatoes, etc. However, the needed information is presently insufficient. It is therefore necessary to undertake research on the supporting technologies, including the relevant facilities and the market potentials of developing them into a regional industry.

2.2.5 Development of ESPA-related policies, with focus on the environment, economics and poverty, and industrial development.

In order to speed up the local economic development and poverty reduction as well as to restore existing deteriorated ecosystems, Ningxia should undertake policy research, in particular on:

- The development and enactment of more focused policies on environmental protection in relation to ecosystem services for poverty reduction.
- Understanding the resource capacity of ecosystems to ensure that appropriate mitigating measures concerning environmental degradation can be developed and implemented on an industrial scale.

2.2.6 Integrated ecosystem management approach.

The forest coverage in Ningxia is rather low, being only about 50% of the national level. With increasing concern on the impacts of climate change that can lead to more frequent as well as more serious drought conditions, it is envisaged that with the passage of time there would be increasing difficulties to undertake desertification control to protect the environment and the associated ecosystems. It is thus urgent that Ningxia should place immediate priority to conduct research towards a deeper understanding of the desertification processes and how to manage the related impacts, including the modes for ecosystem restoration. Among other approaches, simulation modelling should also be given consideration as an important research tool and approach.

3 Strategies for poverty reduction in relation to ecosystem services and management in Ningxia

3.1 Strategies for efficient use of water resources.

This would involve an integrated approach to efficient utilisation of water resources based on a scientific basis and understanding. All available water resources will be taped and allocated systematically; water resources from local water influx, river water of the Yellow River, precipitation, surface and groundwater.

The water will be allocated according to needs to various sectors in order to resolve the existing water shortage problems in some quarters. In particular, attention would be given to the urban residential areas, agricultural production (especially irrigation), the industries, and for activities to protect the ecology of ecosystems and their services. There will be new water pricing mechanism to ensure that there is fair and equitable distribution and use of the water resources, and the production and maintenance of high quality water for human consumption.

3.2 Stategies relating to 'ecological migration'.
The thrust of the strategies would be to ensure that there will be adequate water and other resources available to the poor communities undertaking the 'ecological migration' so that they can move away from poverty. The process would also make certain that there will be none or only limited effects on the environment and its associated ecosystem services, especially ensuring that environmental preservation be given priority consideration so as to create a new harmonious relationships between human and the ecosystem resources. According to 'ecological migration' plan, there are about 200,000 people for re-settling from 2008-2012.

3.3 Strategies on efficient land use.
Ningxia will continuously establish the water conservancy forests, soil and water conservation forests, wind prevention and sand fixation forests, water retention forests on farmlands, protect natural forests, rehabilitate natural grassland vegetation, establishment of more grasslands to improve water conservancy, soil retention, carbon sequestration, oxygen production and environmental purification. It is also planned to have establishment of high-standard basic farmlands to further increase land productivity and reduce soil reclamation rate.

3.4 Strategy on agricultural structure adjustment.
Change will be made to people's passive acceptance of natural adverse conditions (e.g. drought, floods, etc) and not taking pre-emptive measures. A pro-active approach will be initiated and promoted. This will involve strengthening those agricultural industries that have good potentials for high productivity. Farmers and others helping them will be given capacity building to strengthen their self-development on agricultural and rural economy, good and efficient agricultural practices, water-saving methods (through irrigation and otherwise), understanding of and how to pre-empt and be prepared to overcome harsh natural conditions (such as dry land farming). Through local development and promotion, farmers could adopt specific planting/breeding materials and technologies that would fit into the local ecological conditions and are conducive to restoring the ecosystem functions and services. Through such efforts and strategies, people's income can be increase to reduce poverty.

3.5 Demonstration strategy.
To demonstrate the ecological poverty reduction strategies highlighted above, select a tributary of the Yellow River or/and Qingshui River, which has the most fragile ecological environment and the lowest level of poverty. By doing so, all concerned, especially those in poverty, will be able to learn and be convinced on how to take the necessary countermeasures to overcome poverty while at the same time preserve the ecosystems and their services for their benefits.

Annex 5

Ecological zones and land use maps

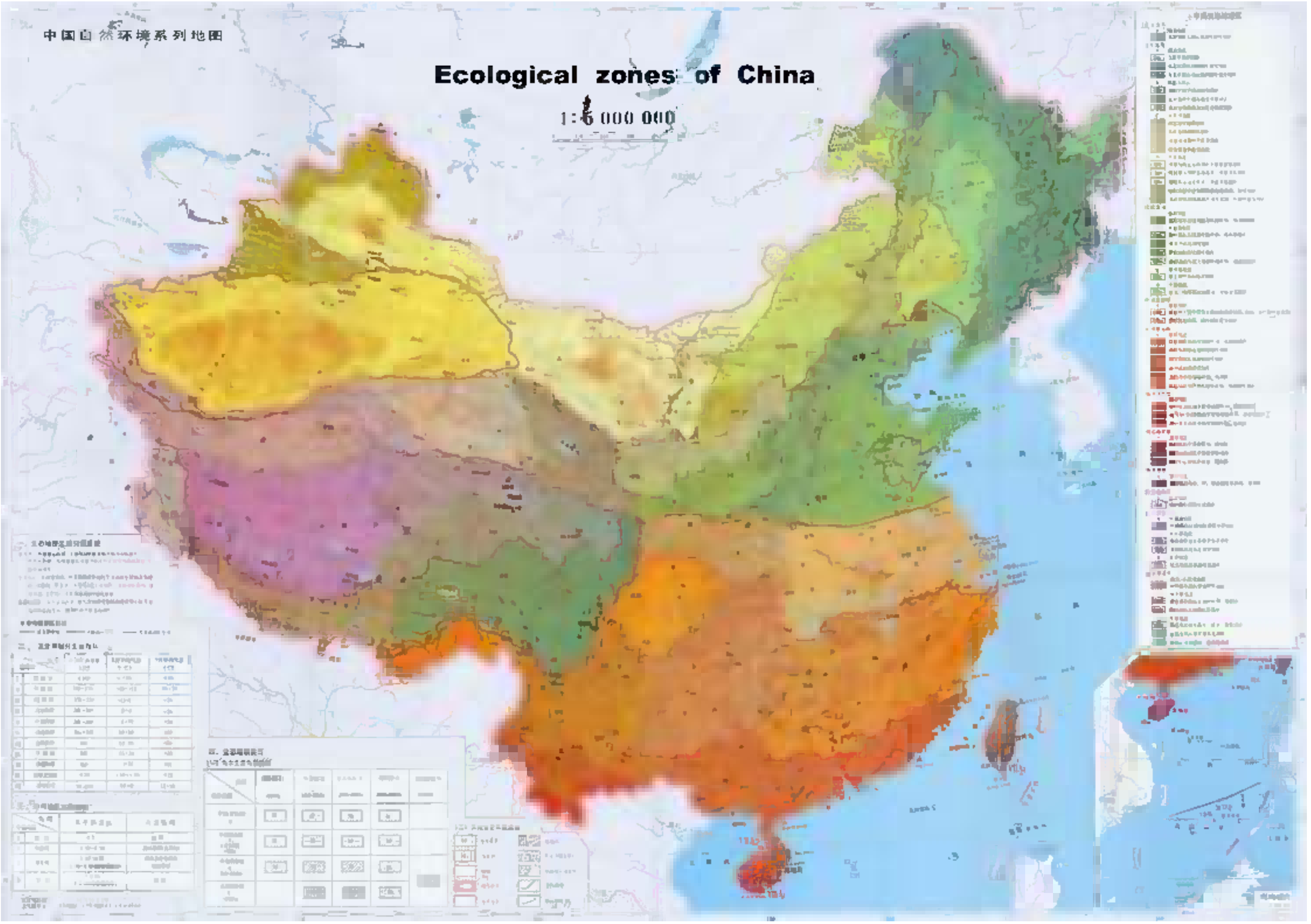


Figure AN5.1 Ecological zones of China (Source: IGCAS, 1999).

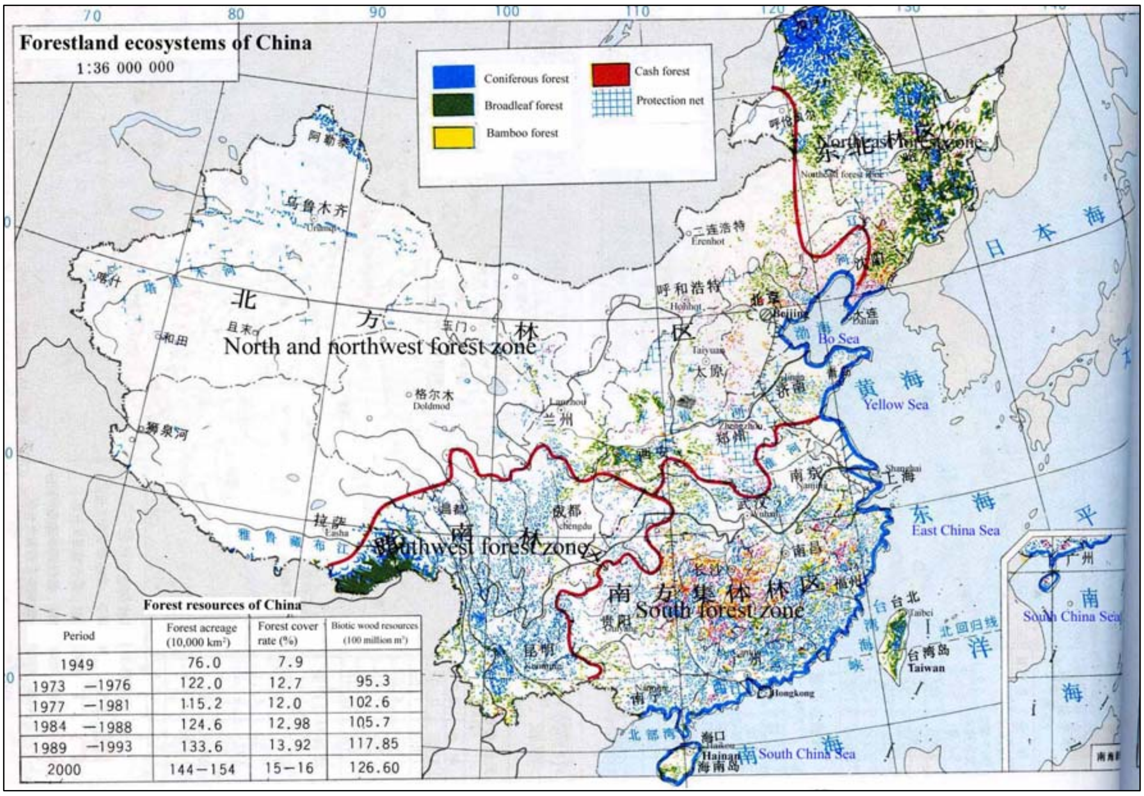


Figure AN5.2 Spatial distribution of forestland in China (Source: Liu, 1998)

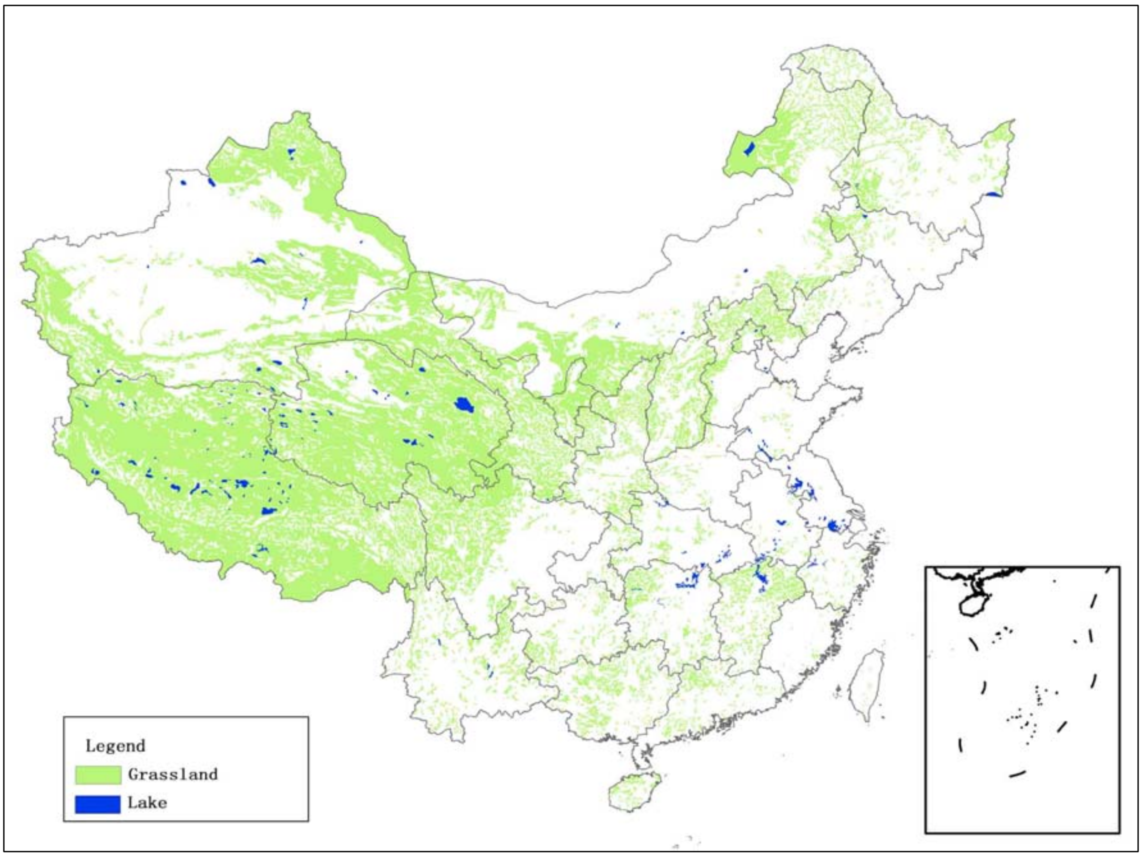


Figure AN5.3 Spatial distribution of grassland in China (Source: Liu, 1998)

Annex6

Ecosystem Services Knowledge Gaps

Ecosystem services	Volume of literature	Details	Knowledge gaps
PROVISIONING SERVICES	**High**	Inventories of many ecosystem products	Interlinkages with other ecosystem services
Timber (and fuelwood)	High (low)	Detailed inventories of timber supply by province, including separation of natural forest and plantation timber. Areas of low and high timber resources identified.	Potential knowledge gap in sustainable production of timber from plantations. Little information on the status of fuelwood resources and demand.
NTFPs	Low	Localised trade and market information on major NTFP products in the Southwest.	Little information for China as a whole. No detailed information for status, distribution and sustainable use levels
Water supply	High	Current water stress issues and regions with low per capita water supply identified. Major river and groundwater supplies well covered.	Less information linking regions with high agricultural water demand and water supply. Little information on water quality.
Freshwater fish (and wild meats)	Medium (none)	Relatively detailed inventories of aquaculture production and trade. Modelled fish capacity production for western China	Limited knowledge of national capacity for fish production, or sub-national distribution of fish resources. Inventories of increased production mask declines in fish stock status. No information on wild meat use and supply
Livestock	High	Detailed inventories of livestock production for the whole of China and by region. Modelled livestock production capacity of western China	Area of grassland used for livestock production and grassland resources per head of livestock.
Arable crops	High	Detailed inventories of areas of arable land and production of food crops (and cotton) by region.	Less emphasis on non-food crops other than cotton. Little information on trends in productivity of cropland.
Genetic resources	Medium	Species inventories and identification of areas of high genetic diversity	Species status and distribution of important bio-medical genetic resources
REGULATING SERVICES	**Medium/Low**		
Erosion regulation	Medium	Large amount of literature outlining erosion as a major environmental issue in China	Detailed information on areas of land with erosion regulating services, and their distribution in relation to poverty areas
Forests	Medium	Some localised example of the importance of forests in preventing soil erosion, mainly in the Yangtze River area. Some localised valuation studies.	Country-wide analysis lacking, needed to inform management strategies. Little analysis of supply according to forest types to inform plantation and land use management

Wetlands	Low	-	Contribution of wetlands to erosion regulation
Grassland	Low	No information on contribution of grasslands to erosion regulation, other than to site their degradation as a cause.	Identification of grassland areas with and without erosion regulation capabilities. Major knowledge gap of how to manage grassland for erosion regulation, particularly in the north and west
Cropland	Low	Identified as being a cause of soil erosion	Arable land use types and practices with high and low erosion regulation capabilities to inform management
Deserts	Low	Identified as a problem in soil erosion	Management options to reduce erosion impacts
Water regulation and conservation	Medium	Identified as one of the major ecosystem services in China given water shortages and flooding problems	Ability of ecosystems to conserve and regulate water in their current states, either nationally or sub-nationally, and linkages to regional patterns of water stress and poverty
Forests	Medium	A number of studies highlight the importance of forests around the Yangtze River.	Analysis restricted to the Yangtze River area. No assessment of contribution of different forest types
Wetlands	Low	Recognition of the importance of wetlands in flooding mitigation and water storage	Contribution of wetlands to water flow regulation and conservation, particularly in north and north west China, and the impacts of wetland degradation on their ability to provide this service.
Grassland	Low	Some information on the potential of grassland vegetation to provide water regulation and conservation, particularly alpine meadows	Contribution of grassland to water flow regulation and conservation, particularly in north and north west China
Cropland	Low	Identification of some areas of cropland, such as paddy fields, that use a lot of water resources. Problems with irrigated land.	Identification of areas in which water shortages are both a problem for and exacerbated by agricultural land use on a national and sub-regional scale to inform management practices.
Deserts	None	-	Desert oases and importance in water conservation
Water purification	Low	Localised individual study on importance of wetlands and forests in water purification, and recent declines in such services due to degraded wetlands	Ability of ecosystems in China to provide water purification services in their current state, in particular wetland areas
Climate regulation	High	National and subnational estimates of carbon storage	Emissions and storage of other GHGs and atmospheric pollutants. Standardised methodologies for carbon estimates in soil and vegetation
Forests	High	Large number of studies on amount of carbon regulation provided, distribution, and trends. Value of different types of forest in carbon regulation	As above

Wetlands	Low	Studies highlighting importance in carbon regulation	Trends and distribution of carbon regulation, role in terms of storage of other GHGs and emissions from degraded wetland area
Grassland	High	Large number of studies on amount of carbon regulation provided, and trends. Large amount of disagreement.	Value of different types of grassland area in climate regulation, and distribution of important areas.
Cropland	Medium	Some studies on ability of cropland to regulate carbon, and emissions of other GHGs Some disagreement on role of croplands as source or sink.	Role of different management practices and types of cropland.
Deserts	Low	Suggested to have minimal climate regulation capabilities	
Disease regulation	None	Anecdotal information regarding potential increase of disease e.g. with reduced river flow	Role and importance of ecosystem functions in China for disease regulation
Pest regulation	None	-	Importance of ecosystem functions in China for pest regulation
SUPPORTING SERVICES	Low		
Primary Productivity	Medium	A variety of estimates on a national scale, general distribution of NPP across China	Detailed analysis on a sub-national level (with the exception of northeast China). Lack of standardised methodologies
Forests	High	Estimates of NPP at a national scale, some regional areas of high productivity identified, and trends identified. Value of different types of forest.	Some estimates vary widely, although general trends remain the same.
Wetlands	None	-	Status, trends, and distribution
Grassland	Medium	National supply and distribution of grassland NPP. Regional areas of high and low productivity identified	Identification of trends in NPP, and value of different grassland types. Implications of low productivity in western areas, interlinkages with poverty areas for identification of potential management strategies
Cropland	Medium	National supply of cropland NPP	Trends and distribution of NPP in cropland areas and implications for the sustainability of agricultural practices
Deserts	Low	A limited number of estimates of NPP of barren land	
Soil formation	None	-	Role of each ecosystem type and management practices in soil formation, particularly in degrading areas.

Nutrient cycling	Low	A limited number of examples of importance of forest ecosystems in nutrient cycling	Analysis of nutrient cycling services provided by all major ecosystems, and interactions with management practices.
CULTURAL SERVICES	Low	Very limited information for some ethnic groups	Status, trends, and values for ethnic and majority groups
Spiritual and religious values	Low	Identification of the importance of nature to a wide number of religions, the existence of sacred groves and spiritually important areas. Particularly in southwest China	Role of natural areas and species in spiritual and religious systems and practices, including agriculture and land water management
Cultural heritage and identity	Low	Identification of long standing cultural traditions involving natural ecosystems	Role of ecosystems and landscapes in cultural practices and language
Knowledge systems	Low	Mention of traditional farming and medicine practices	Traditional knowledge of management of ecosystems and species
Education	None	-	Use of natural areas for education and scientific research for sustainable management and poverty reduction
Recreation and tourism	Low	Figures of tourist numbers, extremely localised	National and sub-national figures of tourist numbers visiting natural areas such as national parks. Potential of natural areas to sustain tourism linked to poverty reduction

Annex7

Additional data and analysis of drivers of change in ecosystems and poverty

Population change (Section-B1)

TableAN7.1 Population growth in China 1965-2050

Year	population, 10000	growth rate
1965	72538	0.0289
1970	82992	0.0288
1975	92420	0.0172
1980	98705	0.0119
1985	105851	0.0143
1990	114333	0.0145
1995	121121	0.0106
2000	126743	0.0066
2005	130756	0.0059
2007	132168	0.0055
2020	139583	0.0031
2050	146903	0.0009

Source: Liang, 2005

TableAN7.2 Urbanization process in China 1965-2050

Population and urbanization forecast year	Total population, 10,000 persons	Urban population, 10,000 persons	Urbanization proportion	Non-agricultural population, 10,000 persons	Non-agricultural population proportion
1965	72538	13010	0.179	12122	0.167
1970	82992	14736	0.178	12660	0.153
1975	92420	16417	0.178	14278	0.154
1980	98705	19765	0.200	16801	0.170
1985	105851	25097	0.237	21478	0.203
1990	114333	30195	0.264	23887	0.209
1995	121121	35174	0.290	28563	0.236
2000	126743	45906	0.362	32613	0.257
2005	130791	56245	0.430	40935	0.313
2007	132168	60042	0.454	44638	0.338
2020	139583	83470	0.598	66871	0.479
2050	146903	109067	0.742	95285	0.648

Source: China Statistical Yearbook 1996-2007, forecast by Liang in January, 2008

Economic growth (Section-B1)

TableAN7.3 Economic growth in China 1978-2006

Year	GDP, 100 million CP Yuan	GDP Net gross rate	index	GDPPC, CP Yuan	GDPPC index
1978	3645.2	111.7	100.0	381.2	100.0
1980	4545.6	107.8	116.0	463.3	113.0
1985	9016.0	113.2	192.9	857.8	175.5
1990	18667.8	104.1	281.7	1644.0	237.3
1995	60793.7	109.3	502.3	5045.7	398.6
2000	99214.6	108.6	759.9	7857.7	575.5
2005	183867.9	111.2	1200.8	14103.3	880.7
2006	210871.0	111.1	1334.0	16084.0	972.9

Data source: China Statistical Yearbook 1996-2007

Economic development forecast (Section-B1)

TableAN7.4 Economic growths in China and major nations 1992-2020 by per capita GDP PPP$

Year	US	UK	Australia	Japan	Germany	France	Argentina	Russia	China
1992	24233	18505	17287	20942	19580	19249	9357	7293	1692
1995	27258	21503	20175	22878	21424	21005	10474	5947	2495
2000	34139	26950	25423	25793	25466	25656	12210	7067	3913
2005	41124	33623	31566	30858	29525	30427	14513	11010	6771
2010	49798	42491	40003	37561	36780	36682	20343	15954	12187
2015	60828	53528	50502	44179	43819	43878	25241	19830	21092
2020	74301	67431	63757	51962	52206	52485	31318	24647	36503

Source: IMF database, forecasted by Liang in January 2008

Development strategy (Section-B2)

The overall regional development strategy in China, as described in the 11th Five-Year plan (2006 – 2011) is to "adhere to the implementation of large-scale development of the western region, revitalize northeast China and other old industrial bases, promote the rise of the central region, and encourage the development of the eastern region to lead the overall development, improve the coordination mechanism for regional interactions, and form a rational regional development pattern."

The regional objectives in 11th Five-Year plan include the following environmental goals:
Western region - consolidate and develop the achievements of returning farmland to forest, and continue to promote grazing ban, natural forests protection and other ecological projects, strengthen the protection of vegetation, increase the strengthen for the desertification and rocky desertification control, and water pollution control in key areas. Strengthen the Qinghai-Tibet Plateau ecological protection and construction of security barriers. Support the transformation of resource advantages into industrial advantages, vigorously develop the characteristics industries, and strengthen the development and processing of clean energy, advantage mineral resources, and support the development of the advanced manufacturing industry, high-tech industry and other competitive industries.

Northeast region - strengthen black soil erosion control and western northeast China's comprehensive management of land desertification.
Central region - Strengthen the construction of modern agriculture, especially major grain-producing areas,

increase input in agricultural infrastructure construction, increase production capacity for grain and other staple agricultural products, and promote value-added processing of agricultural products.
Eastern region - strengthen protection of farmland, and the development of modern agriculture. Raise resources efficiency, especially for land and energy, strengthen environmental protection and increasing sustainable development.

Timber Demand / Production (Section-A3)
China's key forestry projects in "10th Five-Year Forestry Plan" period includes natural forest resource protection project, returning farmland to forest project, Beijing and Tianjin sandstorm source treatment project, "Three North" and the Yangtze River Basin shelter construction project, wildlife Conservation and Natural Reserve Construction Project, and key areas fast growing timber base construction project (State Forestry Administration, 2006).

Three new key forestry projects are added in China's "11th Five-Year Forestry Plan" period, they are Coastal Shelterbelt Program, Wetland protection and restoration project, and comprehensive management on rocky desertification project in South Karsts area. Sixteen key forestry areas in China's "11th Five-Year Plan" period are: river sources region; the upper reaches of the Yangtze River region; the Three Gorges reservoir area; the Danjiangkou Reservoir source region; surrounding areas of Dongting Lake and Poyang Lake; key rocky Desertification area in the South; Beijing and Tianjin sandstorm source areas; the Loess Plateau Area; the Alxa region; Horqin sandy land; Maowusu sandy land; Hulun Buir sandy land; Shiyang River Basin; the southern margin of Junggar Basin and the area around Ebinur Lake Basin; the Tarim Basin surrounding areas; and Tibet's 4 rivers region (11th Five-Year and long-term Forestry development Plan, 2006).

TableAN7.5 Timber production and timber self-sufficiency index in China (1996-2006)

Year	Timber production, 10,000 cu.m	Logs import, 10,000 cu.m	Paper pulp import, 10,000 tons	Wood sawn import, 10,000 cu.m	Timber self-sufficiency index
1996	6710	319	147	93	0.8740
1997	6395	447	154	133	0.8447
1998	5966	482	220	168	0.8000
1999	5237	1014	310	272	0.6779
2000	4724	1361	335	358	0.6081
2001	4552	1686	490	402	0.5338
2002	4436	2433	526	540	0.4679
2003	4759	2546	603	551	0.4664
2004	5197	2631	732	601	0.4620
2005	5560	2937	759	597	0.4631
2006	6612	3215	796	607	0.4905

Note:
Data source: China Statistical Yearbook 1996-2007
Conversion index for calculating timber self-sufficiency index are as follows:
1 cu.m of Logs = 1 cu.m timber
1 ton of Paper Pulp = 3.5 cu.m timber
1 cu.m of wood sawn = 3.5 cu.m timber
Small amount of wood Sawn export in China is not being considered in timber self-sufficiency index calculation. Wood Sawn export in China is 615324 cu.m in 2005, 808270 cu.m in 2006.

International trade of wood related product, paper and paperboard is not being considered in timber self-sufficiency index calculation. Paper and paperboard import in China is 5.21 million ton in 2005, 4.36 million ton in 2006.

Impacts on ecosystem services (Section-A3)
The increasing demand for forest products has driven the growth of artificial forest area, and thus more and more natural forest is covert into artificial forest to meet the increasing human needs. The result of these activity related to ecosystem service is increase of forest products and decrease of biodiversity. The ecosystem's service for human being is growing, but the overall ecosystem service may be decreasing.

Cultivated land use change (Section-A2)
In the five years between 2000-2005, the cultivated land area decreased by 6.161 million hectares, of which land development increased 1.098 million hectares of arable land, agricultural restructuring increases 990,000 hectares of arable land, land consolidation increases 331,000 hectares of arable land, land reclamation increases 288,000 hectares of arable land, construction occupies 1.257 million hectares of arable land, 6.14 million hectares cultivated land was turned into ecological use, agricultural restructuring reduced 2.118 million hectares of arable land, the natural hazard destroyed 316,000 hectares of arable land. Because of arable lands turned into ecological use is low quality arable land, the construction occupation of cultivated land become the main reason in farmland decreasing. In 2000-2005, construction land increased by 1.927 million hectares, in which 1.257 million hectares is arable land, accounts for 65.2% of the new construction lands.

TableAN7.6. Arable land changes in China, 2000-2005

Items, 10000 ha	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2000-2005 accumulative change*
Cultivated land area at year beginning	12920.5	12824.3	12761.6	12593.0	12339.2	12244.4	-676.1
Increase of Cultivated land	60.4	26.6	34.1	34.4	53.0	62.3	270.8
Land consolidation	4.2	4.4	5.2	6.4	5.7	7.1	33.1
Land reclamation	6.6	2.4	3.5	3.3	6.0	7.1	28.8
Land development	18.4	13.5	17.3	21.4	22.8	16.5	109.8
agricultural restructuring	31.3	6.3	8.0	3.3	18.5	31.6	99.0
decrease of Cultivated land	156.6	89.3	202.7	288.1	147.8	98.5	-983.1
Land for construction use	16.3	16.4	19.6	22.9	29.3	21.2	-125.7
destroyed by natural hazards	6.2	3.1	5.6	5.0	6.3	5.4	-31.6
Turned to Ecological use	76.3	59.1	142.6	223.7	73.3	39.0	-614.0
agricultural restructuring	57.8	10.8	34.9	36.4	38.9	32.9	-211.8
Cultivated land area at yearend	12824.3	12761.6	12593.0	12339.2	12244.4	12208.3	-616.1

Liang Shumin, 2006, The evolution of agricultural planting structure in China and its engine analysis, Annual report on economic and technological development in agriculture 2005, China Agriculture Press, Beijing, May 2006, p226-235

Government Agencies most relevant to ecosystem management and poverty reduction (Section-B2)
The State Council Leading Group Office of Poverty Alleviation and Reduction
Ministry of Land and Resources
Ministry of Communications
Ministry of Water Resources

Ministry of Agriculture
State Environmental Protection Administration
National Bureau of Statistics
State Forestry Administration
Other related Ministries and Commissions under the State Council
State Development and Reform Commission
State Ethnic Affairs Commission
Ministry of Finance
Ministry of Railways
State Population and Family Planning Commission

Major land-use and infrastructure projects impacting ecosystems and poverty (Section-B2)
Transportation
11th Five-Year National Comprehensive Transportation System Development Plan
11th Five-Year National Highway and Waterway Transportation Development Plan
11th Five-Year National Railway Network Plan
Medium and Long-Term National Railway Network Plan
National Highway and Express Highway Plan
National Inland Waterway and River Port Layout Plan
National Rural Highway Construction Plan
Qinghai-Tibet Railway
The Yangtze River Waterway Development Plan
West-East Electric Power Conveying Project
West-East Gas Conveying Project
Rural highways construction project, to build or renovate 1.2 million km of rural roads.

Desert Control and Ecological Construction
Desert Control Project in Northern China
Grazing Ban Project – Ministry Of Agriculture
Shelterbelt Afforest Program in the Middle and Upper Reaches Of Yangtze River
Three-North Shelterbelt Afforest Program - State Forestry Bureau.
Turning Cultivated Land to Ecological Use – Ministry Of Agriculture
Turning Cultivated Land to Forests – State Forestry Administration.

Key ecological protection projects in China's 11th Five Year Plan (Section-B2)
A. The natural forest resources protection project, effectively implement the management and preservation for 94.18 million hectares of natural forests and other forest, and afforest 5.79 million hectares in the upper reaches of the Yangtze River, and the upper and middle reaches of Yellow River.

B. The project of returning farmland to forest and grassland, continue to implement the policy of returning farmland to forest and grassland in the Yangtze River and Yellow River Watershed and the northern sandstorms areas.

C. Grazing ban project, improve seriously degraded grasslands in four patches including the eastern part of Inner Mongolia, western part of Inner Mongolia, Gansu and Ningxia, eastern part of Qinghai-Tibet Plateau, and northern part of Xinjiang.

D. Beijing and Tianjin sandstorm source control project, returning farmland to forest 340,000 hectares, afforest of barren hills 290,000 hectares, afforest 1.27 million hectares, afforest by aerial seeding 1.45 million hectares, sand silviculture closure of Grass 950,000 hectares, grassland management 2.91 million ha.

E. Shelterbelt system construction project, including the 4th term of "three north" shelterbelt afforest project, the Yangtze River and Pearl River shelterbelt, and Taihang Mountain shelterbelt, afforest in plains and coastal shelterbelt system works. Push forward the construction of the shelterbelt for Three Gorges Reservoir area.

F. Wetland protection and restoration, establish 222 wetland protection zones, including 49 national wetland protection zones, and restore key wetlands through the rational measures of water resources allocation and management.

G. Ecological protection and construction for 3 river sources nature reserve in Qinghai, including grazing ban 6.44 million hectares, returning farmland to forests and grasslands 6,500 hectares, closing hillsides to facilitate afforest, prevention of land desertification, wetlands preservation, and soil management 800,000 hectares, rodent control 2.09 million hectares, and 50,000 hectares of soil erosion control.

H. Soil and water conservation project, newly increase the soil erosion control area of 19 million hectares. Implementation of the Shiyang River watershed comprehensive management.

I. Wildlife Conservation and Nature Reserves building. Construct and improve a number of nature reserves, and continuing to implement the rescue works for critically endangered species of wild fauna and flora.

J. Comprehensive management of rocky desertification, through vegetation protection, returning farmland to forest, sterile mountain closure for forest and grass restoration, and grass cultivation for livestock, rationally exploit and utilize the water resources, implement measures as land improvement and water and soil conservation, change the cultivation system, construct rural methane pool, poverty alleviation by migration, enforce the management control of rocky and Desertification.

Restricted development zones (22) **(Section-B2)**

Da xiao xing'anling forest ecological function zone
Changbai Mountain forest ecological function zone
Sichuan-Yunnan forest ecology and biodiversity function zone
Qinba biodiversity function zone
Southeast Tibet edge of Plateau forest protection of the ecological function of natural ecosystems.
Xinjiang's Altay Mountains forest ecological function zone
Qinghai 3 river source area grassland, meadow and wetland ecological function zone
Xinjiang's Tarim river desert ecosystem function zone
Xinjiang Aerjin desert grassland ecological function zone
Qiangtang Plateau northwest of Xizang tundra ecological function zone
Sanjiang Plain in Northeast China wetland ecological function zone
Northern Jiangsu coastal wetlands ecological function zone
Sichuan Ruoergai plateau wetland ecological function zone
Gannan Yellow River important water supply ecological function zone
Sichuan-Yunnan dry and hot valley ecological function zone
Inner Mongolia Hulun Buir grassland Desertification prevention zone
Inner Mongolia Horqin desertification prevention zone
Inner Mongolia Hunshandake desertification prevention zone
Inner Mongolia Maowusu desertification prevention zone
Loess Plateau hilly area gully soil erosion control zone
Dabie Mountain soil erosion control zone
Guangxi, Guizhou and Yunnan karsts stone desert prevention zone

Major Water Diversion Projects (Section-B2)

As listed in the11th Five-Year National Water Conservancy Plan:

- Datong River to Qinwangchuang Water Diversion in Gansu
- South-North Water Diversion Project – East, Middle, and West Route
- Wanjiazhai Yellow River Water Diversion in Shanxi
- Three Gorges Key Water Control Project on Yangtze River
- Water Resources Development in Southwest China: The Yarlung Zangbo River, Nujiang, Lancang, and Jinsha, Yalong and Dadu River
- Zhujiang River Watershed Development and Management
- Lancang River Watershed Development
- Comprehensive Development for 3 Rivers in Southern Tibet

TableAN7.7 State of knowledge for impacts of climate change on ecosystem services (Section-B5)

Changes projected for:	*Volume of literature*	*Degree of agreement*
Climate and biodiversity		
Temperature	High	High
Precipitation	High	Medium
Ecosystem distribution	High	High
Species distribution	Low	-
Supporting and regulating services		
Productivity & carbon storage	Medium	Medium
Water regulation and quality	Medium	Low
Soil formation	None	-
Pollination	None	-
Nutrient cycling	None	-
Provisioning services		
Water supply	High	High
Arable crops	High	Medium
Freshwater fish and wild meats	None	-
Fuelwood and timber	Low	-
Biochemicals and genetic resources	None	-
Cultural services	None	-

Annex 8

Sloping Land Conversion Programme (Grain for Green)

The Sloping Land Conversion Programme (SLCP) was introduced in 1999 by returning farmed land on steep slopes to forest or grassland and giving compensation to farmers. Compensation includes grain, hence the alternative name of 'Grain for Green' for the SLCP. The programme in southwest China targets land with 25 degrees of slope or more, and in northwest China it targets land with 15 degrees of slope or more. The ten-year programme aims at converting 32 million hectares of bare or cultivated sloping land into forest or grass land, with a budget of over US$30 billion and affecting 60 million households, making it one of the largest land-set aside programs in the world (CCICED, 2006; Xu et al., 2006). The SLCP is intended to be a voluntary scheme and farmers receive annual compensation for loss of agricultural production (provisioning ecosystem services) of 100-175 kg of grain per mu[1], 20 yuan per mu to increase access to health and education, and 50 yuan per mu for seedlings or saplings planted, as well as free seedlings or saplings in the first year (Weyhaueser et al, 2005). The duration of the compensation depends on whether the specific sloped plot of land is converted to 'ecological' or to 'commercial' forest. Farmers in the upper and middle reaches of the Yellow River are estimated to receive 1,500 kg grain yearly (Yang, 2004).

Ecosystem management tools being used by the SLCP are the plantation of trees or grass and using rest through cessation of farming and exclusion of grazing. The main goal of the SLCP is to manage for regulating ecosystem services, namely reducing soil erosion and flood incidence. Under the SLCP the area prone to soil erosion in Tianshui City reportedly reduced from 314.4km^2 to 90.74 km^2. Ye et al. (2003) considered that the SLCP programme in the Min River basin, Sichuan greatly improved the environmental conditions and increased forest cover of the area, but no field data was provided for this conclusion. Uchida *et al.* (2007) state that under the SLCP "most observers agree that soil erosion has been greatly reduced", although evidence for was not provided. Peng *et al.* (2007) estimate that if the land planted with trees and grasses under the SLCP over 498 km^2 in Zhangye were to successfully maintain this vegetation cover it would result in an estimated 1.71Gg increase in Net Primary Productivity over three years.

It is likely that tree and grass planting on bare and eroded soils will increase the local mineral cycle and capture of solar energy, resulting in increased biomass and improved micro-climates for organic matter decomposition, soil formation and reduced erosion. The impact on the local water cycle is likely to be much more variable, depending on local soil and climate conditions. In regions where evaporation exceeds precipitation (high potential evapotranspiration) the planting of trees can result in a net loss of water from soils (soil dessication, Chen *et al,* 2008). The importance of this is emphasised with reference to the Loess Plateau, where sloping land tends to be dry, and re-vegetation schemes may actually enhance soil erosion, in part due to the disturbance of fragile soils (McVicar et al, 2007). Xu et al. (2006) consider that, "mostly the benefits of the SLCPderive from the effectiveness of the programme in being able to aid in the reduction of the build up of silt in irrigation networks and reservoirs and the reduction in downstream flooding. According to the work of MacKinnon and Xie (2001), the benefits could be as great as 3.9 billion yuan per year in foregone soil loss (which would be realized by less effort needed to clean up irrigation canals and reservoirs and the higher yields associated with more effective water control). Ning and Chang (2002) have estimated that the value of reducing soil erosion in net present value terms would be more than 50 billion yuan (a figure that is consistent with the numbers in MacKinnon and Xie). There would also be significantly less flooding that could benefit China (Xu et al., 2002)."

Several studies have examined the poverty impacts of the SLCP. The primary objective of the SLCP is ecosystem restoration rather than poverty reduction, and of 180 counties with the SLCP in 2004, 104 were poverty counties (Li, 2003). More than 52 million people are estimated to have benefited from the project, and a study found that five out of seven counties assessed reported satisfaction levels of over 90% with the SLCP and an improvement in farmer livelihoods (Xu et al, 2006). Ye et al. (2003) found that the SLCP programme in the Min River basin, Sichuan improved livelihoods because farmers received 11% more grain through the subsidy than otherwise projected from average yield of the area. Uchida *et al.* (2007) concluded that the SLCP has been

[1] 1mu=1/15ha

moderately successful in achieving its poverty alleviation objectives, based on a survey in 2003 of 359 households in Sichuan, Shaanxi, and Gansu provinces. They found that income from livestock activities and other assets of SLCP participants have increased significantly more than those of non-participants (due to programme effects). Only weak evidence was found that participating households have begun to shift their labour into the off-farm sectors.

An assessment of the social sustainability impacts of SLCP showed it to have brought $23.56 million yuan in net income to one million peasants of Zhangye Prefecture, in the Heihe River Basin in Northwest China, (Peng et al, 2007). Between 2002 and 2004, an estimated total of 190.59 million yuan of household income was generated for all rural households involved in the project in Zhangye. This income comprises government subsidies (49.15%), migrant worker income (40.10%), income from other local jobs (9.29%), income from planting grass and breeding livestock (1.27%), and seedling fees (0.19%). The reduction in cropland in rural Zhangye from the SLCP resulted in a sharp increase in surplus labour. Most of the surplus labourers either migrated to other regions to work or engaged in non-agricultural work locally, helped by information and skills training from local government. In Zhangye labour migration has proved to be an important measure to increase local rural household income, which rose by 1.8 times from 2000 to 2003. (Peng et al, 2007). This pattern is consistent with a household production model by Groom *et al.* (2006) which showed how, under certain conditions, the provision of the SLCP subsidies may enable participants to reallocate labor towards more lucrative off-farm activities. However, Grosjean and Kontoleon (2007) report that work by Bennett et al. (2004), Groom et al. (2006), Uchida et al. (2007) and (2005), Xie et al. (2005) and Xu & Cao (2005) suggests that the SLCP impact on participating household income levels, and on shifts to non-crop related income generating activities (such as off-farm labor or livestock activities), are not sufficient to make a substantial and long lasting change to farmers' pre-SLCP production decisions.

An early review of the SLCP (CCICED, 2002) identified a risk of the clearing of new land in a different location as a consequence of land conversion, especially if there were food price increases and shortages. CCICED (2002) reported that when pastureland was closed from grazing, herders tended to shift some of the grazing activities to other locations, for example, from Qinghai to Sichuan. Therefore, implementation of the land conversion program should be conducted in coordination with other programmes that aim to generate off-farm employment and restructure rural economies. CCICED (2002) also identified that in its first phase at least, a serious problem with the SLCP is that it lacked a formal monitoring and evaluation system to determine if the programme's basic environmental objectives are being met and to assess the socioeconomic impacts. Also monitoring and evaluation work was focused on indicators of implementation rather than indicators of program outcomes. For example, monitoring and evaluation reports identify the number of trees planted or the number of trees that have died, but not whether the programme is approaching its goal of restoring the ecosystem (CCICED, 2002).

The sustainability of the SLCP has been questioned, following the cessation of cash and grain subsidies in 2010 (Weyerhauser et al, 2005; Ye et al, 2003). Grosjean and Kontoleon (2007) used choice modeling from household and village level survey data from Ningxia and Guizhou provinces to assess the long-term sustainability of the SLCP. Their analysis found the major constraints on sustainability were weak and incomplete farmer property rights coupled with the high labour mobility transactions-costs associated with oversupply of on-farm labour. They also concluded that if the SLCP were to be renewed an important determinant for securing high levels of long term community support is the provision of better forestry training to local households, as well as enhanced autonomy in managing their reforested trees. Also, in the event that subsidies are not renewed farmers were not expected to reconvert back their reforested lands provided that the expected commercial value of the reforested trees is high.

Another concern about the SLCP has been that it may reduce China's grain output and ability to meet its food provisioning requirements (Ma & Fan, 2006; Xu et al, 2004), but Deng *et al.* (2006) conclude that conversion of cultivated land has not hurt China's national food security. Xu et al. (2006) found from modelling simulations that the SLCP has only a small effect on China's grain production and almost no effect on prices or food imports.

Annex9

Payment for Environmental Services (PES)

In the late 1990's, stimulated by a series of factors such as grassland degradation, decrease of forest, natural disasters like floods, arising environmental awareness, etc., the government began to explore more effective ways of protecting environment. The theoretical basis of PES includes the Value of Environmental Services, Environmental Externalities, Ecosystem, Ecological Asset, Public Goods, etc. The concept rates eco-environment as public goods, and has the features of externality. In China, The concept of PES that Wang Jinnan put forward were widely accepted, Wang thinks the PES includes 5 aspects of compensation: 1) Payment for Ecological Service, i.e. payment for those who provide ecological services; 2) Resource based Ecological Compensation (EC), i.e. compensating one source for occupying one, an EC based on natural resources; 3) Damage-Based EC, i.e. an economic punishment for destroying environment by individuals or enterprises; 4) Development Based EC, i.e. a compensation for those who protecting environment or giving up development opportunities for protecting environment, a compensation for development right; 5) Conservation Based EC, i.e. an investment in regions or objects of important ecological value.

Although the law on PES has not yet been promulgated, there are certain Resources Acts and Environment Protection Acts that have articles or clauses on PES such as the Forest Law, Grassland Law, Environment Protection Law, Sand Control Law, etc., Special Rules by State Council including Ordinance of Basic Farmland Protection, Ordinance of Grain-for-Green, Ordinance of Nature Reserve, etc., further promote the PES.

The practices of PES in China, are prior to the theoretical research, since the natural resource is owned by the state, the protection of natural resources and environment is mainly from the government's budget. From the 1990's, the central government has invested a large amount of money to purchase and pay for watershed services in order to restore the environment in the main river basins, since the watershed environment all over the country has worsened in different scales. At present, PES pilots are in the rich provinces like Zhejiang, Fujian, Guangdong, etc, and the key fields focus on ecological functioning zones, mining areas, watersheds and some ecological factors such as forest.

National purchase of environmental services is one of the main contents of PES in China, and it is mainly carried out through large state projects, including 6 large key forest projects, i.e. Sloping Land Conservion Project (SLCP), Natural Forest Protection Project (NFPP), Sand Control in Beijng and Tianjin Project (SCBTP), Key Shelter Forest in Three-North and Upstream of Yangtze River Project (KSFP), Wildlife Protection and Natural Reserve Construction Project (WPNRCP) and Construction of Fast Growth and Fruitful Forest Base in Key Areas Project (FGFFBP). In 1998 Bill of Amendment of Forest Act, the regulation clearly reads: the state will set up a fund for Forest Ecological Compensation (FFEC), and FFEC project is a state payment for ecological non-commercial forests.

Due to the limitation of central governmental fund which mainly targets the key water source areas, ecological functioning zones, natural reserves and ecological fragile areas, the local governments organize the up and down reaches to discuss, negotiate and sign agreements to pay for watershed services. Take the following for example, the compensation from Beijing municipality to the water source areas in Miyun reservoir and Guanting reservoir, compensation from upstream of Xiaoshun river to Tangpu reservoir in Zhejiang province, payment transfer from Dongjiang river source and water & electricity charges, PES in Qiandao Lake, Jinhua-Pan'an DAP mode in Zhejiang province, subsidy from downstream to upstream in Fujian province, etc.

On preconditions of economy, society, politics and law, plus the unclearness of environmental property right and duty in China, the unbalance between shortage of resources, environmental degradation and regional development has caused serious social and economic problems, having negative impacts on the scientific development and sustainable development. PES has become one of the important strategies of China's environmental and economic policy and development, and it is an inevitable choice when the society, economy and environment develop into a certain phase as in China.

Is the current policy on PES adaptable in China? How to set up and implement the framework of PES in China? Because the property rights of resources and lands are owned by the state, the distinction of property right against environmental services becomes a key obstacle to PES. Meanwhile, the PES faces a great deal of problems due to the lack of legislation and relative institutional arrangement, and it is still in a phase of theoretical research and exploration. It is difficult to define the main bodies and scope of watershed payment; to value the ecosystem services , or to determine the criteria of watershed payment.

Annex10

Studies of climate change impacts on ecosystem services

Theme	Region	Scenarios	Model	Results	Reference
Ecosystems	Global	2 x CO_2.over 100 to 200 years; simulated in seven GCMs: 4 older GISS, GFDL-R30, OSU and UKMO and 3 transient (HADCM2GHG, HADCM2SUL and MPI)	Seven GCMs driving MAPSS and BIOME3 vegetation models	On a global scale, Northeast China is one region experiencing greatest required migration rates for biomes shifting to new spatial locations	Malcolm *et al*. 2002
Ecosystems	Asia	3 X CO_2 = 990 ppmv by 2099	GENESIS driving BIOME3 vegetation model	In China, annual mean temperature increases by 4°C, with a mean change in precipitation of near zero. There are slight in the south of China, and slight decreases in the north. Increase in forest at the expense of savanna and shrubland.	Kutzbach & Behling 2004
Ecosystems and carbon (NPP)	National	2 x CO_2 = 500 ppmv by 2099. Mean temperature increase by 2.2 to 4.4 °C by the end of the 21st century in China	Hadley GCM driving BIOME3 vegetation model	Major expansion of temperate deciduous forest in northeast China, into 50% of the area currently suitable for temperate mixed forest. Decrease in moist savannas and desert. Some replacement of tundra and steppe by boreal forest in western China. NPP increases in all biomes except for xeric woodland and shrub.	Ni *et al*. 2000; Ni 2001
Ecosystems	National	2 x CO_2	CSIRO coupled with REGCM2 driving Holdridge life zone classification	Major shifts in life zones (change over 89% of terrestrial area); new warm arid life zones appear; the area of all forest increases by ~15%, with decreases in desert and Tibetan plateau vegetatio.	Chen *et al*. 2003
Ecosystems	National; focus on Western China	SRES A1F1 and IS92d (HADCM2d1= 0.5% per year CO_2 forcing), to 2099	HADCM2d1 and HADCM3, driving Holdridge life zone classification	Warming of cold ecosystems on Tibetan plateau; ingress of warmer ecosystems from southeast to northwest. Decreases in area of the nival zone, warm temperate moist forest and boreal wet forest; increases in subtropical moist forest and cool temperate forest.	Liu et al. 2005; Yue *et al*. 2006
Ecosystems, land cover	National	SRES A1FI, A2 and B2 to 2099	HADCM3 driving Holdridge life zone classification, driving land cover transition matrix (SMLC)	Woodland increases, especially in hilly and mountainous areas. Almost twice as great an increase under B2 than under A1F1. Desertified lands also increase. Grassland and cultivated land decreases, with proportionately more grassland remaining in western than eastern China.	Yue *et al*. 2007
Ecosystems,	Tibetan plateau	2 X CO_2 = 500 ppmv	HADCM2 driving BIOME3	Large decrease in temperate desert, alpine steppe,	Ni 2000

carbon (NPP), permafrost		atmospheric concentration. Increases in temperature vary from 2-3.6°C over the area, and in precipitation of 0-550 mm / year.	vegetation model	desert and ice/polar desert; large increase in cold-temperate conifer forest, temperate shrubland/meadow, and temperate steppe; and northwest shift of all belts.	
Permafrost	National; focus on Tibetan plateau	Temperature increase: 0.5°, 1.1°, 2.81°	Altitude model (statistical response to temperature)	8, 18, 58% decrease in permafrost respectively	Jin *et al.* 2000
Single species	Northeastern China	2 x CO_2 by 2030 for five GCMs ((GFDL, GISS, NCAR, OSU, UKMO); 0.5% and 1% per year CO_2 forcing until 2030 (2 HADCM2 runs)	(i) mean result of 5 GCMs and (ii) HADCM2; driving GREEN climate envelope	(i) shows northwards shift and slight expansion of potential distribution; (ii) shows decreases in range of up to 45%. NB study did not include present day distribution outside China, so may have underestimated climate tolerances.	Xu & Yan 2001
Carbon (NEP)	National	Recent variability simulated	GLO-PEM and CEVSA vegetation model	Mean NEP 0.07GtC / year, for 1981 to 1998. Decreasing through the period in response to increased temperature.	Cao *et al.* 2003
Carbon (NPP in grasslands)	National	Recent variability simulated	DLEM vegetation model	Ozone pollution in the troposphere limits grassland primary productivity through effects on photosynthesis and stomatal conductance.	Ren *et al.* 2007
Carbon (balance in forests)	National	Canadian CGCM2 with A2 and B2 scenarios Nitrogen deposition included, but not acidification impacts.	InTEC forest model – assumes no change in forest cover; simulates several physiological effects but not water use efficiency impacts of CO_2.	CO_2 fertilisation effect on above and below ground biomass is expected to balance the negative effects of increasing temperature until 2050, and then forest may act as a small carbon source. Gains in NPP by the end of this century are 349.6 and 241.7 TgC per year under A2 and B2 scenarios. Gains are especially high for forests on the Plateau.	Ju *et al.* 2007
Permafrost	Qinghai–Tibet Plateau (QTP),	Air temperature increase only(2009, 2049, 2099)	GIS – aided altitudinal model	0.51°C increase – 8% decrease 1.10°C increase - 18% 2.91°C increase - 58%	Jin et al (2000)
		Warming at an average of 0.4°C per yr for 50 years (based on IPCC	Numerical model	Lag time between surface temp warming and ground temp warming. After 50 years, substantially large river taliks will appear in the interior of the QTP. Alpine permafrost in the southern QTP will largely vanish. If the rises about 0.5°C within the next 20 years, permafrost less than 10 m in thickness will retreat.	

				Consequently, permafrost on the QTP would shrink about 3–5%.	
	Northeastern China and mountains of northwestern and central China	0.5 °C temp rise over 20 years	Not specified	Areal decrease of permafrost distribution would be 5–7%	
		0.5 °C temp rise over 50 years		Permafrost less than 30 m would be affected, and the areal extent of permafrost in China would decrease 12– 16%.	
		1°C over 20 years		Marginal permafrost less than 15 m in thickness on the QTP would be disconnected, and the permafrost area would decrease about 10–14%.	
		1°C over 50 years		Thickness of quasi-stable and transitory permafrost on the QTP would decrease 10–20%,.	
Climate modelling (CNCC scenarios)	All	SRES scenarios, climatic scenarios for the GCM include HadCM2, ECHAM4	RegCM2 with doubling of CO_2 conc. Since 2002 - PRECIS, scaled down HadAM3H to a grid of 50 km _50 km	Increased temperatures, variable precipitation increases Increased water scarcity, reduced permafrost areas, reduced run off to rivers. Identified as one of the major issues for China regarding climate change	Lin et al, 2007
Annual run off	Ningxia, Gansu, Shanxi and Jilin province. (North)	Off-line atmospheric forcing for a range of SRES scenarios	PRECIS driving VIC	Water scarcity likely to be exacerbated Reduced water run off likely to reduce water quality due to increased concentration of pollutant	Lin & Zou (2006) – Stern Contribution
	Fujian, Zhejiang, Jiangxi, (Southern)			Water abundance – floods likely	
Water Yield	All river basins	HadCM2 CGCM1 (CCC models)	GCMs driving water balance models	Meeting the present demand of approximately 14 billion m3 meters will increase from approximately $200 million to $700 million under the CCC 2055 scenario and not be possible under the Hadley Center Scenarios. Regional variation: The Jiangxi river (south) significantly increases yield under a climate change scenario whereas Chang jiang (north) river basin – under CCC for 2085 can decrease from 260BCM (baseline) to 210 BCM	Kirschen et al, 2005
Runoff	North West	7 IPCC models (unspecified) – 1.5-2°C by 2050. precipitation increase 0.7-6%		Less precipitation and higher evapotranspiration than North China. Temperature increase most pronounced in winter. Increased temp will not be compensated for by increased precipitation.	Huang et al

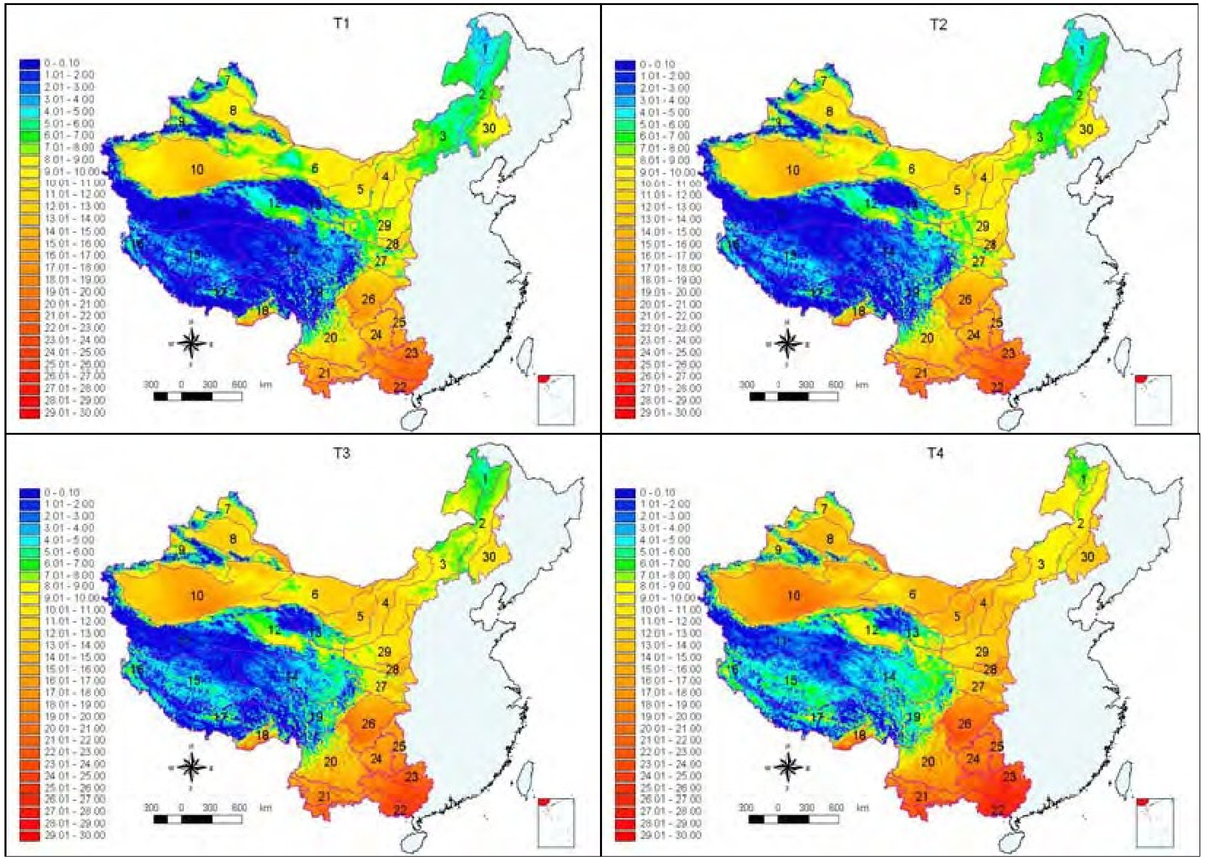
				Reduction in water resources	
Run off	Yellow River	CCC, CCSR, CSIRO, DKRZ, GFDL, HADL, and NCAR allowing for the impact of GHG increase only (GG), and both sulphate aerosol and GHG increases (GS)	Not specified	Greater sensitivity of runoff to precipitation than to temp. Runoff will decrease by 3-7% with a 1°C temp rise, and the more precipitation reduces the more runoff reduces. Trends indicate that temp rise will be largest in the Xinjiang area (north west)	Xu et al (2003) in Lan et al, 2006
Run off	All (9 major hydrological regions)	Temp & precipitation changes for China by **2030** (IPCC). Hadley & MPI models. Comined temp increase or decrease of 1, 2 and 3C with precipitation changes of -100, -50, -25, 0, 25, 50 and 100% to model sensitivity to climatic variables	GCM driven water balance model. GIS techniques used to analyze topography, river networks, land-use, human activities, vegetation and soil characteristics.	MPI predicts precip increase of 1.6% in north, 11.4% in south. Liaohe, Haihe, Ruanhe River basins – runoff small or zero during dry season. Very sensitive to climate. 1°C temp increase and 25% precip = run off change -38% to 36% and -33% to 32% respectively in the Ganjiang and Hanjiang basins. If the precipitation was unchanged and temperature increased from 1°C to 3°C, then run off decreases from -2.83 to -7.83% and -3.00 to -7.64%. Variable temp increases ranging from 1.4-3.1°C across the major hydrological regions. 2.0°C (HD) or 2.38°C (MPI) in north; and 1.8°C (HD) or 1.5 °C (MPI) in south. Water basins in the south such as are less vulnerable to climate change. Run off modeling variable, but generally decreases throughout the north with major declines in the northwest. Potential evaporation will increase by about 4.8% per 1°C increase in temperature	Guo et al, 2002
Precipitation	North west yellow river region	Doubling of GHG concentrations 2030	ECHAM4, HadCM2, GFDLR15, CGCM2, CSIRO	Precipitation to increase in all areas except the Tianshan Mountains, where it is projected to decrease slightly decrease with a limited reduction range	Gao et al, 2003, in Lan et al 2006
Soil moisture	All	Temp, precipitation and evapotranspiration changes by 2020 Greenhouse gas plus sulfate integrations (1% increase scenario selected)	HADCM2 combined with soil moisture data and CRU data	the mean annual temperature in the 2020s is projected to increase by 0.25–1.60 ◦C across China. The most significant warming is found in the northwest, and the lowest increase is in the southeast. Mean annual rainfall in the 2020s is highly variable spatially. It is projected to increase the most in the northwest. Evapotranspiration is expected to decrease generally from 0 to 20mm in south China, and to increase generally from 0 to 20mm in other regions. Under the HADCM2 climate-change scenario, the soil-moisture deficit would decrease by about 20mm in some areas	Tao et al (2003)

				of south China. In other regions, however, especially in central China, the soil-moisture deficit would increase generally.	
Monsoon	QTP & Northwest	Analysis of changes in atmospheric element fields induced by sea surface temperature anomalies		A strengthened winter monsoon would bring cold & rainless weather resulting in large scale droughts, strong summer monsoon would bring high temperatures (rainless weather in much of northwest)	Zhang et al (2002) in Lan et al (2006)
Evaporation (Past trends)	Yellow River	Variations of total evaporation, hours of sunshine, temp, air saturation deficiency in the basin, with special emphasis on the impacts of above factors on the total evaporation,		Total evaporation increase and precipitation decrease directly led to the reduction of runoff and the spread of grassland desertification in the upper basin.	Li et al, 2000 (in Lan et al, 2006)
Evaporation (Past trends)	Yellow River basin	Climatic trend of evaporation of evaporation pans in the past 40 years		Regional climatic trends of evaporation differed. Evaporation of evaporation pans showed a decline trend in the upper and lower reaches of the River and a very gentle rising trend in the middle reaches. More studies required on evaporation because the area and underlying surfaces are varied.	Qui et al (In Lan et al, 2006)
Vegetation shifts	Whole	HadCM3A1FI (increased rates of temp, precip & PET ratio per decade 0.31 °C, 14 mm & 0.009) HadCM3A2 (0.25 °C, 19 mm & 0.007) & HadCM3B2 (0.19 °C, 9 mm & 0.003)	HadCM3 scenarios driving the HLZ classification	With temperature rise, precipitation and evapotranspiration increase, nival area would shrink, and desertification area would expand at a comparatively slow rate. Water area, wetlands and nival areas decrease under all scenarios, but at differing rates and to different degrees under different time frames. Water resources and wetlands shifting southwards, desertification areas shifting northwards	Ni et al (2000)
Ecosystem vulneraibility	Whole	B2 scenario of SRES	PRECIS driving a biogeochemical model (AVIM2)	Northwest China and Tibetan Plateau are likely to be vulnerable and some parts of Northeast and South China are likely to be moderately vulnerable. Extreme high temp likely to occur in North China and extreme drought is likely for the Changjiang River basin	Wu et al, 2007
Biomes	Tibetan plateau (included in the above	A coupled oceanatmosphere GCM(Hadley) including sulfate aerosols was used	GCM (Hadley) driving BIOME	Large reduction in temperate desert, alpine steppe, desert, and ice/polar desert, a general northwestward shift of all vegetation zones. The continuous permafrost would mostly disappear,	Ni (2000)

	study as only polar desert/ice when in fact there are many types of vegetation over simplified in more general models	to drive a 2X GHG scenario to 2100.		whereas the no-permafrost area would greatly increase. The disappearance of permafrost and the expansion of no-permafrost areas would accelerate the desertification of the Tibetan Plateau. Temperature will increase 2–3.6°C by the end of 2100 and precipitation will increase by 0–300 mm in the central and eastern parts of the Plateau and decrease by 0–550 mm in the southwest The greatest increases are likely to be in the winter.	
Mountain ecosystems	Yunnan (South west)	CGCM of China National Climate Centre (CNCC) to simulate surface temp and atmospheric circulation. SRES A2 emissions scenatio and HadCM3 to drive vegetation model	HadCM3 driving the MC1 dynamic vegetation model of high mountain ecosystem processes.	Weakened Asian summer monsoon – decrease in precipitation and increase in temperature. High mountain vegetation would decrease in high altitude area. From 2000-2040, the high altitude alpine meadows would decrease more evidently. From 2050-2090 the alpine meadows almost disappear. From 2080-2090 the vegetation distribution would change more obviously, there would be hardly any high mountain meadows and low species diversity	Sun et al, 2006
Climate & Precipitation	Whole	SRES A2 & B2 scenarios, PRECIS. Regional evaluations – B2 only	Climate only	Summer temperature in North China would obviously increase, while summer precipitation would slightly increase, the climate would become warmer and drier. Precipitation over Central China, East China, and South China would increase evidently in summer but slightly in winter, decreasing markedly in South China over winter. The flooding in summer and drought in winter in southern part of China would be enhanced	Xu, 2006
Precipitation changes (Past)	Arid & Semi Arid Zones	Precipitation and evapotranspiration data from Chinese meteorological centre used to model changes using isohyets		Climate has become warmer and wetter in the northeastern region over the past 50 years, whereas it is becoming much drier in the eastern region. In the central region, the climate is becoming warmer and drier, whereas in the southwest it is relatively stable.	Yang et al 2005
Water supply	All	Scenarios where runoff reduces by 10% and 20% (not specified where such figures obtained and does not seem to include other climatic variables that might influence the	Modelled in a Water Resources Systems Dynamic (WRSD) model in which the business as usual scenario was adopted (population increase, water demand, irrigation, industrial)	Without climate change – Water shortage will be 2.29 billion m3 (4.5%) by 2010. Unless alternative sources are developed, the shortages in 2020 and 2030 will be 6.24 (11.1%) and 6.62 billionm3 (11.2%), respectively/ (without climate change). With two separate scenarios for climate change incorporated, this rises to shortages of 11 billion	Xu et al, 2002

		demand side (e.g. for irrigation)		m3 and 15 billion m3	
Soil degradation and climate change	All	HadCM2 GCM 2021-2030, also included soil degradation, and a combination of the two.	Water balance model. Potential evapotranspiration was calculated using the Penman-Monteith method	Precipitation is projected to increase the most (by more than 60 mm) in the northwest, but is projected to remain constant or decrease by more than 30 mm in central and southwestern China. Under the combined impacts of soil degradation and climate change in northwestern and northeastern China, ET will increase because climate change will offset decreases caused by soil degradation In northwestern China, surface runoff would remain at or near 0 mm because the expected increase in precipitation is not enough to offset the soil moisture deficit.	Tao et al, 2005
Run off	Zamu River northwest	RCM (not specified)	Hydrological model (SWAT) incorporating land use and climate change scenarios	Greater impact of precipitation. The simulated runoff increased with increased precipitation, but the mean temperature increase decreased the runoff under the same precipitation condition. Runoff varied with different land-use type, and the runoff of the mountain reaches of the catchment increased when grassland area increased and forestland decreased.	Wang et al, 2007
Stream flow (past)	Tarim River basin northwest	Temperatrue and precipitation data 1995-2000	Hydrological model	Impact of precipitation greater than that of temperature. Increased streamflow	Chen et al, 2006
Stream flow (past)	Shiyang river basin	Statistical analysis of hydrological time series with climate data and human activities	Hydrological model	Study area has been experiencing a significant upward warming trend and precipitation shows a decreasing trend in the mountainous region but an increasing trend in the plains region. All stream flows in the upper reach and lower reaches exhibit decreasing tendencies. Climate change (0.04–0.07°C) per year and decreased precipitation) is the main reason for the observed flow, with contributions to total flow decrease of 68% and 63%, respectively.	Huo et al, 2007
Water resources, vegetation, carbon sequestration	Hehie River Basin North-West China	Past observations		Distribution of water resources in vegetation landscape zones controls the ecosystems. Trend in reduced vegetation and increased desertification over past 40 years. Distribution of NPP obviously restricted by water conditions	Kang et al, 2007

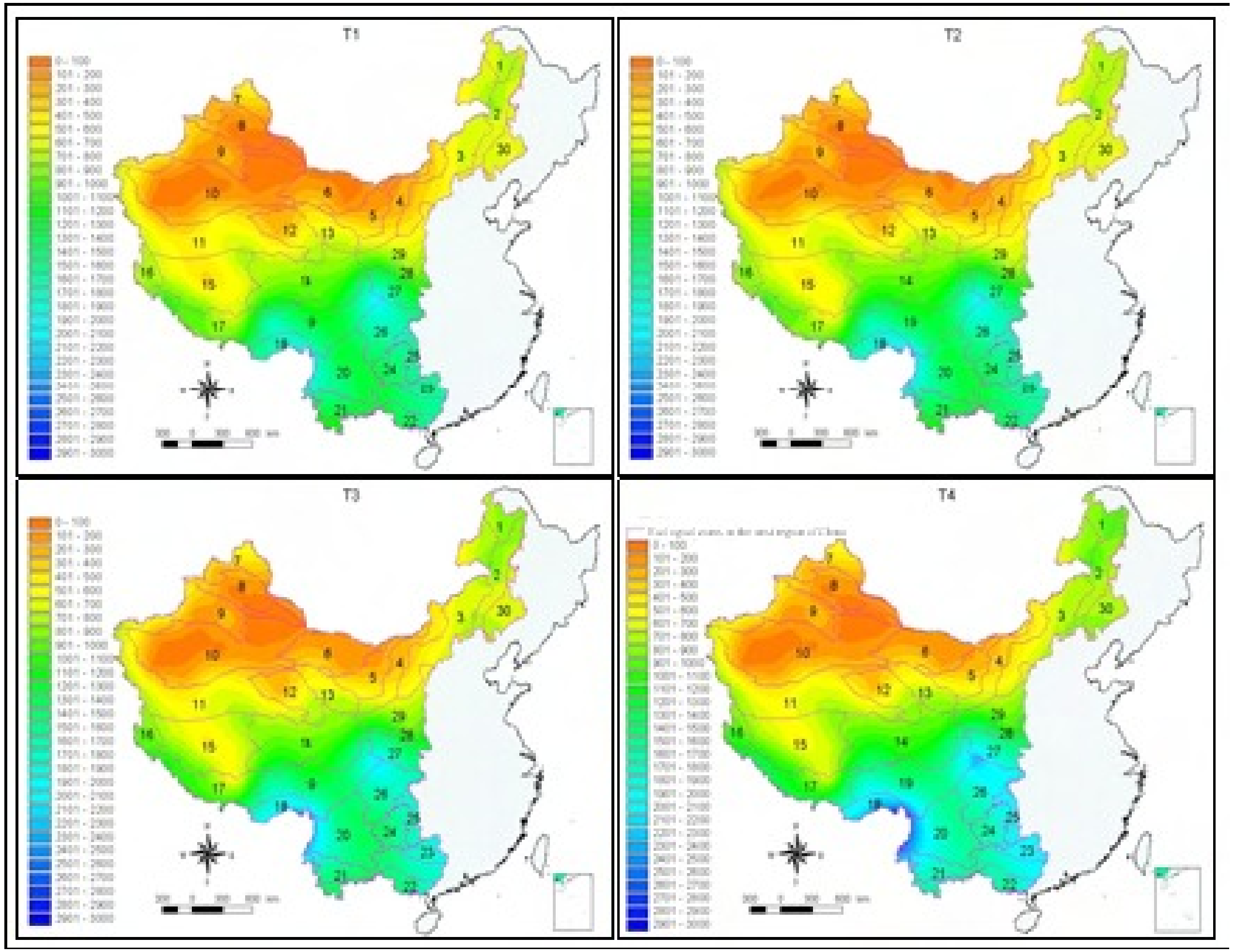
Runoff	Northwest	DoubledCO2 concentration	Reg-CM2 based on CSIRO simulations	The annual temperature will increase by 2.7 ◦C and annual precipitation by 25%. The cooling effect of aerosols and natural factors will reduce this increase to 2.0 ◦C and 19% of precipitation. Increased run off in the XinJiang area due to glacial melt	Shi et al, 2007
Climate	All	SRES B2 scenario 2080	PRECIS	Obvious increase in North temp relative to South. Overall increase in precipitation, with decreases in the winter in the south. Precipitation decrease in some areas of north and northeast China. Temperature could increase 4-4.5 degrees in Xinjiang. Large precipitation increases in the Yangtze. Precipitation decreases over parts of the Yellow River	Xu et al, 2006b
Permafrost	North west arid areas	Trend analysis of observed glacial retreat		Increase in temperature will lead to decreased glacial area and glacial runoff, even with increased precipitation	Lu et al, 2005



FigureAN10.1 projected biotemperature[2] change for China by 2099, based on climate projections from the HADCM3 Hadley Centre model, using emissions scenario B2a [see MAWEC p. 71].

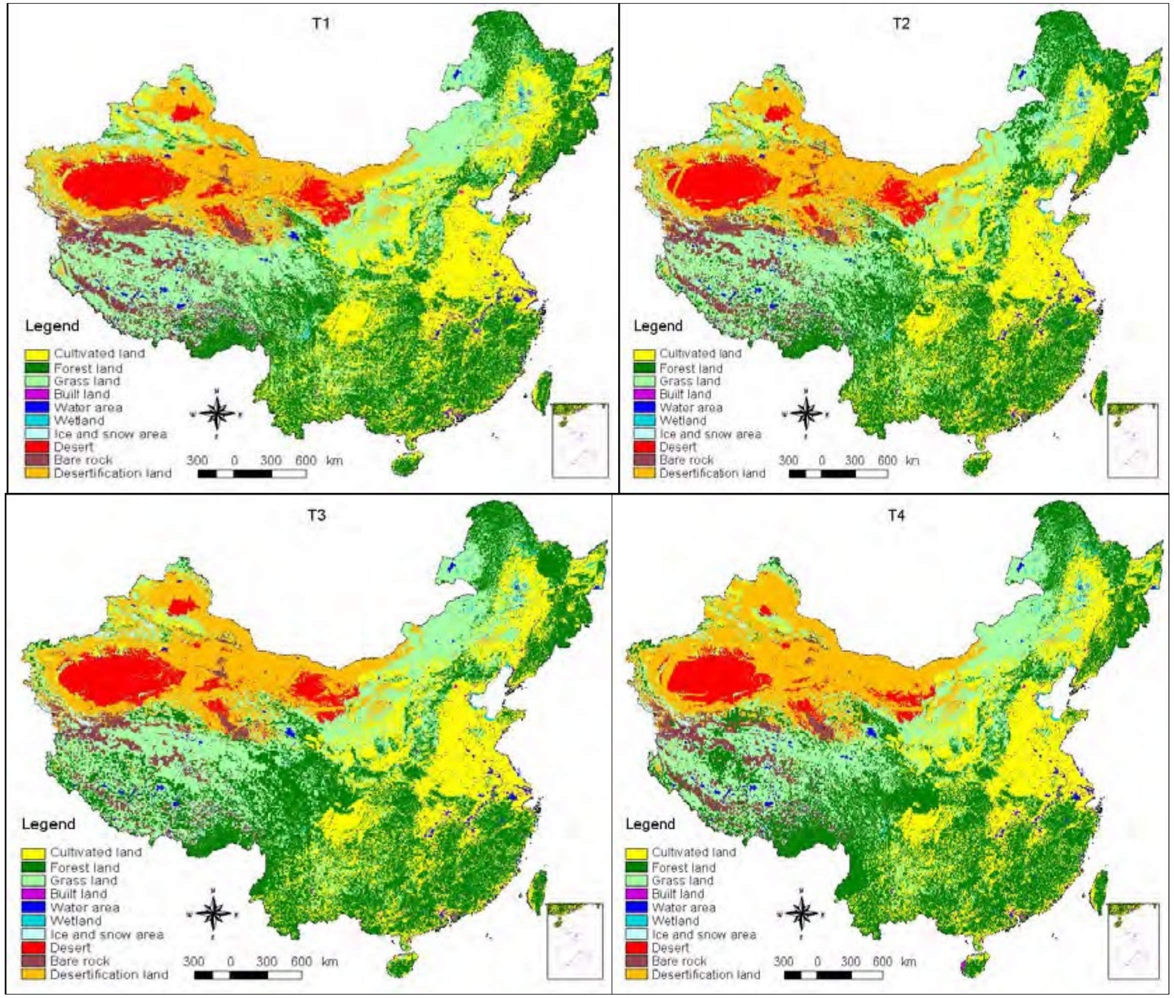
(T1, T2, T3 and T4 represent the periods from 1961 to 1990, from 2010 to 2039, from 2040 to 2069 and from 2070 to 2099,respectively)

[2] Adjusted mean temperature, derived by substituting zero for all values below 0°C and above 30°C



FigureAN10.2 projected precipitation change for China by 2099, based on climate projections from the HADCM3 Hadley Centre model, using emissions scenario B2a [see MAWEC p. 74]

(T1, T2, T3 and T4 represent the periods from 1961 to 1990, from 2010 to 2039, from 2040 to 2069 and from 2070 to 2099,respectively)



FigureAN10.3 land cover change for China based on climate projections from the HADCM3 Hadley Centre model, using emissions scenario B2a [Liu *et al*., 2005; MAWEC p. 82].

(T1, T2, T3 and T4 represent the periods from 1961 to 1990, from 2010 to 2039, from 2040 to 2069 and from 2070 to 2099 respectively)

Annex11

IAS supporting information

Global perspective of IAS

As a key finding from MA, the introduction of IAS has been recognized as one of the global direct drivers of changes that directly affect ecosystem conditions and service (MA 2003 & 2005). IAS have caused ecological disasters and economic losses in various ecosystems- agriculture lands, forests, grassland, islands, fishery, marine and natural conservation areas. The socioeconomic and ecological costs of IAS to the global environment have been conservatively estimated to exceed US $1.4 trillion annually (Pimental, 2002). This is roughly 5% of the global economy and equivalent to the gross domestic product of China for 2003 (IMF 2003). In recent years, the introduction and spread of IAS has increased in frequency due to global trade, transportation, international travel and ecological tourism. For example, the explosive increase in trade between the United States and China, which share comparable ecosystem types, has resulted in the spread of IAS with increasingly negative impacts to both countries and/or neighbour countries (Jenkins and Mooney, 2006).

There is a growing number of scientific and IAS management communities which are devoted to the IAS issue worldwide and many local, national and international strategies now target IAS, although coordination and implementation still stand out as major failings (Jenkins and Mooney, 2006). Many international instruments or technical guidelines are dealing with IAS issues from various perspectives: plant and animal health, biodiversity conservation, aquatic ecosystems and some sectoral pathways, etc. New programmes and tools have been developed, notably the Global Invasive Species Programme (GISP)[3] which actively promotes practical regional cooperation and cross-sectoral coordination between institutions and stakeholders at all levels. GISP has published a Global Strategy on Invasive Alien Species (McNeely *et al*., 2001) and a Toolkit of Best Prevention and Management Practices (Wittenberg and Cock, 2001).

The Convention on Biological Diversity (CBD), which came into force in 1994 and of which China is a party to, has identified IAS as a major cross-cutting theme. This global treaty requires Parties “as far as possible and as appropriate, (to) prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species” (Article 8(h)). In 2002, the CBD Conference of the Parties adopted a specific Decision and Guiding Principles[4] to help Parties implement this requirement. The Principles urge Parties, other governments and relevant organizations to prioritise the development of IAS strategies and action plans at national and regional level and to promote and implement the CBD Guiding Principles.

IAS status and trend in China

China, spanning 50 degrees of latitude and five climatic zones, is the world’s third largest country and one of the riches in terms of biodiversity (Wang *et al*., 1997). With a wide range of habitats and environmental conditions, China is especially vulnerable to the establishment of invasive alien species (Xie *et al*., 2001). Potential IAS from most areas of the world may find suitable habitat somewhere in China. Not surprisingly, within the list of the world’s 100 worst IAS[5], half of these species have been found in China (Wan *et al*., 2005).

China’s rapid economic development in the 20th century, including explosive growth in trade and transportation systems, is increasing the pathways for the introduction and spread of IAS among regions within China and the introduction of new IAS to China from other countries. Crofton weed, *Ageratina adenophora,* has invaded large area of grasslands in southwest China, and is still continuing to spread with an average expansion rate of 20 km per year throughout the south and middle subtropical zones, and 6.8 km per year in north subtropical areas

[3] GISP was founded in 1997 to address the global IAS threat and to provide support to the implementation of CBD Article 8(h). In early 2005, GISP was constituted as a legal entity with Founding Members IUCN, CABI, The Nature Conservancy, and the South African National Biodiversity Institute (SANBI).

[4] Decision VI/23 on Alien Species that threaten ecosystems, habitats and species (COPVI, The Hague, April 2002) to which are annexed the Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species that threaten Ecosystems, Habitats or Species.

[5] “100 of the World’s Worst Invasive Alien Species”, compiled by Invasive Species Specialist Group of IUCN (www.issg.org).

(Wang and Wang, 2006). Road and streams are main conduits for the spread of crofton weed in its dispersal (Lu and Ma, 2006). Vegetable leaf miner, *Liriomyza sativae* was first reported in Guangdong and Hainan Provinces in 1994 and has since spread through China in less than 8 years. Banana moth, *Opogona sacchari,* was first found in Guangdong Province in 1995 and has now spread to more than 20 provinces (Wan *et al*., 2004). In 2002, 1,310 alien species and 22,448 batches of harmful organisms were intercepted by quarantine authority. The frequency of interception by quarantine authorities increased by 1.5 and 3.4 times respectively compared with those of the previous year (Wan *et al.*, 2005). As China's trade, tourism and domestic development continue, IAS pose a major challenge to the sustainable development of the country in the new millennium (Xie *et al*., 2001; Wan *et al.*, 2005).

Currently, IAS are occurring widely in almost every ecosystems, including forests, wetlands, farmlands, freshwater and marine areas. They are represented by many taxonomic groups, including mammals, birds, amphibians, reptiles, fishes, arthropods and crustaceans, algae, ferns and seed plants, fungi, viruses, bacteria, and other microorganisms. To date, baseline data of IAS in China is still incomplete. It is conservatively estimated that there are currently more than 400 IAS in China, of which more than 100 species are serious threats (Wan *et al.*, 2004). Wan *et al.* (2005) provided a detailed record of 279 IAS (including 188 plants, 49 arthropods and 42 microorganisms) in agriculture and forestry ecosystems in China, and identified 30 worst IAS including 10 weeds, 10 insect pests and 10 invasive or potential alien pathogens.

IAS have caused ecological disasters and economic losses in various ecosystems in China. Documented major impacts include extinction of native species in natural ecosystems and major economic losses in agriculture, forestry, animal husbandry, fisheries, road and water transportation and other related industries (Wan *et al.*, 2004; Xu *et al*., 2006). The total economic losses (including direct economic loss 16.59% and indirect economic loss 83.41%) caused by 283 IAS to China were estimated to be USD 14.45 billion, accounting for approximately 1.36% of China's GDP in 2000 (Xu *et al*., 2006). It was estimated that 11 IAS in agriculture and forestry have caused RMB 57.4 billion economic losses per year (Wan *et al*., 2002). *Mikania micrantha*, a harmful exotic weed, invaded nature protected area and coastal islands of Guangdong Province, South China, causing an estimated economic loss of RMB 4.5-10.13 million on Neilingding Island, for which RMB 38.3-86.3 million accounted for losses in forestry ecosystem service function such as water preservation, CO_2 concentration, O_2 production, pollution reduction, insect pests/diseases decrease and health care etc, and RMB 0.67-1.5 million accounted for biodiversity losses (Zhong *et al*., 2004).

The introduction of IAS is one of the major causes of species extinction in freshwater ecosystems in China. Yunnan Province is one of the richest provinces in China in terms of biodiversity. The province had 432 documented fresh water fish species, accounting for 42.2% of total fish number in China (Chen *et al*., 1998; Xie *et al*., 2001). However, currently one third of Yunnan's 432 fish species are either threatened or extinct due to the cumulative effects of overfishing, dam construction, water pollution, vegetation destruction, and land reclamation from lakes. In recent years, the spread of IAS was found to correlate with local extinctions and population reductions of remaining native fish species. By early 1970s, more than 30 alien fish species had been introduced into Yunnan's Dianchi Lake. Correspondingly, the number of indigenous fish species declined from 25 in the 1940 to 15 in 1978 and 8 in 1982. An investigation in 1997 showed that, except three widely distributed native species, there were only two endemic species remaining but in small population numbers (Chen *et al*., 1998; Xie *et al*., 2001). A similar situation is observed in Erhai Lake of Dali, Yunnan (Wan *et al*., 2004). There were 17 native fish species, all having important economic value to the rural families living around the lake. However, after the introduction of 13 alien fish species either intentionally or unintentionally, 5 native fish species are nearly extinct due to competition with alien fish on food and habitat resources and predation of their eggs by the invasive fish.

Another serious effect of IAS to the ecosystem structure is the genetic effect on species through hybridization or serious losses in genetic diversity. Invasive hybridization with local species has been recorded in ducks, wild cats, donkeys, fish, birds and grasses elsewhere outside China (Brooke et al., 1986; Hammer et al., 1993; Holcik, 1991; MacDonald et al., 1989; Moyle, 1976; Ryman, 1991). So far, research in this field is very scarce in China. Laboratory study has already shown that *Haliotis rufescens* and *Haliotis fulgens*, two introduced abalone from the United States, can hybridise and reproduce with native species *Haliotis dscus hannai* (Liang and Wang, 2001). Liu *et al.* (2007) found that the whitefly *Bemisia tabaci* biotype B is spreading through China by increasing their own reproductive success rates while reducing the reproductive success rates of indigenous whiteflies and thus displacing indigenous subtypes of this species.

IAS pose direct threats on sustainable agriculture and forestry production (Wan *et al*., 2005). For example, pinewood nematode, *Bursaphelenchus xylophilus*, a forest pest native to North America, was first reported in Nanjing, Jiangsu Province in 1982 and has now already spread to 6 provinces including Shanghai with known distribution in Taiwan and Hong Kong. The nematode can kill a pine tree within six months. Cumulatively, 1.5 million pine trees in mainland forests were devastated by the nematode between 1982 and 2000 (Wan *et al*., 2005). Luo and Wu (2004) reported that the pinewood nematode has already spread to 87,000 ha forests, and caused about 40 million pines cumulatively killed and a direct economic losses amounting to RMB 25 billion.

National IAS strategy in China

In recent years, the Chinese Central Government has invested significantly in efforts to tackle the IAS problem. Most significantly, in 2003, the State Department designated the Ministry of Agriculture (MOA) as the nodal Ministry to co-ordinate and lead plans and actions across all ministries. MOA have a central Office of Alien Species Management (OASM) at MOA headquarter, and a research centre (Centre for Management of Invasive Alien Species - CMIAS) at the Chinese Academy of Agricultural Sciences (CAAS). IAS have been also addressed in the National Medium and Long Term Science and Technology Development Plan (2006-2020), which was released by the State Council on 9 February, 2006. Three National IAS projects[6] (2003-2010, total amount of RMB 67.4 million) have been funded by the Ministry of Science and Technology to support basic research, prevention and management techniques and risk assessments. A national research team of more than 100 senior scientists from more than 30 institutions has been organized to work on the national IAS projects. In addition, MOA, SEPA and State Forestry Administration and other ministries have also invested millions to combat IAS. It should also be noted that, CAAS and CABI coorganised a workshop on the Prevention and Management of IAS in China – Building a Strategy for National, Regional and International Actions –in Beijing on 2-4 November, 2004. From this workshop, a National IAS Strategy was developed and submitted to the government for approval.

Climate change and IAS

Climate change, especially warmer regional temperatures, has already affected biodiversity and ecosystems, causing changes in species extinction risks, species distributions, population sizes, timing of reproduction or migration events and an increase in the frequency of pest and disease outbreaks (Gitay *et al*. 2002; Kappelle *et al*. 1999; Parmesan and Yohe 2003; Root *et al*. 2003; Walther *et al*. 2002; Thomas *et al*. 2004).

Climate change can affect IAS either directly or indirectly via changes to the ecosystem components and processes. Climate change facilitates IAS invasion directly by favouring introduced over native species due to altered physical-chemical conditions, such as changing temperatures more favourable to IAS growth (Stachowicz *et al*., 2002; Wiedner *et al*., 2007). Climate change can also facilitate invasions by increasing environmental stress on ecosystems, possibly reducing their resistance, and extending ranges of IAS. In marine ecosystems, climatically driven changes may affect both local dispersal mechanisms, due to the alteration of current patterns, and competitive interactions between IAS and native species, due to the onset of new thermal optima and/or different carbonate chemistry (Occhipinti-Ambrogi and Sheppard, 2007). Zhong *et al.* (2007) concluded that climate change would expand the potential distribution of *P. hysterophorus* in China. While climate change may extend the geographic range of some IAS currently limited by temperature, distribution area of some IAS might be reduced.

[6] Three National IAS Research Projects: Invasion biology and control strategy of alien species in agriculture and forestry (2003-2008), Development of better prevention and management techniques (2006-2010) and IAS survey and their bio-security assessment (2007-2009).

Annex12

Data gaps for ecosystem management for poverty reduction in China

Data gaps (Section-C2)
The diverse aspects of data gaps that cover poverty; ecosystems and the major policies and programmes affecting them; supply and valuation (including lack) of ecosystem services; impacts of pollution, climate change, and invasive alien species (IAS) on ecosystem services and poverty alleviation; underlying drivers of ecosystem change and poverty; and the role of science and technology in ecosystem management for poverty reduction, are as highlighted hereunder.

1. Poverty in China
- Lack of data on subsistence level poverty and role of different ecosystem goods as livelihoods of the poor.
- Insufficient gender focus or intra-household analysis.
- Inadequate data on degree of poor direct dependence on ecosystem services.
- Lack of information on nutrition of poor people.

2. Ecosystems in China
- Insufficient information on grassland types and status for identification of priorities and needs.
- Insufficient information on food production and water regulation in wetlands to identify priorities and needs.
- Insufficient data on soil formation, nutrient cycling, and water regulation in grassland, particularly in the context of water stress issues.
- Inadequate data to highlight mountainous areas which are both ecologically and poverty vulnerable.
- Insufficient information in arid area of northwest China and other priority areas in Western China, in particular on description of characteristics, e.g. rest response, transformation risk, ecosystem integrity and state of ecosystem processes.

3. Supply of ecosystem services in China
- Inadequate information on spatial distribution of natural capita at national level.
- Insufficient data on the ecosystems' capacity for regulating services in Northern and western China, particularly northwest.
- Data on supporting services is very limited, particularly in areas of nutrient cycling and soil formation.
- Significant data gaps and lack of recognition of cultural services.
- Insufficient data on flow, water levels, and water quality at the regional scale.

4. Underlying drivers of ecosystem change and poverty

5. Major policies and programmes affecting ecosystems in China
- Identify areas in which specific policies and drivers are operating and the issues and successes that they are having.
- There is absence of evidence of any research behind policy decisions. Is it issue of transparency or otherwise?
- Lack of information on examples of good governance of natural resources.
- Evaluate current IAS-relevant regulations and policies to identify barriers to coordinated action, clarify responsibilities for each relevant sector, define reporting process and establish transparent coordination and implementation mechanism.

6. Valuation of ecosystem services
- Lack of valuation of ecosystem service.

7. Pollution impacts on ecosystems and poverty

- Inadequate data on the extent and how pollution, over-exploitation and water development affect fish growth and reproduction and indirectly the livelihoods of poor ecosystem users.
- Insufficient information about the extent of non-point source pollution and its impact on water ecosystem services compared to other sources of pollution.
- Lack of information on the extent of non-beneficial use of fertilizers and pesticides and the loss of potential income for (poor) farmers.
- Incomplete data on the economic costs of over-exploitation of water resources.

8. Potential impacts of climate change on ecosystem services in China

- Expand current research on climate change impacts on ecosystems in mid- and western China to enhance a wide-area understanding of climate change issues, particularly to demonstrate their relevance to the sub-regions, provincial and county level.

9. Impact of invasive alien species (IAS) on ecosystem services and poverty alleviation

Annex13

Methodology and findings of stakeholder surveys

Three separate sessions of stakeholder surveys have been conducted in the process of carrying out this project, two during stage 1 of the project and another during stage 2.

1. Stakeholder survey part 1: Survey on relevant on-going work in China on ESPA
Stakeholders have been divided into 3 groups - government agencies, research institutions and NGO (refer to Annex 16 for list of institutions and agencies consulted). 3 sets of semi-structured questionnaires were developed, targeting these three types of stakeholders. The number of interviewees is approximately 18 from 6 different government agencies, 6 from research institutions and 4 from NGOs. These interviews were conducted via face-to-face sessions, telephone and emails. The findings of the survey was presented to the project team during the ESPA China mid-term workshop and deliberated among team members. Following feedbacks, further revision was made to refine the survey results. Some of the significant findings of the surveys are presented below.

1.1 *Poor understanding among policymakers and farmers of poverty environment linkages*
At local and national levels, the understanding of poverty-environment linkages is often weak. The opportunities and risks that poverty presents to poverty reduction are poorly understood by both policy-makers and farmers. The environment is not valued – the goods and services generated by natural resources are generally unaccounted for in national statistics. As such, developmental agencies and national governments have often undervalued the potential role they can play in poverty reduction and economic growth. One of the possible solutions to this is to stimulate debate amongst various stakeholders. Universal messages on the linkages between the environment, poverty and economic growth can be powerful if used in the right context and time. More context-specific information can be researched and/or collated if necessary once the issue is raised on the national agenda.

1.2 *Politically weak ministries*
The various environmental and natural resources ministries tend to have weaker linkages with the Ministry of Finance (Treasury) and national planning departments. They suffer from low budget allocations and less donor support than other sectors such as health and education. To enhance political awareness and support for ecosystem management to achieve poverty alleviation, better rapport with and support from important sectors such as the Treasury, local governments, private sectors and the media are required. These different target audiences must be identified and influenced to support sustainable management of ecosystems for poverty reduction. It is important and necessary for the environmental and natural resources ministries to provide evidence of sustainable environmental management that has contributed to helping these groups (Treasury, local governments and others) achieve their goals and meet the targets of the Poverty Reduction Strategy (PRS) developed by the government. For example, when working with the Treasury, it is critical to speak the language of economics and development by showing how the environment contributes to the national goals of poverty reduction and economic growth.

1.3 *Weak voice from civil society*
Environmental non-governmental organizations (NGOs) and community-based organisations (CBOs) are often not engaged in the process of decision making. At the same time, many environmental NGOs and CBOs underestimate the importance of the PRS to their work and/or do not have the appropriate skills (advocacy, social analysis, macro and microeconomics) to evaluate the impact of PRS on their issues of concern.

2. Stakeholder survey part 2: Farmer households' perception of ecosystem services – case study in Ningxia

Ningxia province was chosen as the survey site. It is one of the poorest regions in China, located in the middle reaches of the Yellow River in northwest China. 10 semi-structured interviews were carried out to examine the farmers' perceptions on changes in ecosystem services. The interview has been designed to understand the impacts of changes in ecosystem services to farmers (through the farmers' view), particularly, in the situation of natural disaster such as drought, sandstorms, hail and frost that they have experienced. It was identified that farmers believe that natural disasters have the greatest influence on agricultural production and rural livelihood; and the poorest are the most vulnerable to natural disaster; rich farmers are perceived to have greater capacity to respond climate variability. Farmers have been prevented from taking countermeasures against weather-related calamities due to various reasons including lack of money, infrastructure, technology and water. Factors that play an important role in determining a farmer's ability to adopt measures to mitigate weather-related disasters are availability of transportation, geographic location, farmers' ideas, education, gender and level of local economic development.

3. Stakeholder survey part 3: Capacity of researchers and policymakers to conduct research or implement ESPA

Stakeholders have been divided into 2 groups – policymakers and researchers. 2 sets of semi-structured questionnaires were developed targeting these two types of stakeholders. These interviews were conducted during Ningxia regional workshop or via mail and emails. We have distributed more than 200 copies of questionnaire to researchers whose research fields are related to ecosystem management or/and poverty reduction. We have received 93 copies of completed questionnaires, which include 71 copies from ecosystem management or related institutes, 15 copies from poverty alleviation or related institutes, and 7 copies from the institutes relevant to both fields. We have also distributed 80 copies of questionnaire to government agencies whose roles are related to ecosystem management and/ or poverty reduction. We have received 38 copies of completed questionnaires, which include 22 copies from government agencies relevant to ecosystem management, 12 copies from government agencies relevant to poverty alleviation, and 3 copies from the agencies relevant to both areas.

3.1 Conceptual understanding of ecosystem management/ poverty reduction/ its linkage

Most of the interviewees have some degree of understanding of ecosystems, but the term ecosystem services is still unfamiliar to approximately a quarter of researchers and policy makers surveyed. 35% researchers and 62% policymakers are not aware of the Millennium Ecosystem Assessment. On the concept of ecosystem management, 44% of researchers surveyed are unfamiliar with it. 83% of researchers and 95% of policymakers believe that ecosystem management can benefit poverty alleviation efforts.

Changes in local land use and land cover are recognized as the most important driver of change by both policymakers and researchers. Other important drivers identified are external inputs (e.g. fertilisers, pest control and irrigation etc.), climate change, resource consumption, species introduction/removal, and technology adaptation and use. Demographics and economic development arre considered the most important indirect drivers of ecosystem change by both researchers and policymakers. Notably, 63% of researchers believe that science and technology are important indirect drivers of change but only 35% of policymakers considered science and technology as significant indirect drivers of change.

Both researchers and policymakers feel that large differences in the level of knowledge of staff involved in ecosystem management and poverty reduction is a critical issue. Policymakers also recognized that they and their agencies face critical knowledge gap with regard to the concept of ecosystem management. Training has been identified by both researchers and policymakers as the most useful way to reduce knowledge gap. Policymakers overwhelming chose training as the best way to overcome knowledge gaps over other methods including making more information available (e.g. manuals, internet databases, CD-ROMs), regional networking, setting up systems for information/knowledge sharing between countries, technical assistance and meeting/workshops. More than 50% of researchers also identified that information availability and access will be very useful to reduce knowledge gap.

3.2 Information availability and accessibility

For researchers, internet is the most important source of information instead of library and workshops/meetings, though 48% of interviewees complained of slow internet connection. 62% of researchers expressed that there are insufficient information available to carry out relevant research. Key problems encountered by researchers when accessing information are insufficient information in the library, slow internet connection and low library accessibility. Internet is ranked first in terms of ease of access followed by books, up-to-date journals and meetings/ workshops/ conference proceedings. Internal exchanges between stakeholders either formally or informally ranked last. Direct exchanges of information between researchers / agencies / countries were also very limited.

For policy makers, technical guidelines, research findings, guidance notes and databases are types of information that are most useful to support decision-making. However, 68% of policymakers surveyed believe that there is an absence of comprehensive record keeping and information retrieval system to enable the provision of appropriate information to relevant parties on request. Internet is also recognized by the policymakers as a very important source of information, but workshops are considered the easiest source to information. Internal exchanges between stakeholders either formally or informally and direct exchanges of information between researchers / agencies / countries are recognized as sources of information but it is noted that it is difficult to obtain access to information from the former. 49% of policymakers surveyed communicate regularly with researchers. However, only 38% of policymakers received regular researcher-initiated communication.

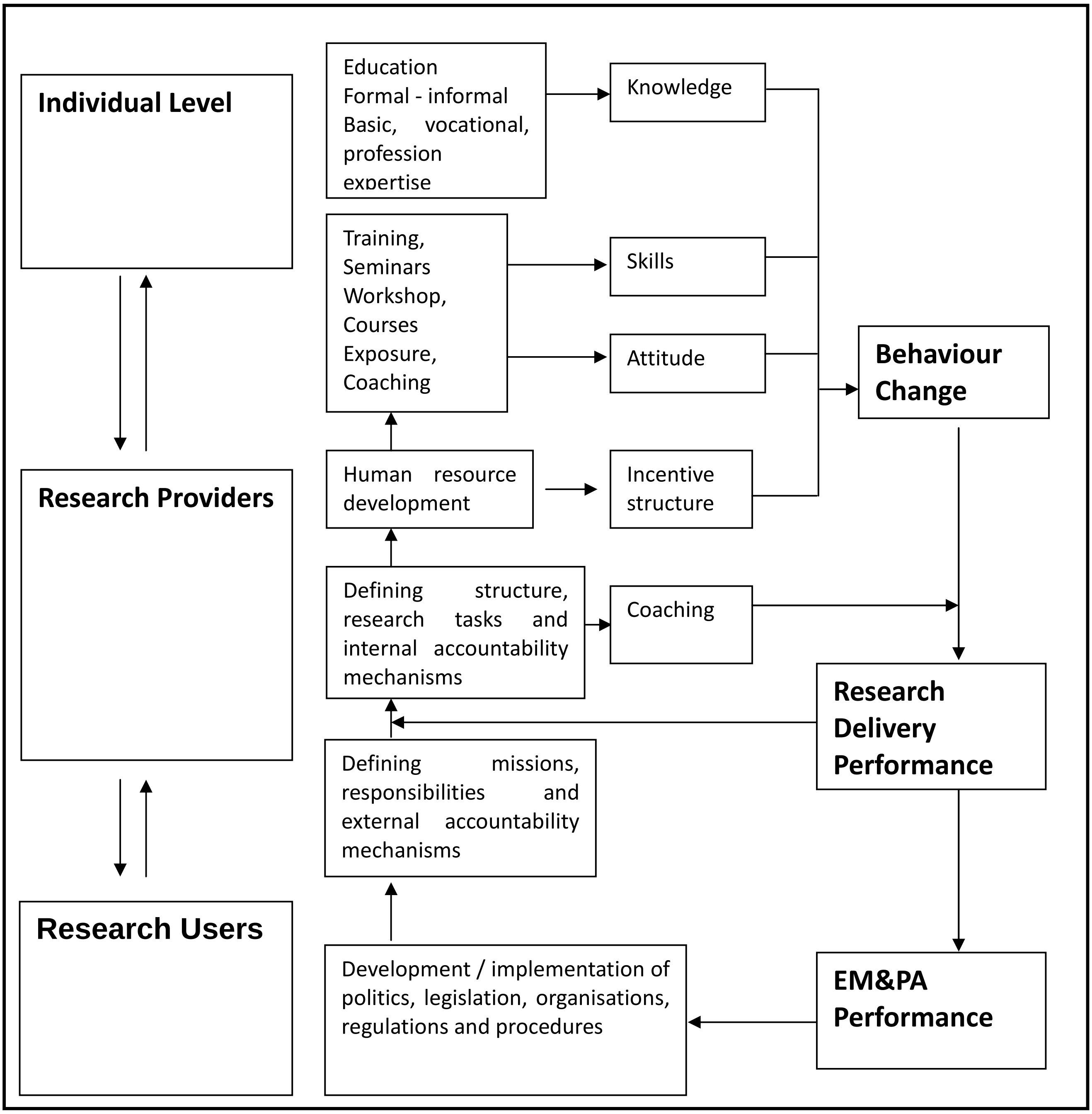
3.3 Expertise on ecosystem management

78% of researchers believe that their teams have the technical capacity to follow through with the analytical task if all needed information is available. In terms of English language capacity, most researchers surveyed have a certain degree of command of English language; 44% of researchers believe that their teams have good command of the language. English language skills are not considered necessary to improve research but 68% of the researchers believe that better technical expertise will improve research. 80% of researchers have received some degree of assistance for capacity building but it is considered insufficient. In terms of regional cooperation, 54% of researchers have had some collaboration with external organizations and/ institutions but these collaborations had been constrained largely by funding inadequacy. Other constraints to regional collaborations include communication, lack of opportunity, political condition of the region and information availability. 58% of researchers stated that their research findings and conclusions have been relayed to policymakers to garner support and funding resources.

For policymakers, 59% of interviewees believe that technical skills of staff are important to improve decision making. In terms of the technical capacity of supporting staff, 57% of supporting staff are described as highly experienced while 43% are described as moderately experienced. Human resource (for administrative work) is not an issue for 76% of policymakers. Among the information resources considered important to the interviewees for decision-making are reports and databases, followed by guidance notes, technical guidelines and research findings. Most interviewees believe that current policies are supportive of sound ecosystem management for poverty alleviation. A high percentage of policymakers have received some degree of assistance for capacity building but the support has been considered by most as insufficient; 89% of policymakers believe that assistance in terms of capacity building would be useful.

Annex14

Capacity development strategy framework



FigureAN14.1 Capacity development: Levels, activities, outputs and goals (modified from Van Hofwegen, 2004). EM: ecosystem management; PA: poverty alleviation.

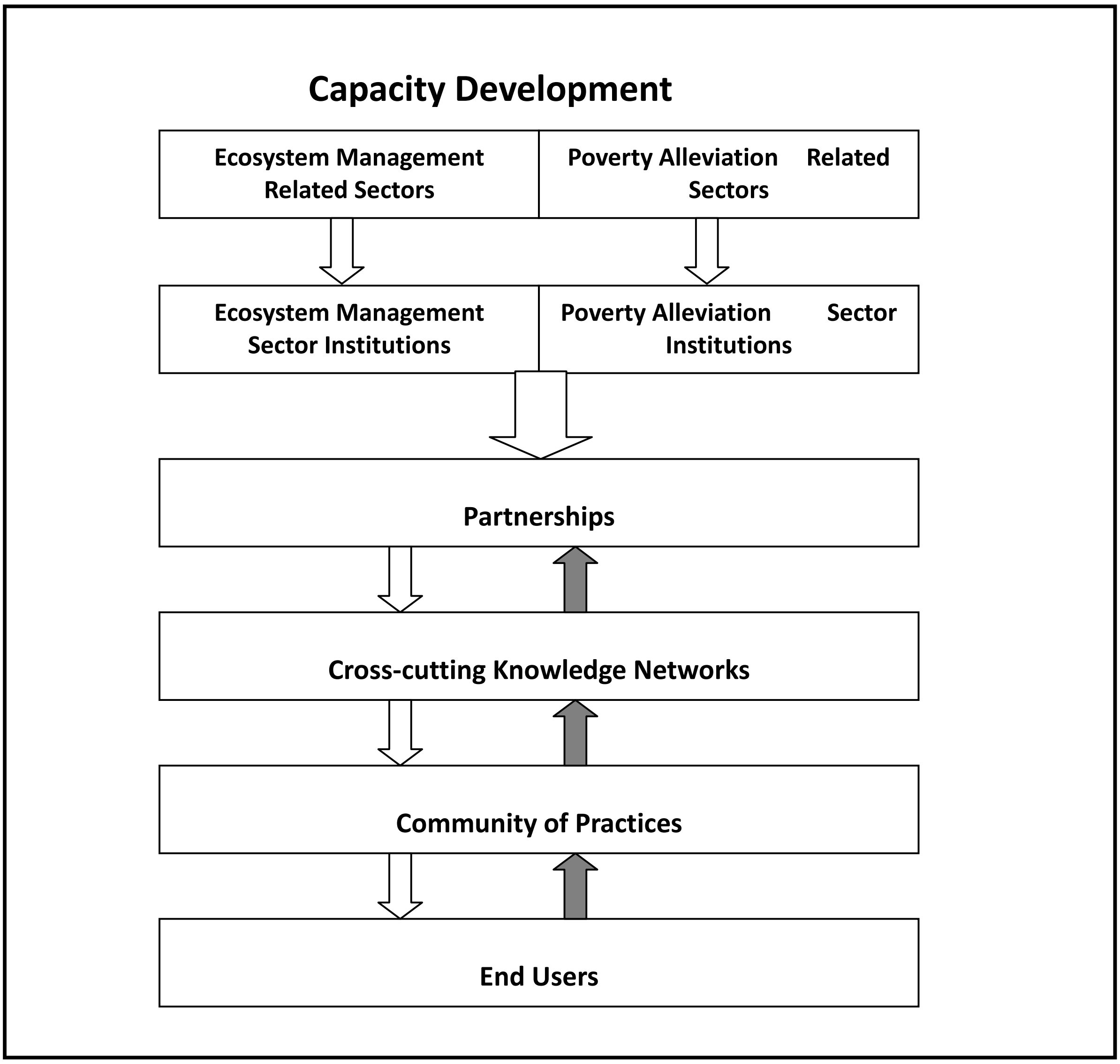
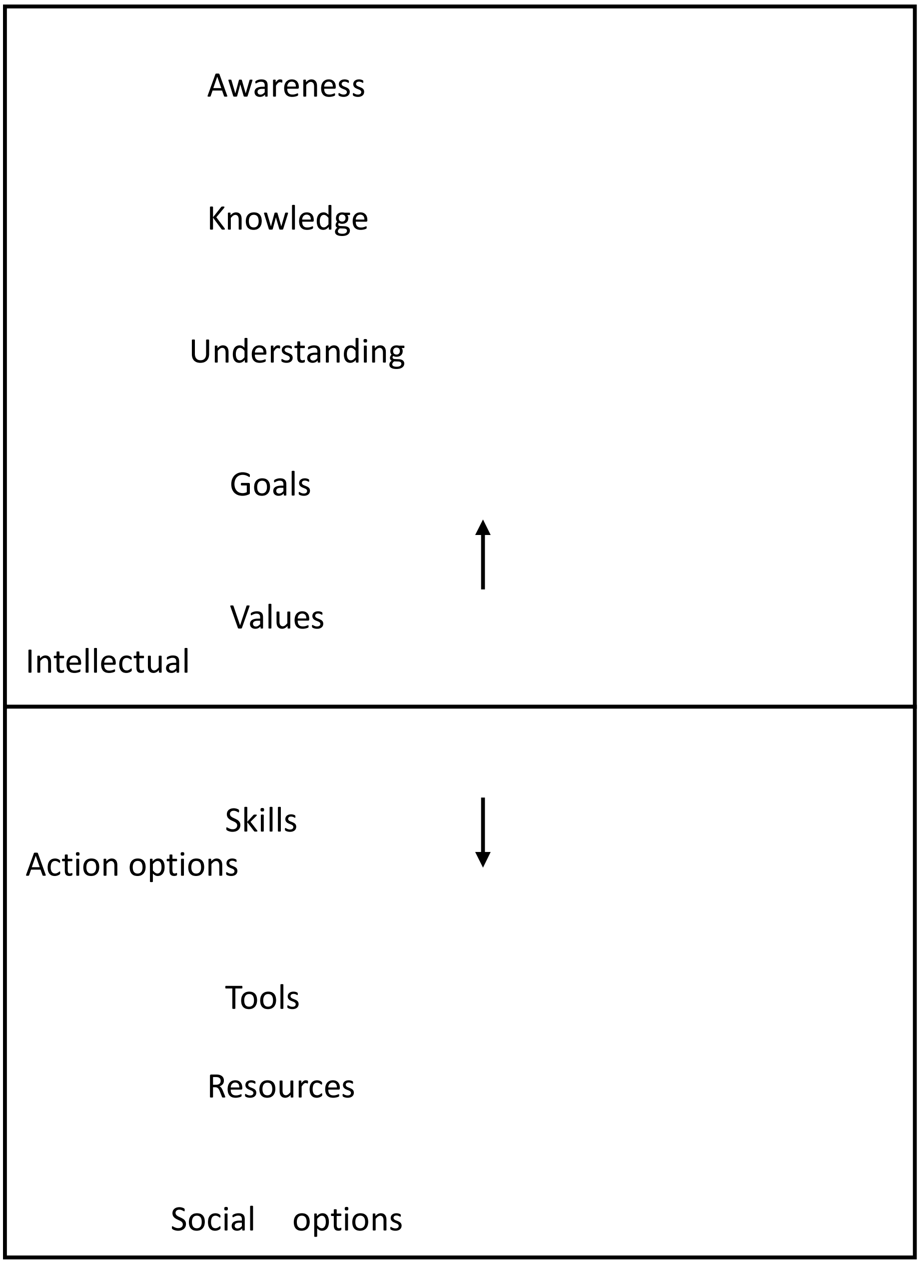


Figure AN14.2 Institutional framework for capacity building (modified from Luijendijk & Mejia-Velez, 2005)



FigureAN14.3 Model of the components of decision-making

Annex15

Advisory Committee

Name	Office
Pamela Kempton	DFID-NERC
Liz Wilson	DFID China
Carol Rennie	Research Councils UK China office
Roger Calow	Water Entitlements and Trading Project (WET),Beijing
Andrew Scanlon	Jiuzhaigou Valley National Park and National Scenic Area Administrative Bureau
Luis Waldmüller	Sino-German Project on Sustainable Development of Agrobiodiversity GTZ (German Technical Cooperation), Beijing
Wu zhong	State Council for Poverty Alleviation
Meng chun	State Council Policy Research Center
Shi yanquan	Ministry of agriculture
Li Yuan	Ecology Department, State Environmental Protection Administration (SEPA)
Hu Tao	State Environmental Protection Administration (SEPA)
Wu shulin	National Development and Reform Committee (NDRC)
Liao Chongguang	FAO China office
Chen Min	Natural Capital Project
Liu jiyuan	Institute of geographic sciences and natural resources research CAS
Wang Rusong	Ecological environment research centre, CAS
Deng Xiangzheng	Center for Chinese Agricultural Policy, CAS
Sun Ruomei	Rural Development Institute , Chinese Academy of Social Sciences (CASS)
Lin Erda	Chinese Academy of Agricultural Sciences (CAAS)
Cai Yunlong	Peking University
Wang Sangui	Renmin University of China
Zhao yanning	Beijing forestry university
Jin Leshan	College of Humanities and Development, China Agricultural University
Liu Zuoyi	Guizhou academy of agricultural sciences
Zhang Hui	Assessment Centre for Environmental Engineering, SEPA

Annex 16

Institutional list of interviewees surveyed in ESPA China Project

CABI SEA
China Agricultural University
China Foundation for poverty alleviation
Chinese Academy of Sciences
Chinese Academy of Social Sciences
CIP Beijing Liaison Office
Foreign Capital Project Office for Poverty Alleviation of Guizhou Province
Hainan University
Haiyuan County Office for Poverty Alleviation, Ningxia
Hebei Academy of Agricultural Sciences
Jiangsu Academy of Agricultural Sciences
Jilin Academy of Agricultural Sciences
Lanzhou University
Ministry of Agriculture
Ministry of Land and Resources
Ministry of Water Resources
Nanjing Agricultural University
Natural Capital Project
National Agro-technical Extension and Service Centre
Ningbo Academy of Agricultural Sciences
Ningxia Academy of Environmental Sciences
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Ningxia Development and Reform Committee
Ninxia Party School
Peking University
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Shanghai Academy of Agricultural Sciences
Shenyang Agricultural University
South China Agricultural University
State Academy of Forestry Administration
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Annex 14 - Capacity development strategy framework

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Annex20

Glossary

Adaptive management: The mode of operation in which an intervention (action) is followed by monitoring (learning), with the information then being used in designing and implementing the next intervention (acting again) to steer the system toward a given objective or to modify the objective itself.

Baseline: A set of reference data sets or analyses used for comparative purposes; it can be based on a reference year or a reference set of (standard) conditions.

Benefits transfer: Economic valuation approach in which estimates obtained (by whatever method) in one context are used to estimate values in a different context. This approach is widely used because of its ease and low cost, but is risky because values are context-specific and cannot usually be transferred.

Bias: Systematic error in a data set due to approaches and methods and their application in sampling, investigation, measurement, classification, or analysis.

Biodiversity: The variability among living organisms from all sources including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within and among species and diversity within and among ecosystems.

Biomass: The mass of living tissues in either an individual or cumulatively across organisms in a population or ecosystem.

Capability: The combinations of doings and beings from which people can choose to lead the kind of life they value. Basic capability is the capability to meet a basic need.

Capacity building: Capacity development is the process by which individuals, organizations, institutions and societies develop abilities (individually and collectively) to perform functions, solve problems and set and achieve objectives

Capital value (of an ecosystem): The present value of the stream of future benefits that a ecosystem will generate under a particular management regime. Present values are typically obtained by discounting future benefits and costs; the appropriate rates of discount are often a contested issue, particularly in the context of natural resources.

Change in productivity approach: Economic valuation techniques that value the impact of changes in ecosystems by tracing their impact on the productivity of economic production processes. For example, the impact of deforestation could be valued (in part) by tracing the impact of the resulting changes in hydrological flows on downstream water uses such as hydroelectricity production, irrigated agriculture, and potable water supply.

Characteristic scale: The typical extent or duration over which a process is most significantly or apparently expressed.

Climate change: A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Climate ensemble: A group of climate model simulations. Each ensemble member may differ by the climate model used, or by the processes or parameter values within the climate model.

Common pool resource: A valued natural or human-made resource or facility in which one person's use subtracts from another's use and where it is often necessary but difficult to exclude potential users from the resource. See also *common property resource*.

Common property resource: A good or service shared by a well-defined community. See also *common pool resource*.

Constituents of well-being: The experiential aspects of well-being, such as health, happiness, and freedom to be and do, and, more broadly, basic liberties.

Conservation value: See *existence value*.

Consumptive use: The reduction in the quantity or quality of a good available for other users due to consumption.

Contingent valuation (CV): Economic valuation technique based on the stated preference of respondents regarding how much they would be willing to pay for specified benefits. A detailed description of the good or service involved is provided, along with details about how it will be provided. CV is designed to circumvent the absence of markets by presenting consumers with hypothetical markets in which they have the opportunity to buy the good or service in question. The methodology is controversial, but widely accepted guidelines for its application have been developed.

Cultural landscape: See *landscape*.

Cultural services: The nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experience, including, for example, knowledge systems, social relations, and aesthetic values.

Decision-maker: A person whose decisions and actions can influence a condition, process, or issue under consideration.

Determinants of well-being: Inputs into the production of well-being, such as food, clothing, potable water, and access to knowledge and information.

Direct use value: In the total economic value framework, the benefits derived from the goods and services provided by an ecosystem that are used directly by an economic agent. These include consumptive uses (e.g., harvesting goods) and non-consumptive uses (e.g., enjoyment of scenic beauty). Agents are often physically present in an ecosystem to receive direct use value. Compare *indirect use value*.

Domain (of scale): The combined range of characteristic scales for a given process in both space and time.

Downscaling: The process of converting data or information at a course resolution to a finer resolution.

Driver: Any natural or human-induced factor that directly or indirectly causes a change in an ecosystem.

Driver, direct: A driver that unequivocally influences ecosystem processes and can therefore be identified and measured to differing degrees of accuracy.

Driver, indirect: A driver that operates by altering the level or rate of change of one or more direct drivers.

Ecological footprint: The area of productive land and aquatic ecosystems required to produce the resources used and to assimilate the wastes produced by a defined population at a specified material standard of living, wherever on Earth that land may be located.

Ecological security: A condition of ecological safety that ensures access to a sustainable flow of provisioning, regulating, and cultural services needed by local communities to meet their basic capabilities.

Ecosystem: A dynamic complex of plant, animal, and microorganism communities and their nonliving environment interacting as a functional unit.

Ecosystem approach: A strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way. An ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions, and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems.

Ecosystem assessment: A social process through which the findings of science concerning the causes of ecosystem change, their consequences for human well-being, and management and policy options are brought to bear on the needs of decision-makers.

Ecosystem boundary: The spatial delimitation of an ecosystem, typically based on discontinuities in the distribution of organisms, the biophysical environment (soil types, drainage basins, depth in a water body), and spatial interactions (home ranges, migration patterns, fluxes of matter).

Ecosystem function: An intrinsic ecosystem characteristic related to the set of conditions and processes whereby an ecosystem maintains its integrity (such as primary productivity, food chain, and biogeochemical cycles). Ecosystem functions include such processes as decomposition, production, nutrient cycling, and fluxes of nutrients and energy.

Ecosystem health: A measure of the stability and sustainability of ecosystem functioning or ecosystem services that depend on an ecosystem being active and maintaining its organization, autonomy, and resilience over time. Ecosystem health contributes to human wellbeing through sustainable ecosystem services and conditions for human health.

Ecosystem interactions: Exchanges of materials and energy among ecosystems.

Ecosystem management: Management of land and/or water bodies to achieve a particular aim, with consideration to maintain the supply of the desired ecosystem service(s).

Ecosystem managers: Individuals or groups who manage ecosystems with considerations to maintain the supply of desired ecosystem services.

Ecosystem properties: The size, biodiversity, stability, degree of organization, internal exchanges of materials and energy among different pools, and other properties that characterize an ecosystem.

Ecosystem rest response: Different ecosystems vary in their response to being rested or disturbed by people or large animals. Some ecosystem types respond to rest with a diversification of the ecosystem processes, with more complex and increased solar energy flow, mineral and water cycling, and biodiversity dynamics. Diversification of the ecosystem processes results in an increased supply of ecosystem services. Other ecosystem types respond to rest by a simplification of the ecosystem processes, which eventually results in desertification. The tendency of an ecosystem to have a simplifying or diversifying rest response is indicated by the percentage of the year when organic decomposition occurs. Where temperature and humidity permit organic decomposition throughout the year an ecosystem will have a diversification rest response. If organic decomposition is possible for less than half of the year the ecosystem processes will tend to simplify under rest.

Ecosystem services: The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth. The concept “ecosystem goods and services” is synonymous with ecosystem services.

Ecosystem stability: A description of the dynamic properties of an ecosystem. An ecosystem is considered stable if it returns to its original state shortly after a perturbation (resilience), exhibits low temporal variability (constancy), or does not change dramatically in the face of a perturbation (resistance).

Ecosystem transformation risk: Different ecosystems have a low or a high risk of being transformed to a different state by human actions.

Equity: Fairness of rights, distribution, and access. Depending on context, this can refer to resources, services, or power.

Existence value: The value that individuals place on knowing that a resource exists, even if they never use that resource (also sometimes known as conservation value or passive use value).

Extent: The length or area over which observations were made or for which an assessment was made or over which a process is expressed.

Externality: A consequence of an action that affects someone other than the agent undertaking that action and for which the agent is neither compensated nor penalized. Externalities can be positive or negative.

Forecast: See *prediction*.

Freedom: The range of options a person has in deciding the kind of life to lead. Freedom is similar to the concept of capability and can be used interchangeably.

Functional redundancy: A characteristic of species within an ecosystem in which certain species contribute in equivalent ways to an ecosystem function such that one species may substitute for another. Note that species that are redundant for one ecosystem function may not be redundant for others.

Geographic information system (GIS): A computerized system organizing data sets through a geographical referencing of all data included in its collections. A GIS allows the spatial display and analysis of information.

Global scale: The geographical realm encompassing all of Earth.

Habitat: Area occupied by and supporting living organisms. Also used to mean the environmental attributes required by a particular species or its ecological niche.

Health: Strength, feeling well, and having a good functional capacity. Health, in popular idiom, also connotes an absence of disease. The health of a whole community or population is reflected in measurements of disease incidence and prevalence, age-specific death rates, and life expectancy.

Hedonic price methods: Economic valuation methods that use statistical techniques to break down the price paid for goods and services into the implicit prices for each of their attributes, including environmental attributes such as access to recreation or clean air. Thus the price of a home may be broken down to see how much the buyers were willing to pay for a home in a neighborhood with cleaner air.

Herbivory: The consumption of plants by animals.

Indicator: Information based on measured data used to represent a particular attribute, characteristic, or property of a system.

Indirect use value: The benefits derived from the goods and services provided by an ecosystem that are used indirectly by an economic agent. For example, an agent at some distance from an ecosystem may derive benefits from drinking water that has been purified as it passed through the ecosystem. Compare *direct use value*.

Institutions: The rules that guide how people within societies live, work, and interact with each other. Formal institutions are written or codified rules. Examples of formal institutions would be the constitution, the judiciary laws, the organized market, and property rights. Informal institutions are rules governed by social and behavioral norms of the society, family, or community.

Interventions: See *responses*.

Intrinsic value: The value of someone or something in and for itself, irrespective of its utility for someone else.

Invasive alien species: An alien species whose establishment and spread threaten ecosystems, habitats or species with economic or environmental harm. Invasive species occur in all major taxonomic groups, including viruses, fungi, algae, mosses, ferns, higher plants, invertebrates, fish, amphibians, reptiles, birds and mammals. Also referred to in short as *invasives*.

Irreversibility: The quality of being impossible or difficult to return to, or to restore to, a former condition. See also *option value*, *precautionary principle*, *resilience*, and *threshold*.

Land cover: The physical coverage of land, usually expressed in terms of vegetation cover or lack of it. Influenced by but not synonymous with *land use*.

Land use: The human utilization of a piece of land for a certain purpose (such as irrigated agriculture or recreation). Influenced by but not synonymous with *land cover*.

Landscape: An area of land that contains a mosaic of ecosystems, including human-dominated ecosystems. The term cultural landscape is often used when referring to landscapes containing significant human populations.

Megadiversity country: One of 17 countries (Australia, Brazil, China, Colombia, Democratic Republic of Congo, Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Peru, Philippines, Papua New Guinea, South Africa, United States, and Venezuela) home to the largest fraction of known species in the world.

Metadata: The collection of information related to the type and characteristics of data sets and their location in a data archive.

Open access resource: A good or service over which no property rights are recognized.

Opportunity cost: The benefits forgone by undertaking one activity instead of another.

Option value: The value of preserving the option to use services in the future either by oneself (option value) or by others or heirs (bequest value). Quasi-option value represents the value of avoiding irreversible decisions until new information reveals whether certain ecosystem services have values society is not currently aware of.

Passive use value: See *existence value*.

Pastoral system: The use of domestic animals as a primary means for obtaining resources from habitats.

Policy-maker: A person with power to influence or determine policies and practices at an international, national, regional, or local level.

Pollination: The completion of the sexual phase of reproduction in some plants by the transportation of pollen. In the context of ecosystem services, pollination generally refers to animal-assisted, pollination, such as that done by bees, rather than wind pollination.

Poverty: By common definition, "Poverty" exists when one or more persons fall short of a level of economic welfare deemed to constitute a reasonable minimum, either in some absolute sense or by the standards of specific society.

Precautionary principle: The management concept stating that in cases "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation," as defined
in the Rio Declaration.

Precision: The ability of a measurement to be consistently reproduced. Also, the degree of accuracy.

Prediction (or forecast): The result of an attempt to produce a most likely description or estimate of the actual evolution of a variable or system in the future. See also *projection* and *scenario*.

Primary production: Assimilation (gross) or accumulation (net) of energy and nutrients by green plants and by organisms that use inorganic compounds as food.

Private costs and benefits: Costs and benefits directly felt by individual economic agents or groups as seen from their perspective. (Externalities imposed on others are ignored.) Costs and benefits are valued at the prices actually paid or received by the group, even if these prices are highly distorted. Sometimes termed "financial" costs and benefits. Compare *social costs and benefits*.

Probability distribution: A distribution that shows all the values that a random variable can take and the likelihood that each will occur.

Projection: A potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Projections are distinguished from "predictions" in order to emphasize that projections involve assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized; they are therefore subject to substantial uncertainty.

Provisioning services: The products obtained from ecosystems, including, for example, genetic resources, food and fiber, and fresh water.

Rangeland: An area where the main land use is related to the support of grazing or browsing mammals, such as cattle, sheep, goats, camels, or antelope.

Regulating services: The benefits obtained from the regulation of ecosystem processes, including, for example, the regulation of climate, water, and some human diseases.

Reporting unit: The spatial or temporal unit at which assessment or analysis findings are reported. In an assessment, these units are chosen to maximize policy relevance or relevance to the public and thus may differ from those upon which the analyses were conducted (e.g., analyses conducted on mapped ecosystems can be reported on administrative units).

Resilience: The capacity of a system to tolerate impacts of drivers without irreversible change in its outputs or structure.

Resolution (of observation): The spatial or temporal separation between observations.

Responses: Human actions, including policies, strategies, and interventions, to address specific issues, needs, opportunities, or problems. In the context of ecosystem management, responses may be of legal, technical, institutional, economic, and behavioral nature and may operate at local or micro, regional, national, or international level and at various time scales.

Risk: The probability or probability distribution of an event or the product of the magnitude of an event and the probability of its occurrence.

Scale: The physical dimensions, in either space or time, of phenomena or observations.. See also *level*.

Scenario: A plausible and often simplified description of how the future may develop,based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technology change, prices) and relationships. Scenarios are neither predictions nor projections and sometimes may be based on a "narrative storyline." Scenarios may be derived from projections but are often based on additional information from other sources.

Security: Access to resources, safety, and the ability to live in a predictable and controllable environment.

Social costs and benefits: Costs and benefits as seen from the perspective of society as a whole. These differ from private costs and benefits in being more inclusive (all costs and benefits borne by some member of society are taken into account) and in being valued at social opportunity cost rather than market prices, where these differ. Sometimes termed "economic" costs and benefits. Compare *private costs and benefits*.

Spatial resolution: See *resolution*.

Stakeholder: An actor having a stake or interest in a physical resource, ecosystem service, institution, or social system, or someone who is or may be affected by a public policy.

Statistical variation: Variability in data due to error in measurement, error in sampling, or variation in the measured quantity itself.

Strategies: See *responses*.

Supporting services: Ecosystem services that are necessary for the production of all other ecosystem services. Some examples include biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat.

Sustainability: A characteristic or state whereby the needs of the present and local population can be met without compromising the ability of future generations or populations in other locations to meet their needs.

Threshold: A point or level at which new properties emerge in an ecological, economic, or other system, invalidating predictions based on mathematical relationships that apply at lower levels. For example, species diversity of a landscape may decline steadily with increasing habitat degradation to a certain point, then fall sharply after a critical threshold of degradation is reached. Human behavior, especially at group levels, sometimes exhibits threshold effects. Thresholds at which irreversible changes occur are especially of concern to decision-makers.

Time series data: A set of data that expresses a particular variable measured over time.

Total economic value framework: A widely used framework to disaggregate the components of utilitarian value, including *direct* and *indirect use value*, *option value*, quasi-option value and *existence value*.

Travel cost methods: Economic valuation techniques that use observed costs to travel to a destination to derive demand functions for that destination. Developed to value the recreational use of protected areas, they have limited applicability outside this context.

Uncertainty: An expression of the degree to which a future condition (e.g., of an ecosystem) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined terminology or uncertain projections of human behavior.

Upscaling: The process of aggregating or extrapolating information collected at a fine resolution to a courser resolution or greater extent.

Utility: In economics, the measure of the degree of satisfaction or happiness of a person.

Value: The contribution of an action or object to user-specified goals, objectives, or conditions.

Value systems: Norms and precepts that guide human judgment and action.

Valuation: The process of expressing a value for a particular good or service in a certain context (e.g., of decision-making) usually in terms of something that can be counted, often money, but also through methods and measures from other disciplines (sociology, ecology, and so on).

Well-being: A context- and situation-dependent state, comprising multiple constituents including basic material for a good life, freedom and choice, health, good social relations, and security.