REVIVING LAKES AND WETLANDS IN THE PEOPLE'S REPUBLIC OF CHINA, VOLUME 3

BEST PRACTICES AND PROSPECTS FOR THE SANJIANG PLAIN WETLANDS

ASIAN DEVELOPMENT BANK

50 YEARS

ADB

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ASIAN DEVELOPMENT BANK

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Printed in the Philippines.

ISBN 978-92-9257-109-2 (Print), 978-92-9257-110-8 (e-ISBN)
Publication Stock No. RPT168005

Cataloging-In-Publication Data

Asian Development Bank.
Reviving lakes and wetlands in the People's Republic of China, Volume 3: Best practices and prospects for the Sanjiang plain wetlands.
Mandaluyong City, Philippines: Asian Development Bank, 2016.

1. Wetland. 2. Sanjiang. 3. People's Republic of China. I. Asian Development Bank.

Notes: In this publication, "$" refers to US dollars.
ADB recognizes "China" as the People's Republic of China, and "Vietnam" as Viet Nam.

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Foreword

Aquatic ecosystems in the People's Republic of China (PRC) are being destroyed by the combined effects of depletion, pollution, and development. Lakes and wetlands are especially at risk. Over the last 15 years, the Government of the PRC has invested substantially in restoring lakes and wetlands, but the efforts have not been as successful as planned.

The Asian Development Bank (ADB) closely studied issues of lake and wetland rehabilitation and published *Reviving Lakes and Wetlands: Lessons Learned from the People's Republic of China*, in 2008. ADB also published *Reviving Lakes and Wetlands: Lessons Learned from the People's Republic of China, Volume 2: Lessons Learned on Integrated Water Pollution Control from Chao Lake Basin*, in 2015.

Sanjiang Plain in Heilongjiang Province is one of the PRC's richest areas in globally significant flora and fauna. However, the wetlands have shrunk to a fifth of their original size in the last 5 decades because of increasing population, grain production, and exploitation of biological and water resources. To develop wetland management expertise and knowledge to reverse the continuing reduction and degradation of the wetlands and to protect wetland-dependent wildlife, an ADB loan cofinanced by a Global Environment Facility grant for the Sanjiang Plain Wetlands Protection Project was approved in 2005 and successfully completed in 2012. The project components were (i) watershed management, (ii) wetland nature reserve management, (iii) alternative livelihood programs, and (iv) education and capacity building. To expand successes under the project to other wetlands through capacity development, dissemination of wetland protection models, and sharing of accumulated knowledge, ADB provided technical assistance for Strengthening Capacity for Wetland Protection for Sanjiang Plain in 20152016.

Building on lessons from the Sanjiang Plain Wetlands Protection Project and based on a comprehensive literature review and discussions under the technical assistance, this knowledge product synthesizes current knowledge on the Sanjiang Plain wetlands, specific best practices, and options for action for achieving sustainable wetland management. This knowledge product should prove useful to those concerned with reviving the aquatic ecosystem in the PRC and other countries.

Ayumi Konishi
Director General
East Asia Department
Asian Development Bank

Acknowledgments

This knowledge product is based on a review of the Sanjiang Plain Wetlands Protection Project financed by the Asian Development Bank (ADB) and the Global Environment Facility. It is also based on findings from the technical assistance (TA) project Strengthening Capacity for Wetland Protection for Sanjiang Plain provided by ADB to the Heilongjiang provincial government in the People's Republic of China (PRC).

ADB staff member Yoshiaki Kobayashi administered both the Sanjiang Plain Wetlands Protection Project and the TA, and had overall responsibility for producing this knowledge product.

The authors are consultants for the TA. James T. Berdach was primarily responsibile for guiding the preparation of this knowledge product. Xiubo Yu was primarily responsibile for assisting the team leader in the preparation of this knowledge product. Andrew J. Mittelman was responsible for recommendations on options for harmonizing sustainable economic development and environmental conservation. David T. Parkin was responsible for preparing the watershed elements of the publication. Xiaohai Liu provided technical inputs on capacity building, environmental assessment, and related subjects. Xuemei Zhang prepared alternative livelihood elements of the knowledge product.

This publication benefited from close cooperation with the Heilongjiang provincial government of the PRC, particularly Heilongjiang Provincial Forestry Department (HPFD). ADB is particularly grateful to Cheng Shaoxia, director of the TA management office and senior engineer of Foreign Capital and Cooperation Office of HPFD; and Li Weina, staff of the HPFD TA management office.

Reviewers in ADB, Mark R. Bezuijen and Thuy Trang Dang, offered valuable comments during the preparation of this knowledge product.

Erika Joy Arcillas, Fangtang Li, and the Publishing Team of the Department of External Relations helped edit, design, and produce this publication.

The gathering of relevant information would have been impossible without the inputs and participation of many experts listed in Appendix 6. Readers who wish to obtain more information on the Sanjiang Plain and challenges being faced in balancing economic growth with preservation of unique biodiversity are encouraged to conduct further research. The references in Appendix 7 are a valuable resource which can be tapped for this purpose.

About the Authors

James T. Berdach is the international wetland nature reserve management specialist and team leader of capacity development technical assistance for the Asian Development Bank for the Sanjiang Plain (TA 8541-PRC) and has had the primary responsibility of guiding the preparation of this knowledge product. Berdach has over 25 years of international experience in the formulation, implementation, and monitoring and evaluation of more than 70 major development projects in natural resources and environmental management throughout the Asia and Pacific region, including four projects dealing with wetland restoration and management in the People's Republic of China (PRC) in Ma Luan Bay Wetlands, Xiamen; Baiyangdian Lake and Wetland; Jiangsu Yancheng Wetlands; and the Sanjiang Plain Wetlands). He holds a master's degree in botany from the University of Minnesota, and a bachelor's degree in general science (biology) from the University of Rochester, New York.

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Xuemei Zhang is the national alternative livelihoods specialist for TA 8541-PRC for the Sanjiang Plain. Zhang has over 15 years of experience in the formulation, implementation, and monitoring and evaluation of social development projects in the PRC, financed by various development agencies such as the Asian Development Bank, the World Bank, the United Nations Development Programme, the European Union, the Department for International Development, KfW Development Bank, and the Canadian International Development Agency. Zhang holds a PhD in agricultural economics from the Chinese Academy of Agricultural Sciences, Beijing, the PRC, and a master's degree in sociology from Wageningen Agricultural University, Wageningen, the Netherlands.

About the Knowledge Product

The Sanjiang Plain wetlands are among the most important remaining wetland areas in the People's Republic of China (PRC), representing unique habitats, species, and ecology. As a result, there is a considerable body of literature, both in the PRC and internationally, devoted to various aspects of these wetlands, including not only their ecological values but also the significant role they have increasingly played over the past several decades in the PRC's efforts to achieve national food self-sufficiency.

This knowledge product synthesizes the current state of knowledge regarding the Sanjiang Plain wetlands based on a comprehensive literature review and discussions with nearly 100 local and international experts, most of whom have been directly involved in wetland conservation efforts and sustainable development projects in the Sanjiang Plain. The knowledge product builds upon lessons that have emerged from the Asian Development Bank/Global Environment Facility–supported Sanjiang Plain Wetlands Protection Project and a review of proven effective methods from the PRC and global experience over the past 2 decades. The knowledge product goes on to discuss how sustainable economic development and wetlands conservation in the Sanjiang Plain can be harmonized. It presents basic sustainability guidelines that provide a foundation for achieving sustainable management of the wetlands in the Sanjiang Plain, as well as specific best practices, or "options for action," that are considered as being the most likely to be effective in achieving this objective.

Abbreviations

ADB	Asian Development Bank
CWA	Clean Water Act
EBM	ecosystem-based management
ESV	ecosystem services value
HPFD	Heilongjiang Provincial Forest Department
IWRM	integrated water resources management
NGO	nongovernment organization
NNR	national nature reserve
NR	nature reserve
NTFP	nontimber forest product
PES	payment for ecosystem services
PNR	provincial nature reserve
PRC	People's Republic of China
SEA	strategic environmental assessment
SFA	State Forest Administration
SPWPP	Sanjiang Plain Wetlands Protection Project (ADB)
UAV	unmanned aerial vehicle

Weights and Measures

ha	hectare
km^2	square kilometer
m	meter
m^2	square meter
m^3	cubic meter

Conversion Factors

CNY1 = $0.161 (as of 31 July 2015)
1 mu = 0.06667 hectare

Executive Summary

Over the past several decades, the People's Republic of China (PRC) has achieved a historic pace of economic development, with living standards improving exponentially, and the challenge of ensuring food security for over one billion people having largely been met.

This economic transformation has been especially evident on the Sanjiang Plain, a vast alluvial floodplain in the Heilongjiang Province in northeastern PRC. The Sanjiang Plain, formed by the confluence of three major rivers—the Heilongjiang, the Songhua, and the Ussuri—comprises a complex of forests, farmlands, and diverse wetland ecosystems. The wetlands of the Sanjiang Plain cover an area of more than 9,100 square kilometers and provide essential habitat to 23 globally threatened animal species, including 11 vulnerable species of migratory waterfowl, among them the oriental stork and red-crowned crane.

Although the wetlands of the Sanjiang Plain are vital as habitat for the rich endemic biodiversity they support, the area has also become one of the PRC's most important regions of food production. Since 1950, 80% of its natural wetlands have been converted to agricultural land to meet the food requirements of a large and growing population, also reflected in government targets for food self-sufficiency. However, large areas of ecologically sensitive land have been converted into areas of food production at a significant cost to the environment. In the process of draining and converting large wetland areas into areas suitable for agricultural production, the habitat that these former wetlands provided for the threatened animal species has been lost. In addition, the hydrological balance of the watersheds of the Sanjiang Plain has been adversely affected. With the development of large-scale agricultural irrigation systems, much of the water that previously sustained the wetlands has been diverted. This has led to receding water tables and an increasing frequency of droughts. Also, the water retention capacity of the wetlands has been compromised, resulting in floods that have become more common.

In recognition of the global importance of the Sanjiang Plain wetlands as habitat for many species of vulnerable, endangered, and threatened migratory waterbirds, as well as other important flora and fauna, a cooperative project of the Asian Development Bank and the Heilongjiang Provincial Forestry Department, titled the Sanjiang Plain Wetland Protection Project (SPWPP), was implemented from 2005 to 2012. The project had four main areas of focus—(i) watershed management, (ii) wetland nature reserve (NR) management, (iii) sustainable livelihood development, and (iv) capacity building. The SPWPP had many notable successes in each of these four target areas. These successes were largely made possible through the extensive capacity building and educational activities that were carried out, which gave conservation practitioners the knowledge and tools needed to address and

to progressively resolve many of the issues threatening the sustainability of the wetlands of the Sanjiang Plain.

However, the activities of the SPWPP were confined to just six of the 25 NRs that are established on the Sanjiang Plain. Thus, there is clear scope to expand and replicate the successful actions of the past projects to the other NRs. In addition, more attention needs to be paid to interventions that address issues outside the NRs, within the broader watershed.

Since farming on the Sanjiang Plain plays such an important role in contributing to the food security of the nation, it is clear that agricultural production will continue to be a top priority for the area. For this reason, restoration of large expanses of the Sanjiang Plain wetlands to their original ecological state is unlikely in the foreseeable future. Nonetheless, there are many remaining wetland areas both within and outside the NRs that are ecologically sensitive and important. Conservation and improved management of these "hotspots" will enhance critical habitats and improve ecosystem connectivity. This will have a significant positive impact on the overall ecological profile of the Sanjiang Plain wetlands and the capacity of the wetlands to provide a host of vital ecological services. In addition, by adopting a basin-wide watershed management approach, potential adverse impacts that originate outside the wetlands, but which nonetheless affect sensitive wetland areas, can be identified, and avoided or minimized.

This knowledge product has been prepared through the efforts of a team of specialists working in close coordination with the Heilongjiang Provincial Forestry Department and the Asian Development Bank in a participatory process that involved consultations with stakeholders coming from the NRs and the surrounding communities, as well as representatives from other government agencies, academia, and nongovernment organizations. It provides background to inform readers about the history of environment change on the Sanjiang Plain, and it identifies the key lessons learned from experience through the SPWPP that could be applied for more effective management of wetlands in the future.

Perhaps, most important of all, the knowledge product also presents detailed recommendations—key "sustainability guidelines" and a range of innovative best practices, or "options for action"—that could further strengthen efforts for conserving, protecting, restoring, and managing the Sanjiang Plain wetlands and their attendant biodiversity resources in the future.

The main *sustainability guidelines* presented here, which can provide the foundation for a successful integration of wetlands conservation initiatives and sustainable economic development in the Sanjiang Plain, are the following:

(i) **Using a precautionary approach.** The precautionary principle is one that is intended to ensure the integrity of the ecosystem and its vital ecological functions, by requiring that the impacts of human activities are avoided and minimized to the extent possible. For any significant impacts that are unavoidable, ecological compensation measures must be carried out.

(ii) **Adopting ecosystem-based management and integrated water resources management.** Ecosystem-based management is an integrated area management approach that considers the entire ecosystem, including humans. Through attention to the biological, hydrological, socioeconomic, and policy and regulatory conditions that define a site or a given situation, ecosystem-based management can provide the optimal means to achieve integrated sustainable environment management and economic development. Integrated water resources management provides a means for coordinating management across multiple sectors, throughout the entire watershed, especially taking into consideration as to how upstream actions can cause impacts that affect the wetlands downstream.

(iii) **Supporting sustainable livelihoods.** Over the long term, the promotion of sustainable, alternative livelihood options is an element that will prove especially important for the continued survival of the Sanjiang Plain wetlands. The livelihoods of the large majority of farmers and others living on the Sanjiang Plain are inextricably linked to the land. By reducing the amount of land required to support households who currently depend on cultivating relatively large tracts of land, more land could be freed up for reconversion back to wetland. By definition, sustainable livelihoods also cause lesser environmental impacts and can produce revenue streams that can be used to support conservation efforts.

(iv) **Using participatory planning methods.** One of the fundamental principles of integrated watershed management practice is using participatory planning methods to engage a wide spectrum of stakeholders, to be given a voice in planning and decision making. Because water and other resources are used for diverse purposes by different groups, it is important to promote better dialogue between them in order to arrive at agreements concerning issues that affect them all. This is particularly important because of the close interdependency between upstream uses and downstream impacts. Local stakeholders, having developed a strong sense of ownership during the planning stages, also have an important role to play in the comanagement of watersheds and wetland areas during implementation.

(v) **Continuing awareness raising, education, and capacity building.** Applying a wide-reaching and multifaceted educational, awareness-raising, and capacity-building program will strengthen the likelihood that behaviors and attitudes of important groups of stakeholders, including decision makers, NR managers, children and youth, and grassroots community members, will be positively influenced to play an active role in conserving and protecting sensitive natural habitats, ecosystems, and biodiversity.

Some of the specific "options for action" that have been identified in this report, which have been recommended for application in the Sanjiang Plain, include the following:

(i) **Strengthening water quality monitoring programs**. It has been observed that water quality in the wetlands of the Sanjiang Plain has failed to meet the required legal standard. The first step to ensure that water quality can be improved is to implement more consistent and rigorous monitoring, complemented by actions that will help to reduce discharge of sediments, nutrients, and other pollutants that ultimately find their way to waterways and the wetlands.

(ii) **Improving land management and other practices related to plantation forestry.** These are methods that can be employed during planting, cultivation, and harvesting, to promote better hydrological functioning within the watershed.

(iii) **Applying environmental principles in farming.** Included here are best practices that can help control soil erosion, conserve water, and minimize pollution in agricultural runoff.

(iv) **Developing and strengthening management plans for NRs.** This option discusses the fundamental requirement for comprehensive management plans to be developed to guide the operation of NRs and similar protected areas.

(v) **Identifying ecological hotspots and biodiversity corridors as priority sites for wetland conservation.** While much of the remaining wetlands of the Sanjiang Plain are found within the boundaries of the NRs, there are still important wetland areas that lie outside the NRs that are not being adequately protected. Identifying and protecting these "hotspot" areas, along with riparian corridors and potential corridors along flyways, can help to improve habitat connectivity. This will serve to better support the multiple functions of the wetland ecosystem as habitat for wildlife and as a regulator of hydrological function.

(vi) **Improving habitat for nesting and breeding waterbirds.** Within this option, suggestions are made for selectively manipulating habitat to improve the survival of waterbirds, especially during nesting. Options include building up areas of raised ground to prevent nest flooding, protecting nests from predation on artificial islands, and improving natural food supplies for foraging and nesting birds.

(vii) **Improving wetland restoration results by applying research-based technological advances.** Discussed here are methods developed by research scientists to promote faster and more successful propagation of wetland plants, which could be used to accelerate wetland reconversion and recovery.

(viii) **Applying new technologies to improve monitoring of waterbirds.** Presented in this option is the use of unmanned aerial vehicles or "drones," as a tool for monitoring waterbirds that would otherwise be inaccessible.

(ix) **Providing support and advocacy for inclusion of wetland sites on the Sanjiang Plain on the Ramsar list of wetlands of importance.** This option is proposed as an effective mechanism that can help improve awareness about important wetland sites and generate stronger support for their conservation and protection.

(x) **Using ecosystem services valuation and payment for ecosystem services as foundations for sustainable financing of conservation.** All too often, key decision makers are not fully aware of the economic value of goods and services that are provided by the natural ecosystem. Once made aware of the importance of the economic contributions made by the natural system, they are more inclined to lend support for the protection of wetlands, watersheds, and other important natural areas. Successful implementation of payment for ecosystem services schemes can help to ensure that resource users are giving appropriate compensation to persons or entities who are working to protect the natural ecosystems that provide important economic benefits.

(xi) **Supporting development of a wide range of sustainable livelihood options.** Discussed here are specific opportunities for sustainable livelihoods that offer an alternative to conventional farming practices, including, among others, ecotourism, greenhouse farming and hydroponics, cultivation of high-value nontimber forest products, handicraft production, and farming on floating gardens.

The options for action mentioned here are described in greater detail in this report (see Section V, Part B). In addition, Appendix 3 provides a concise but comprehensive listing totaling more than 30 suggested approaches and actions that can help to promote improved management of critical resources on the Sanjiang Plain.

Given the global significance of the flora and fauna that depend on the wetlands of the Sanjiang Plain for their survival, and the critical ecological services that are provided by the wetlands, this knowledge product has been developed as a "call to action" for government, the private sector, civil society, and development partners to provide the necessary support for the protection of these vital resources. Supporting the implementation of the key principles and best practices described in this knowledge product will enable the continued preservation and sustainable management of the Sanjiang Plain wetlands' unique ecosystems, while enabling continuing sustainable economic development in northeastern PRC. It is therefore envisioned that applying the measures described here will deliver "win–win" results in which the rehabilitation and protection of the ecology of the Sanjiang Plain, and thereby, its vital natural functions, will contribute to the achievement of priority long-term economic development objectives in an environmentally sustainable manner.

I. Introduction

During the past several decades, the People's Republic of China (PRC) has achieved a pace and scale of economic development never before witnessed in human history. Living standards in the PRC have improved exponentially, while the monumental challenge of ensuring food security for over one billion people has largely been met. But as large areas of ecologically sensitive land have been placed into production, these economic achievements have come at a considerable cost to the environment.

Nowhere has this transformation been more evident than on the Sanjiang Plain, a vast alluvial floodplain in Heilongjiang Province in northeastern PRC. Although the wetlands of the Sanjiang Plain are vital as habitat for the rich endemic biodiversity they support, the area has also become one of the PRC's most important regions of food production. Since 1950, 80% of its natural wetlands have been converted to agricultural land to meet the demands of a large and growing population and concurrent government targets to achieve food self-sufficiency. During the past 3 decades, rice production in Heilongjiang Province increased more than 20-fold, from 795,000 to 18,439,000 tons, with an average annual growth rate of 11%.[1]

Thus, the rapid development that began in the 1950s, and accelerated further from the 1970s onward, has resulted in the widespread loss of pristine wetland ecosystems that have been converted primarily to agricultural land for grain production. Rapid in-migration of large numbers of people to Heilongjiang Province, to meet the growing demand for an agricultural labor pool, has placed added pressure on land and other natural resources. Also, industrial development and mining in the upstream watersheds, increased water extraction from the main river systems, and agricultural pollution have all caused significant impacts that have adversely affected the extent and ecological integrity of the Sanjiang Plain wetlands. As a result of all these effects, over the last 5 decades, the Sanjiang's wetlands have shrunk to one-fifth their original size.

Recognizing the national and global environmental significance of wetlands and of the rich biodiversity that they support, during the 1990s, the Government of the PRC designated eight national wetland nature reserves (NRs). Six of these original national-level wetland reserves were on the Sanjiang Plain. In addition to this recognition at the national level, the Heilongjiang provincial government has given its commitment specifically to conserving and restoring the wetlands of the Sanjiang Plain. In 1998, the Heilongjiang Province decision about strengthening conservation of wetlands was promulgated. Complementing and reaffirming this commitment from the government, in 2002, three of Heilongjiang's

[1] J. Huang, X. Wang, and H. Qui. 2012. *Small-Scale Farmers in China in the Face of Modernization and Globalization*. London/The Hague: IIED/HIVOS. p. 8.

wetland areas were nominated as wetlands of international importance under the Ramsar Convention. Further, in 2003, the *Regulation about Conservation of Wetlands in Heilongjiang Province* ordered stoppage of all further reclamation in wetland areas in Heilongjiang Province, the first law of its kind in the PRC. More recently, in 2013, the Heilongjiang provincial government established a Wetland Conservation Management Center, as a repository of information and expertise regarding wetland management throughout the province. Finally, there are currently 15 provincial-level NRs that have been established in the Sanjiang Plain. All of these factors offer strong evidence of the support for wetlands conservation at the provincial level.

In 2005, the Heilongjiang Provincial Forest Department, in conjunction with the Asian Development Bank (ADB) and Global Environment Facility, embarked on a 7-year, $55 million project, the Sanjiang Plain Wetlands Protection Project (SPWPP). The overall goal of this effort was to sustainably manage natural resources and protect the globally significant biodiversity found in the Sanjiang Plain wetlands, while promoting economic development in Heilongjiang Province. The immediate objective of the SPWPP was to protect the natural resources of the Sanjiang Plain wetlands and their watersheds—including biodiversity, water, and forest resources—from continued threats. The project also promoted sustainable resource use through the integrated conservation and development of selected wetlands and forest areas and supported the development of sustainable livelihood options to improve the well-being of local communities. The SPWPP included four key implementation components, such as (i) watershed management, (ii) wetland NR management, (iii) alternative livelihoods, and (iv) education and capacity building.[2] Under the project, various pilot wetland protection activities were conducted in six model NRs.[3] The main results of the project activities for each of these four components were:

(i) **Component 1: watershed management.** Under the project, 10,090 hectares of new forestry plantations were established, and 39,769 hectares of existing forestry was maintained. Integrated watershed-level and local-level NR water resource planning and water management schemes were formulated. Practical water allocation and management schemes for promotion of water efficiency were put into operation. Implementation of new rural policies was improved, the information system for water resources management was strengthened, and pilot demonstration projects were implemented.

(ii) **Component 2: wetland NR management.** Wetland restoration, wildlife species protection, and habitat recovery were carried out using a variety of methods. Reform of conservation regulations and strengthening of enforcement activities was undertaken. Sustainable utilization of natural resources, including such uses inside NRs, according to NR regulations, was initiated. Field investigations were conducted in NRs, including targeted surveys and monitoring of endangered species. Practices for NR financing were reformed. Integrated planning was conducted for NRs, including the preparation of management plans. Institutional systems for nature conservation were strengthened, and assistance was provided for capacity building in wetland management and restoration. Pilot

[2] A fifth component of the SPWPP was project management.

[3] The model nature reserves (NRs) of the SPWPP were Anbanghe NR, Dajiahe NR, Naolihe NR, Qixinghe NR, Xingkaihu NR, and Zhenbaodao NR.

and demonstration projects for wetland restoration and species recovery were conducted.

(iii) **Component 3: alternative livelihoods.** Development of alternative livelihood options was undertaken through improved community planning and included such activities as intercropping of nontimber forest products, greenhouse farming, and ecotourism. Improved enforcement of existing wetland and NR regulations and instruction of stakeholders included coverage of sustainable livelihood options, focusing on reducing natural resource exploitation to sustainable levels according to regulations. Sustainable financing of alternative livelihood activities was also investigated.

(iv) **Component 4: education and capacity raising.** Assistance was provided to increase capacity of NR personnel in wetland management and restoration, through education programs. Key topics covered included enforcement, management, and wildlife conservation.

In order to disseminate lessons learned from the SPWPP, the ADB included the Sanjiang Plain as one of several case studies presented in its knowledge product entitled, "Reviving Lakes and Wetlands: Lessons Learned from the People's Republic of China."[4] That report made a compelling case, on scientific, historic, cultural, and economic grounds, for decision makers in the PRC to give strong support to maintaining the health of the PRC's vital lake and wetland ecosystems.

The multiple accomplishments of the SPWPP were impressive. They have contributed to restoring or maintaining valuable wetland areas of the Sanjiang Plain. However, given the vast geographic area and the complex and challenging nature of the issues and problems to ensure their conservation, it is also clear that much work remains to be done—and must be done—to guarantee the continuing survival and integrity of these fragile environments comprising the Sanjiang Plains.

This knowledge product has been prepared through the efforts of a team of specialists working in close coordination with the Heilongjiang Provincial Forest Department and ADB, in a participatory process that involved consultations with stakeholders from the wetland NRs and the surrounding communities, as well as representatives from other government agencies, academia, and nongovernment organizations. It provides background to inform readers about the history of environmental change on the Sanjiang Plain, and it identifies the key lessons learned from experience through the SPWPP, that could be applied for more effective management of wetlands in the future.

Perhaps, most important of all, the knowledge product also presents detailed recommendations—key "guiding principles" and a range of innovative best practices, or "options for action"—that could further strengthen efforts for conserving, protecting, restoring, and managing the Sanjiang Plain wetlands and their attendant biodiversity resources in the future. Thus, this knowledge product serves as a "call to action" to inform a broad audience—including key decision makers, researchers, and the concerned public—of the urgent need for strengthened conservation, protection, and management of the Sanjiang Plain wetlands.

[4] Q. Zhang et al. 2008. *Reviving Lakes and Wetlands: Lessons Learned from the People's Republic of China.* Manila: Asian Development Bank.

II. Background and Importance of the Sanjiang Plain Wetlands

Location

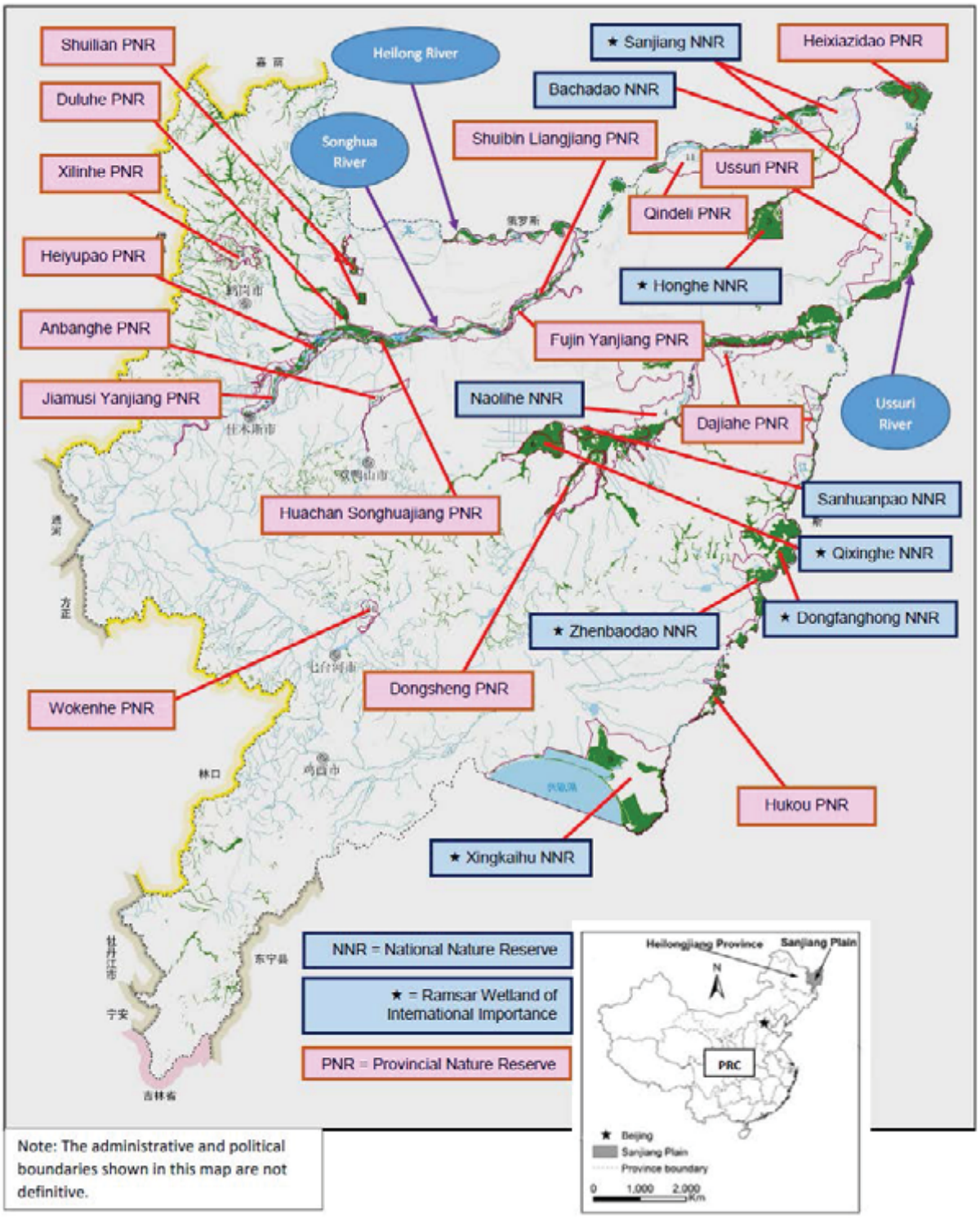
The Sanjiang Plain is a highly modified alluvial floodplain that is located at the confluence of three major rivers, Heilongjiang, Songhua, and Ussuri, in Heilongjiang Province in northeast People's Republic of China (PRC). The plain covers an area of more than 108,900 square kilometers and encompasses a diverse complex of farmlands, forest, and wetland ecosystems.

Of the total area of the Sanjiang Plain, some 9,100 square kilometers—or approximately 9%—are wetlands, the largest concentrated area of freshwater wetlands in the PRC (Map 1). These wetlands—often referred to as "nature's kidneys"—support about 37 different types of plant communities, 1,000 species of plants, and 528 species of vertebrate fauna.

Located between approximately 45° 01› 05» N ~ 48° 27› 56» N and 130° 13› 10» E ~ 135° 05› 26» E, the Sanjiang Plain encompasses 21 counties that belong to the cities of Jiamusi, Hegang, Shuangyashan, Qitaihe, and Jixi, as well as Muling County in Mudanjiang City and Yilan County in Harbin City. Topographically, the land slopes gradually from the southwest to the northeast. The continuum of the low-lying alluvial plain is broken by low terraces, rivers, marshes, and swamp meadows that are developed across the floodplain. Most of the rivers in the area are marshy and are characterized by a slight gradient and a sinuosity index that generally ranges between 1.5 and 3.0. Vegetation consists mostly of swamp meadow and marsh vegetation of the Changbai flora. The soils of the Sanjiang Plain are highly fertile. The Sanjiang Plain falls within the temperate humid and semihumid continental monsoon climate zone, with a mean annual precipitation of 500 millimeters–650 millimeters and a mean annual air temperature of 2.5°C–3.6°C. The mean air temperature is –18°C in January and 21°C–22°C in July.[5]

[5] K. Song et al. 2008. Land Use Change in Sanjiang Plain and its Driving Forces Analysis Since 1954. *Acta Geographica Sinica*. 63 (1). pp. 93–104.

Map 1: Map of the Sanjiang Plain Wetlands and Nature Reserves, Heilongjiang Province, People's Republic of China



Source: Heilongjiang Provincial Forestry Department.

Biodiversity Significance of the Sanjiang Plain Wetlands

The Sanjiang Plain wetlands support 23 globally threatened species[6] and 16 endemic species of wildlife, plus four rare endemic plant[7] species. Eleven of the threatened wildlife species are migratory waterfowl, such as cranes, storks, ducks, and geese (examples are shown in Figures 1–4), which require extensive, undisturbed wetlands during their migration and breeding seasons.

Much of the area of the Sanjiang Plain that serves as habitat for endangered and threatened wetland-dependent species is found within the designated nature reserves (NRs). As shown in Map 1, 25 NRs are located on the Sanjiang Plain, administered either as national nature reserves or provincial nature reserves. Of these, six national nature reserves are listed as sites containing wetlands of international importance under the Ramsar Convention:[8] Honghe NR, Sanjiang NR, Xingkaihu NR, Qixinghe NR, Dongfanghong NR, and Zhenbaodao NR. Together, these six NRs represent around 13% of the total coverage of Ramsar sites in the PRC, by land area. A summary description of the NRs of the Sanjiang Plain is provided in Appendix 1, and a listing of endangered and threatened species of fauna reported from six NRs (those that were the pilot areas for the Sanjiang Plain Wetland Protection Project) is provided in Appendix 2.

Considerations for the Management of Wetland Habitat in the Sanjiang Plain

Although much of the original wetland area of the Sanjiang Plain has been converted to agricultural land, some tracts of unprotected wetland habitat still remain outside the boundaries of established wetland NRs or wetland parks. Some of these are designated as "special habitats" (*bao hu xiao qu*) that are specifically intended to maintain areas utilized by populations of endangered species. These lands are important nesting and foraging habitats for oriental storks and red-crowned cranes (both globally endangered), White-naped cranes (vulnerable), and menzbier's pipits (endemic subspecies). During migration, these lands are important staging areas for ducks (baer's pochard and baikal teal, both vulnerable) and geese (swan goose, endangered; lesser white-fronted goose, vulnerable). However, unlike the NRs, which fall under the State Council Nature Reserve Management Regulation, there are no national regulations or policies to support conservation efforts within these "special habitats."

6 Listed on the International Union for Conservation of Nature Red List of Threatened Species.

7 "Study in China One-Stop Services" website: "Top Five Wetlands Rich in Local Features in China;" http://news.at0086.com/China-tours/Top-Five-Wetlands-Rich-in-Local-Features-Most-in-China.html

8 The Ramsar Convention is an international treaty for the conservation and sustainable utilization of wetlands, named after the city of Ramsar in Iran, where the convention was signed in 1971.

Figures 1–4: Representative Threatened and Endangered Species of Migratory Waterfowl of the Sanjiang Plain

Figure 1. Red-crowned crane (*Grus japonensis*)

Figure 2. Oriental stork (*Ciconia boyciana*)

Figure 3. Baikal teal (*Anas formosa*)

Figure 4. Siberian crane (*Grus leucogeranus*)

Sources: Figure 1: Liu, Yi. May 2010. "Top 6 Swamps/Wetlands in China w. Google Earth Links," ChinaBlog.cc: http://chinablog.cc/2010/05/top-6-swampswetlands-in-china-w-google-earth-links/; Figure 2: Dajiahe NR; Figure 3: Irving, Dave. "Baikal Teal." flickr: https://www.flickr.com/photos/dave_irving/5855027440; Figure 4: Oriental Bird Club Database. http://orientalbirdimages.org/search.php?Bird_ID=819&Bird_Image_ID=2285&p=32

Furthermore, there are no full-time staff or operational budget assigned for the conservation of the special habitats. Finally, in the Sanjiang Plain, very few special habitats have been designated by local governments. These deficiencies represent a significant gap in wetland management practice, which needs to be addressed to ensure that the last remaining areas of intact wetlands—and particularly, areas that serve as critical habitat for endangered species—are preserved.

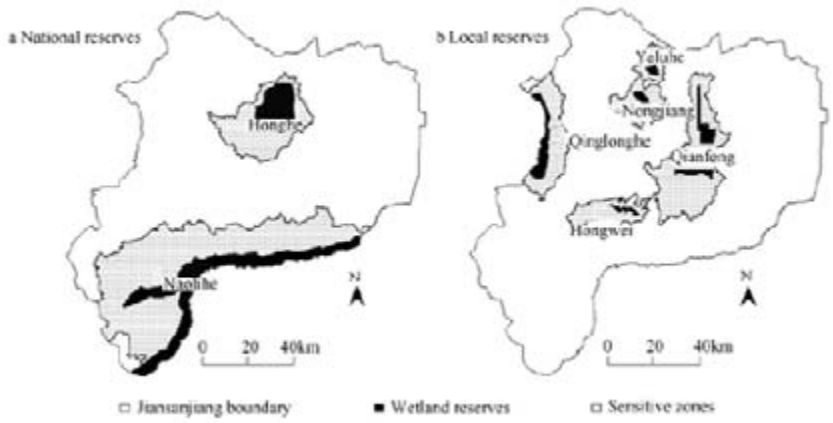
Hydrological Functions of the Sanjiang Plain Watershed and Wetlands

The healthy functioning of the wetland ecosystems of the Sanjiang Plain is closely linked to the health of the total watershed. Low-lying wetland areas are a physical "sink" that are subject to impacts that flow downstream from many potential "source" areas in the watershed above. The understanding and application of the principles of hydrology forms the basis for allocating and managing water quantity and quality for competing uses such as agriculture, domestic and commercial water supply, and for passive uses—especially, the "minimum ecological flow" required to maintain wetlands and other ecosystems within the watershed. The wetlands, in turn, play a key role in controlling floods and filtering nutrients and pollutants from surface waters that percolate into subsurface layers to recharge groundwater aquifers. Taken collectively, these functions are extremely important for maintaining the overall ecosystem health, which provides benefits not only for the wildlife that depend on the habitat and water resources of the wetlands but also the human population that utilizes the water and other resources of the watershed.

Because the wetlands are strongly influenced by effects that may originate from activities in the upper and middle reaches of the watershed, success in maintaining the important ecological functions of wetland areas of the Sanjiang Plain cannot be assured *only by management within the boundaries of the wetland* NRs—*preserving the ecological function of the wetlands is very much dependent on the effective management of the watershed as a whole*. In the Sanjiang Plain, the manner in which forested areas and agricultural lands are managed is particularly important in determining the impacts on lower-lying wetlands.

Map 2 helps to illustrate the linkage between wetlands and the surrounding areas. It shows how the wetland NRs are located within much larger hydrological "zones of influence"

Map 2: Location of Selected Sanjiang Plain Wetland Nature Reserves and Their Hydrologically Sensitive Zones



Source: X. Bai et al. February 2008. Differences of Ecological Functions Inside and Outside the Wetland Nature Reserves in Sanjiang Plain. *Acta Ecologica Sinica*. 28 (2). pp. 620–626.

within the watershed. Any action within these larger zones that result in changes in water flow volumes, or changes in water quality, can affect the functioning of the wetlands (e.g., for flood control, groundwater recharge, maintenance of the food chain, and habitat for larger animals). Therefore, managing the watersheds in an integrated, holistic manner is essential for ensuring the sustained health and functionality of the wetlands.

Carbon Sequestration and Climate Change

Forests in the upper watershed areas of the Sanjiang Plain also function as carbon sinks that absorb carbon dioxide from the atmosphere, converting it to organic carbon that can be stored as biomass. Like forests, wetland areas are effective in absorbing carbon from the atmosphere. Carbon continues to be stored in wetland plants, or gets transferred to other living organisms, as plants decay and contribute organic matter to the soil.

In fact, research findings suggest that wetlands can sequester carbon more effectively than trees do. This is because in wetland ecosystems, carbon that is removed from the atmosphere is captured in plant tissues and held not only in the plants themselves but also in significant concentrations in the soil, as soil organic carbon. In addition, because wetlands act as sinks to collect and concentrate carbon and sediment generated throughout the broader landscape,[9] carbon sequestration is further enhanced. According to one wetlands expert at the University of Ohio (Columbus, Ohio, United States):

> "...wetlands are probably the best ecosystem on the planet to sequester carbon."[10]

Thus, wetland conservation can play an important role as part of the overall effort to control and reverse global climate change. Conversely, the loss of wetlands on a large scale contributes to an acceleration of global warming and related climate change impacts. In a recent study from Canada,[11] it was reported that drainage of wetlands can have a dramatic impact on carbon stores. Large quantities of carbon are released back to the atmosphere when seasonal, semipermanent, and permanent wetlands are drained. This loss is further amplified if the drained wetland basin is converted to cropland.

History of Wetland Conversion on the Sanjiang Plain

The conversion, or "reclamation," of the wetlands of the Sanjiang Plain to farmland is a process that dates back to at least the early 1900s, which possibly began more than 100 years ago. Box 1 briefly describes the history of reclamation on the Sanjiang Plain.

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9 J. Kusler. (n.d.). *Common Questions: Wetland, Climate Change, and Carbon Sequestering.* Association of State Wetland Managers, Inc. in cooperation with The International Institute for Wetland Science and Public Policy. http://www.aswm.org/pdf_lib/11_carbon_6_26_06.pdf

10 Dr. William Mitsch, as quoted in *An Unseen Carbon Sink*. Nature Reports—Climate Change. http://www.nature.com/climate/2009/0912/full/climate.2009.125.html (accessed 26 November 2009).

11 P. Badiou, C. Edwards, and M. Gloutney. 2010. *TEEBcase: Wetland Restoration for Carbon Sequestration in Prairie Canada.* http://doc.teebweb.org/wp-content/uploads/2013/01/Wetland-restoration-for-carbon-sequestration-in-Prairie-Canada.pdf

Box 1: A Brief History of Wetland Reclamation on the Sanjiang Plain

Land transformation in the Sanjiang Plain, with conversion of much of the original wetland area to agricultural land, has been a steady but gradual process carried out over many decades, and one that has dramatically altered the nature of the physical and biological environment. The conversion of wetlands to agricultural land in northeastern China probably had its beginnings at the end of the Qing Dynasty (late 19th to early 20th century). However, this process accelerated dramatically during the four subsequent phases of agricultural development: first in the 1950s, with 100,000 demobilized officers and soldiers sent to the region to plow virgin lands to plant rice and corn for the establishment of state farms; then, accelerating further with the influx of educated urban youth as workers during the Cultural Revolution in the 1960s–1970s (see Figure 5); continuing with growing economic development from approximately 1976 to 1982; and finally, expanding further during the period of major economic reform and investment from around 1986 to 1998.

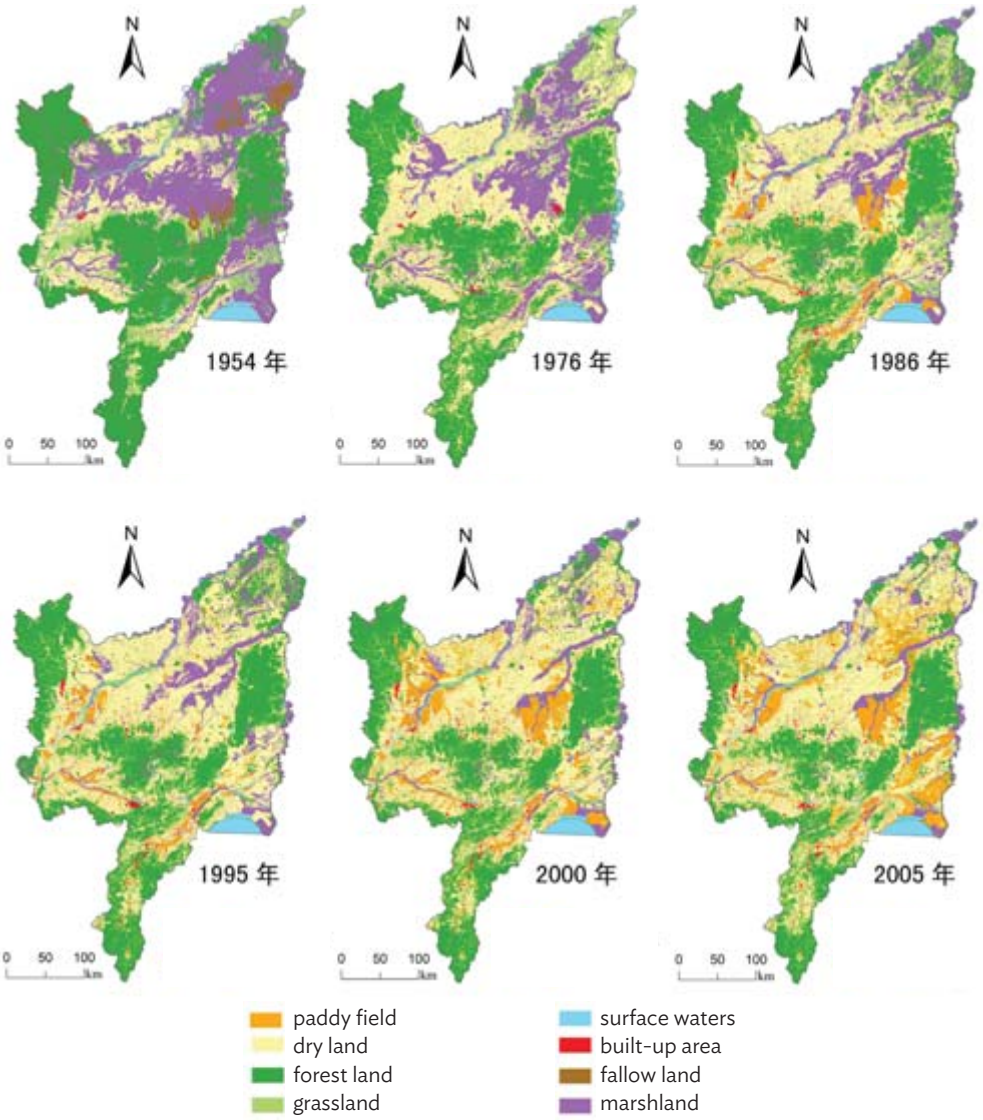
Since the 1950s, 52 state-owned farms have been established. A large number of farmers, demobilized officers and soldiers, and educated youth moved into the area. As a result, the population density in the Sanjiang Plain increased from 12.84 persons per square kilometer in 1949 to 78.39 persons per square kilometer in 2000, a fivefold increase. The large-scale land-use practice has been focused on marsh reclamation, as well as on deforestation and development of water diversion and retention structures for irrigation. For this reason, the wetland area has been in steady decline, with about 64.8% of the original wetland area lost thus far. Over the last half-century, while the area of farmland and land for residential and industrial use has increased, the area for other land-use types declined to varying degrees, in particular the wetlands and grasslands. Time-series maps produced in a recent study (Map 3) illustrate the dramatic growth in the percentage of farmland and decline in wetlands and forestland area during the period from 1954 to 2005 (farmland: 15.91% in 1954 to 51.17% in 2005; wetland: 32.74% in 1954 to 8.81% in 2005; and forestland: 38.18% in 1954 to 31.63% in 2005).

Sources: X. Liu and X. Ma, 2002. *Natural Environmental Changes and Ecological Protection in the Sanjiang Plain*. Beijing: Science Press. pp. P60–P65; 171–172; H. Liu et al. 2004. Impacts on Wetlands of Large-Scale Land-Use Changes by Agricultural Development: The Small Sanjiang Plain. *Ambio*. 33 (6). pp. 306–310.

Figure 5: Workers Reclaiming Wetlands for the Establishment of State Farms in Sanjiang Plain (ca. 1954)

Source: Anbanghe Nature Reserve Reclamation Museum.

Map 3: Time-Series Map Showing Land-Use Change on the Sanjiang Plain, 1954–2005



Source: Zongming Wang, professor, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences.

Figure 5 shows historic images of reclamation activities. In Map 3, time-series maps show the progressive loss of wetland area from 1954 to 2005, while Figure 6 shows the current state of much of the land that has been converted from wetlands to farmland. In addition, in recent years, livestock production has also been a developing industry (Figure 7). Sheep, goats, and cattle are grazed not only on drained wetlands but also inside some NRs. Naturally, land conversion for farmland or grazing area results in the direct loss of large areas of wetland, significantly reducing the availability of suitable habitat for sensitive and vulnerable species. As shown in Table 1, by the year 2000, the wetland area of the Sanjiang Plain was reduced to only around 28% of its prior extent in 1949.

Figure 6: Reclaimed Land under Cultivation on the Sanjiang Plain

Source: Panoramio photo [Google Earth] at Fujin, Jiamusi.

Figure 7: Reclaimed Land on the Sanjiang Plain Used for Grazing of Livestock

Source: Guo Yumin; at http://amur-heilong.net/pho/07_landuse_argiculture/07_agri/07_china/index.html

Table 1. Wetland and Farmland Areas in the Sanjiang Plain
('000 hectares)

	1949	1975	1985	1990	1995	2000	2013
Wetlands	5,350	3,240	2,720	2,110	1,980	1,480	910
Farmlands	780	2,050	3,490	3,600	3,740	4,570	...

... = data not available.

Sources: Heilongjiang Environmental Protection Bureau and Heilongjiang Research Institute of Environmental Protection. Environmental Impact Assessment of Integrated Agricultural Development and Environmental Protection Planning of Sanjiang plain. Harbin. 1996. 2000 figures from Liu et al. 2004; 2013 figures from Heilongjiang Provincial Wetland Conservation and Management Center.

Policy, Planning, and Institutional Context

Some 16 government ministries and agencies have mandates and responsibilities for various aspects of wetland resource management in the PRC. At the national level alone, these include (among others) the National Development and Reform Commission, Ministry of Environmental Protection, State Forestry Administration (SFA), Ministry of Agriculture, Ministry of Land and Resources, Ministry of Water Resources, and State Oceanic Administration. National laws, such as the Agriculture Law, Fishery Law, Grassland Law, Forestry Law, Wildlife and Plant Conservation Law, Water Law, Environment Law, Sea Law, and Nature Reserve Management Regulation, empower these ministries and agencies for the various corresponding elements of wetland ecosystem management.

At the national level, SFA is the leading agency for wetland conservation and management and is responsible for the coordination of implementation of the Ramsar Convention. In 2005, the State Council announced the establishment of the National Wetland Conservation Center under the SFA.

As mentioned in the preceding paragraphs, significant steps have been taken, including the promulgation of various laws, both at the national and the provincial level, to preserve and improve the condition of existing wetlands. Furthermore, support has been given not only for conserving the remaining wetlands but also for restoring prior wetland areas through reconversion of agricultural lands back to their original state. With funding from the National Development and Reform Commission, the Heilongjiang Provincial Forestry Department managed a program that targeted restoring 150,000 hectares (ha) of farmland to wetlands and replanting 68,500 ha yearly by 2010; a number of former wetland areas have been successfully restored as planned. In 2014, the national government allocated further funding of CNY 125 million for restoring an additional 8,300 ha of wetland from farmland in Heilongjiang Province. The funding and area specified represent 80% of the targeted funding and area for restoring wetland from farmland nationwide, as stipulated in the wetland management plan of the SFA.[12]

However, in many cases, implementing these laws and plans has been proven to be difficult, *even within wetland NRs*. This is because of two major factors: (i) complexity of land ownership arrangements and (ii) legal conflicts and contradictions that exist between laws and policies aimed at wetlands conservation versus other laws and policies that are aimed at ensuring improved agricultural production and food security. Further information regarding the tenurial and legal complexities surrounding wetlands management on the Sanjiang Plain is presented in Box 2.

As indicated in the example highlighted in Box 2, there are a number of apparently contradictory elements within the land ownership and legal framework that have a direct impact on the effectiveness of wetland management. Until these are reconciled, it will be difficult to ensure, on a consistent basis, that the most fragile and valuable areas of the wetland ecosystem of the Sanjiang Plain are accorded the protection that they require to preserve the remaining habitats and their ecological and hydrological functions.

[12] State Forestry Administration (PRC). 2014. *Annual plan of National Wetland Conservation Project*.Beijing.

Box 2: Land Ownership and Legal Conflicts Relating to Wetland Management in Nature Reserves of the Sanjiang Plain

For six wetland nature reserves (NRs) that were pilot sites for wetland management under the Sanjiang Plain Wetland Protection Project (SPWPP), land-use rights and management rights are held in various ways. Of these, only Qixinghe NR owns 100% of land-use rights, Anbanghe NR only owns 37%, and others own none. According to land-use ordinances ("Nature Reserve Land Management Provisions" [enacted in 1995 Guotu [Fa] Zhi No. 177 Ordinance by State Land Administration and State Environmental Protection Bureau on July 24, 1995]), "the legal land ownership and use rights shall not be altered in any newly defined nature reserves," indicating that the establishment of NRs only endows NR management bureaus with the rights to manage NRs in accordance with relevant regulations and laws on NRs, rather than any land-use rights.

This poses problems for NRs when they want to make changes in land use (e.g., conversion to wetlands) or to lease land for a specific purpose. Any appropriation of collectively owned lands or state-owned lands for newly established NRs, or for NR expansion or identification of core zones and buffer zones, requires approval through a legal process described under the "Land Management Law." This can be an expensive process and no funds are available in master plans to support the transfer of land-use rights. Furthermore, when it comes to land-use disputes, it is hard to come up with appropriate solutions.

An example of the above problem of conflicts in land ownership and use rights is found in Xingkaihu national nature reserve. Under the SPWPP, a plan was developed to convert a 333-hectare plot of land in the core area to wetlands. However, this land is owned by the State Farm Bureau, 29th Brigade Farm, and the land is classified as "basic farmland." Under state law, basic farmland is "protected by law" and cannot be used for any other purpose. But the Heilongjiang Provincial Government Regulation on Protection of Wetlands in Heilongjiang Province (2003), in Article 28, states that farmlands are prohibited within core zones of NRs, while the National Nature Reserve Regulations (1994) state that farming is not permitted in core or buffer zones.

Lessons learned from the SPWPP show that the main impediments to a provincial farmland-to-wetland restoration program are not technological constraints, but policy and regulatory constraints.

The example of Xingkaihu national nature reserve mentioned above provides a good case study on the problem of conflicting policies whereby the conversion of agricultural land to wetlands within the NR cannot be undertaken, since the land is protected as basic farmland.

In addition, paradoxically, farming is the primary activity that sustains the NRs financially: it is through farming activities that the NRs generate the revenues to pay for their operations and salaries of staff, and support the management of the ecological values they are meant to conserve and protect. For this reason, restoring farmland to wetland is not seen as a net gain to the NRs but as a significant loss of much-needed income. Thus, unsurprisingly, NRs are reluctant parties to wetland restoration efforts.

Source: Adapted from Landell-Mills. 2012. *Reviving Lakes and Wetlands: Lessons Learned from the Sanjiang Plain*. Harbin, China: Sanjiang Plain Wetlands Protection Project. p. 31.

III. Situation Analysis: Threats to the Wetland Ecosystem

Land Conversion and Continuing Pressure on Habitat and Biodiversity

The actions that have resulted in wetland loss in the Sanjiang Plain have already been identified in the Introduction section. Reflecting the scale of the conversion from wetlands to farmland, the State Farm Sub-Bureaus in the Sanjiang Plain now constitute the People's Republic of China's (PRC) largest commercial agricultural production base.[13] Heilongjiang Province's area of arable land, at 11.3 million hectares (ha), is now the largest of all provinces in the PRC. Over the past 50 years, the Sanjiang Plain has become one of the most important grain-producing areas in the PRC, and agricultural production here contributes 10% of the total national output.[14] What was once known colloquially as the "Great Northern Wilderness" or *beidahuang* has been transformed into what is now called the PRC's *beidacang* or "Great Northern Grain Barn."[15]

In recent years, several specific national and provincial laws and regulations have been promulgated with the specific aim of preserving and restoring wetland areas. However, on the back of very high rates of aggregate economic growth, other laws, regulations, and policies have been set in place to provide further economic stimulus for achieving national food self-sufficiency, providing the so-called "perverse incentives" that have added to wetland loss through land conversion:

(i) In 2004, as part of its efforts to raise the living standards of the rural agrarian population, the PRC enacted the reform of rural taxes and administrative charges, with Heilongjiang Province the first to adopt it. By reducing taxation on agricultural products and increasing the profitability of agriculture, the policy provided further stimulus to converting wetlands for agricultural use.

(ii) Sharp rises in grain prices occurred in 2004–2005, further stimulating agricultural production and making conversion of wetlands and other nonagricultural lands into farmlands much more profitable than during the prior 5 years.

(iii) In 2004, out of 2.2 million ha of land reclaimed nationwide, it is believed that up to 250,000 ha of new grain fields were (illegally) reclaimed in Heilongjiang province,

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13 Landell-Mills. 2012. *Reviving Lakes and Wetlands: Lessons Learned from the Sanjiang Plain. Sanjiang Plain Wetlands Protection Project: Harbin, China.* Trowbridge, UK. p. 27.

14 Schneider, Keith. 9 November 2012. "Scarcity of Water and Land Shifts Geography of Food Production and Irrigation Networks to China's Northeast." http://www.circleofblue.org/waternews/2012/world/scarcity-of-water-and-land-shifts-geography-of-food-production-to-chinas-northeast/

15 Y. Tianyu. 2009. Restoring China's Disappearing Wetlands. *China Daily*. 9 November.

mostly from floodplain wetlands. And while the conversion of forests and wetlands to arable land is now officially banned in the basin provinces, it is still reported to continue.[16]

(iv) Primarily because of rapid growth in the PRC's urban areas, the total area of land devoted to agricultural production nationwide declined from 127.6 million ha in 2001 to 121.7 million ha in 2007. In response, in 2007, the PRC put in place the "Red Line Policy," which stipulated that the nation must maintain a minimum of 120 million ha of land under agricultural production, thus creating a deterrent to the maintenance of wetlands and other natural areas across the PRC.

(v) In 2009, a new food security project in Heilongjiang Province contributed to conversion of further areas of the Sanjiang Plain wetlands for agricultural use.[17]

In addition to increasing land reclamation and conversion, the increased incentives for crop and livestock production exacerbate water deficits in natural wetlands while increasing the overall volume of agrochemical usage, contributing to increased nonpoint source pollution (footnote 16).

The extent and diversity of wildlife habitats in the Sanjiang Plain have been significantly reduced because of large-scale wetland reclamation. Habitats within the marsh landscape have become fragmented, altering the living environment for wetland flora and fauna. More and more biological species, especially rare species, have become endangered or locally extirpated because of loss of living space. Meanwhile, the interruption of the biological food web, as well as the disruption of energy and nutrient flows, has impaired the self-regulatory capacity of the wetland ecosystems and reduced their stability.

Once abundant species of marsh vegetation have become reduced in number and extent. For example, the common reed (*Phragmites communis* or *Phragmites australis*), which was extensively distributed in the Sanjiang Plain in the 1970s, can rarely be seen at present. Mannagrass (*Glyceria acutiflora* sp. *japonica*), which could be found everywhere in the past, has become almost extinct locally. With the reclamation of wetlands and damage to habitats, the numbers of many rare bird species such as the red-crowned crane and the oriental stork (which have first-order protection status in the PRC) have been reduced. Over 23 red-crowned cranes and 400 oriental storks were observed in the area of Honghe nature reserve (NR) in the early 1970s, but only three individuals of the crane and five individuals of the stork were recorded during uninterrupted observation between 2003 and 2004. This represents nearly a 90% loss since the 1970s. For most waterfowl, *the farmlands and paddy fields that have been created cannot replace the natural habitats required by these species*.[18] The shrinking of natural marshlands has a clear negative impact on the existence of both the waterfowl as well as fish populations and other aquatic biodiversity.

Box 3 describes changes over time in bird and plant species abundance and composition in the "Small Sanjiang Plain," which includes the Naoli River Basin, Honghe NR, and

[16] "Amur-Heilong River Basin" website: "Amur-Heilong River Basin." http://amur-heilong.net/http/06_economic_development/0624Strategic_environmental_assessment.html

[17] Zhu and Yan 2011; and Yu 2011, as cited in K. Song et al. 2014. Wetland Degradation: Its Driving Forces and Environmental Impacts in the Sanjiang Plain, China. *Environmental Management*. 54. pp. 255–271.

[18] Z. Luan and D. Zhou. 2013. Impacts of Intensified Agriculture Developments on Marsh Wetlands. *The Scientific World Journal*. 2. 409439, 10 pages. doi: http://dx.doi.org/10.1155/2013/409439

Box 3: Changes in Waterfowl and Plant Species Composition in the Small Sanjiang Plain

Wetlands in the Small Sanjiang Plain (SSP) before reclamation were a mixture of wet meadow, reed swamp, forest swamp of birch and poplar, and sedge (*Carex* spp.) marshes. However, with large-scale agricultural development over five decades, wetlands have gradually been lost and fragmented.

Decline of Waterbirds

Biogeographically, the SSP belongs to the Palaearctic region, which has a rich avifauna; in particular, many migratory birds use this area as a resting site during migration. Breeding cranes, storks, and the white-tailed sea eagle are among the most important species in the region. The population of red-crowned crane all over the world is only 1,650–1,800. Of these, 1,050–1,200 have their habitats in Asia, with 620 of those among the known breeding population in the People's Republic of China. Only 72 individuals are reported in the nature reserve (NR) of Honghe. However, with the development of agricultural reclamation, populations of some rare and endangered waterfowls declined dramatically in this region. For example, in the beginning of 1950, before agricultural reclamation, red-crowned cranes, great swans (*Cygnus cygnus*), and oriental white storks were the dominant waterbirds in this region, with thousands of them being observed every year. However, in 1984, only 309 breeding red-crowned cranes were observed by aerial survey. This number declined to 100 in 1990 and to 20–22 in 2000. In the 1960s, great swans were often seen in the SSP, with thousands of swans observed every year, but these declined to 289 in 1981–1984, and only 60 remained in 2000. The main reason for the rapid decline in waterfowl populations is habitat loss. Before 1982, all kinds of wetlands, including marshes, wet meadows, reed swamps, and forest swamps, which waterfowl rely on for breeding and habitat, were rich and widely distributed over an extensive area. The landscapes were diverse. But, by 2000, almost all forest swamps had been clear-cut, resulting in a major impact on the breeding and habitat conditions of the oriental white stork. A total of 83% of reed swamps and 64% of wet meadows that red-crowned cranes need to rear their fledglings and to maintain abundant supply of their diet were lost and fragmented, and this had a dramatic impact on these waterfowls. Further impacts, which continue even today, are caused by the increase in runoff from the surrounding farmlands. Normally, water would have been held in wetlands over a large area, but because of increased drainage and reduced wetland holding capacity downstream, water levels downstream are higher than normal during rainfall periods, resulting in flooding which hampers bird breeding, because of flooding of nests. Thus, the number of red-crowned cranes in the Naoli River Basin has declined drastically. One of the likely causes for the decline in the observed numbers of red-crowned cranes is the increase in flash flood events, which destroy the nests during the incubation period, in combination with habitat loss and destruction by agricultural development.

Decline in Wetland Plant Species Diversity

Wild plants, some of them being from the important genetic stock from which we have developed our present-day wide array of economically important species, are decreasing in distribution range and abundance. The diversity of wild plant species has been replaced by simple agricultural systems in the SSP. Compared with the plant communities in 1982 when the first plant species survey began, the situation has changed greatly. For example, the wetlands in the core area of Sanjiang NR were waterlogged 20 years ago, with a water depth of 20 cm and high tussocks, but today the same wetland is dry and the tussocks have been burned, resulting in a change in flora, with significant reduction of marsh plant species. Twenty years ago, the

continued on next page

Box 3: *continued*

tussocks were well developed with *Carex schmidtii* (Schmidt sedge), but now Schmidt sedge has been replaced by *Calamagrostis angustifolia* (small leaf reed grass), and companion plants have been reduced to only two to three species, in the same sampling research plots. According to data, the marsh plants *Stachys baicalensis*, *Pedicularis grandiflora*, *Spiranthes amoena*, *Limnorchis hologlottis*, and *Dysophylla yatabeana* were the most common companion species in marshy meadows 20 years ago. Today, they have disappeared from the Sanjiang NR, and only some are occasionally found in Honghe NR. Neither *Stachys baicalensis* nor *Limnorchis hologlottis* have been found so far in either of these reserves. There are six nationally protected plant species in Honghe NR and Sanjiang NR, but of these, only one young tree of *Fraxinus mandshurica* (Manchurian ash) has been found recently in the Sanjiang NR, while the other rare and endangered species are no longer found at all. It appears that the main reason for flora reduction and vegetation change is water loss due to drainage.

Source: Adapted from H. Liu et al. 2004. Impacts on Wetlands of Large-Scale Land-Use Changes by Agricultural Development: The Small Sanjiang Plain. *Ambio*. 33 (6). pp. 306–310.

Sanjiang NR. These changes came about as a direct result of wetland habitat loss through land conversion, coupled with significant changes in water flow and water quality that degraded remaining wetland areas.

Water Issues

Watershed and Hydrology

The healthy functioning of the wetlands of the Sanjiang Plain is closely linked to the health of the entire water basin, including the watersheds of the Heilong, Songhua, and Ussuri rivers. These watersheds have three main components: headwater forests, the plain itself, and the wetlands. Headwater forests provide the first level of protection for the wetlands. The PRC has a very comprehensive forest classification system.[19] The comprehensive functionality of forests and their importance as an overarching umbrella for the protection of downstream lands and water resources is clear.

Forests play a vital role in the hydrological cycle by affecting the rate of water transpiration and evaporation and influencing how water is routed and stored within a watershed. Forests also contribute toward regulating soil erosion and pollution and preventing desertification and salinization of soil (intrusion of salt water) in coastal areas. The capacity of forests to capture and store water also helps to mitigate floods during periods of heavy rain and to ensure steady water flow during drier seasons. Individually and collectively, trees in forests require little or no fertilizer, and they store carbon, enhance biodiversity, and improve landscape aesthetics.

[19] State Forest Administration (PRC). 2009. *Seventh National Forest Resource Inventory Report*. Beijing.

Alluvial plains and wetlands also play a critical role in maintaining many natural cycles, including water absorption and water retention capacities, which help in the formation of aquifers that provide the basis for water supplies and attenuation of floodwaters, and support a wide range of biological diversity. These varied functions are known as ecosystem services.

In a recent study on the Small Sanjiang Plain, ecosystem service values were analyzed and changes over a 30-year period were measured according to land use. These are presented in Table 2.

Table 2: Ecosystem Services Values in the Small Sanjiang Plain, 1980–2010, According to Land Use

	ESV (CNY, x 1 million)		
Year	**1980**	**2000**	**2010**
Cropland	8,516	11,258	14,123
Forestland	28,107	27,175	23,089
Grassland	1,291	1,212	110
Wetland	42,243	23,524	13,847
Total ESV	**80,157**	**63,169**	**51,169**

ESV = ecosystem services values.

Source: J. Chen et al. 2014. Land Use Changes and their Effects on the Value of Ecosystem Services in the Small Sanjiang Plain in China. *The Scientific World Journal*. 2014, 752846.

The same study also conducted an economic valuation based on consideration of the following specific ecosystem service values: greenhouse gas regulation and moderation of climate change, hydrological regulation, moderation of erosion, waste reduction, maintenance of biodiversity, provision of food resources, provision of other raw materials, and tourism and recreation. The total value lost for these ecosystem services from 1980 to 2010 was some CNY 29 billion.[20] Given the fact that the value of the significant loss of ecosystem services also represents a major economic loss, policymakers of land use and development would be well advised to give these factors serious consideration, when formulating government policy for the future (footnote 20).

Water Quantity

From a hydrological perspective, in the past, the wetlands and forests of the Sanjiang Plain played an essential role in absorbing floodwaters and sustaining water flows. In recent years, due to the conversion of these ecosystems, the capacity of the land to absorb floods and to sustain stream flows has been significantly reduced.

[20] J. Chen et al. 2014. Land Use Changes and Their Effects on the Value of Ecosystem Services in the Small Sanjiang Plain in China. *The Scientific World Journal*. 2014, 752846.

Research has found that over the past decade, rice cultivation in the Sanjiang Plain has led to large decreases in available groundwater in Tongjiang and Baoqing counties—by nearly 5 meters (m) in Tongjiang (an annual reduction of 0.44 m) and by nearly 4 m in Baoqing (an annual reduction of 0.33 m). Similarly, during the process of converting wetlands into farmlands, the construction of large-size drainage systems has adversely affected the health and composition of wetland ecosystems. Wetlands are fully or partially supported by groundwater and are thus directly affected by these altered hydrological conditions.[21]

Reduction of groundwater resources has led to the degradation of wetland vegetation, which serves as the principal habitat for waterfowl in the Sanjiang Plain. In addition, in the long run, the reduced groundwater level also results in higher costs to local farmers for access to a reliable water supply and may lead to land subsidence. On reclaimed lands in the Sanjiang Plain, the frequency of droughts and floods has increased. Between 1950 and 1970, the average time interval was 4.2 years for extreme droughts and 3.5 years for catastrophic floods, whereas between 1971 and 1990, the interval was reduced to 1.8 years for extreme droughts and 2.4 years for catastrophic floods (footnote 6). A case study from Qixinghe NR, that illustrates the problems of water loss on the Sanjiang Plain, is presented in Box 4.

Box 4: Wetlands in Crisis: Water Loss in Qixinghe Nature Reserve

The Qixinghe wetland is facing a serious water loss problem. The water table decreased by as much as 12 meters in some wells in the surrounding area between 1997 and 2005, with an average annual decrease of 2.5 meters. Water-use conflicts intensify during the irrigation season. Water shortages are expected to increase in the future for several reasons. First, according to Baoqing County's development plan, there will be a huge increase in water demand in the next few years; the estimated total water demand in 2010 was 73% higher than that in 2006. Second, agricultural expansion along the river will accelerate water drainage in the region, as the water diversion systems are fully developed. Third, the water inflow from upstream is expected to continue to decrease because of increased water diversion, lower precipitation, and reduced floodwater volume entering the wetland.

Source: J. Wu et al. 2012. Securing Water for Wetland Conservation: A Comparative Analysis of Policy Options to Protect a National Nature Reserve in China. *Journal of Environmental Management*. Issue 1, February, pp. 102–111.

Pollution and Water Quality

In addition to water *quantity*, another significant issue of concern is water *quality*. As the quality of raw water deteriorates, its availability and suitability for domestic and commercial water supply, agricultural use, and ecosystem services is compromised.

Pollution is created by the cumulative effects of waste discharges into natural water sources. It arises from a variety of human uses of water—domestic, commercial, industrial,

[21] X. Liu and X. Ma. 2002. *Natural Environmental Changes and Ecological Protection in the Sanjiang Plain. Beijing: Science Press*. pp. 60–65; 171–172.

and agricultural. The pollution of water causes serious economic, environmental, and social issues that are difficult to remedy.

Of particular concern in the Sanjiang Plain has been the substantial increase in the use of agricultural chemicals. While early settlers in the Sanjiang Plain depended almost exclusively on the residual fertility of the alluvial soils supplemented by organic fertilizers for production, with increasing production demands, the use of organic fertilizers has declined steadily, with a converse increase in the use of inorganic fertilizers, pesticides, and herbicides. As a result of excess fertilizers and pesticides contained in runoff from agricultural lands, water pollution in the Sanjiang Plain has increased significantly and, besides land conversion, is the second most serious threat to the area's ecology.[22] While pollutants also originate from mining, industrial, and urban waste sources, agricultural chemicals are by far the largest contributor to pollution of surface and groundwater in the Sanjiang Plain.[23]

The clear conclusion is that increased usage of chemical inputs for agricultural production, coupled with increasing demand on groundwater resources, is likely to cause further degradation of surface and groundwater resources.[24] The entry of pollutants into surface and groundwater supplies is a concern not only because it affects the area's unique flora and fauna but also because it impairs the quality of urban and local domestic water supplies for human use. In addition, the pollutants that are introduced into groundwater aquifers through agricultural practices, including fertilizers and pesticides, typically have a long retention time. In addition, retention time in lakes and wetlands is longer than in faster-moving surface waters, such as rivers and streams. In the case of the Sanjiang Plain wetlands, impaired water quality will likely take significant time and investment to reverse.

The PRC has a well-organized environmental water quality standard for the classification of permitted water uses based on water quality.[25] Under this standard, water quality in NRs is required to meet Class I standard. However, water quality in the NRs of the Sanjiang Plain has failed to meet the Class I standard, especially for nitrogen (N) and phosphorus (P) parameters. In this scenario, the more pragmatic view being taken is that Class III standard (which is defined to be suitable for fisheries) should be adequate for maintaining overall biological viability in the wetlands. It is worth noting, however, that waters in many of the wetland areas of the Sanjiang Plain currently fail to meet even this relaxed standard—recent monitoring of groundwater and surface water indicates serious deterioration, with surface water quality in the range of Class III–V and groundwater quality currently on average meeting the Class III standard. Table 3, which shows the Sanjiang Plain Wetland Protection

[22] There is a mitigating factor in Heilongjiang and the Sanjiang Plain with regard to the use of chemical inputs for agriculture—because of the long, cold winters in this area, pest problems are not so serious, and pesticide use is lesser than in warmer areas.

[23] J. Watts. 2010. Chinese Farms Cause More Pollution than Factories, Says Official Survey. Asia Environment Correspondent. *guardian.co.uk*. 9 February.

[24] Wo et al. 2009; Qiu 2010, Gong et al. 2011; Yu 2011; Zhu and Yan 2011; Song et al. 2012 cited in K. Song et al. 2014. Wetland Degradation: Its Driving Forces and Environmental Impacts in the Sanjiang Plain, China. *Environmental Management*. 54. pp. 255–271.

[25] Class I water is suitable as a drinking water source (i.e., without treatment) and for national-level nature reserves; Class II is suitable as a Class A water source for centralized drinking water supply, in sanctuaries for rare species of fish, and in spawning grounds for fish and crustaceans; Class III water is suitable as a Class B water source for centralized drinking water supply, in sanctuaries for common species of fish, and for swimming; Class IV is suitable for use as general industrial water supply and for recreational use involving no direct human contact with the water; Class V is water only suitable for agricultural and general landscaping use; and Class V+ water is unsuitable for any use (PRC Environmental Water Quality Standard GB3838-2002).

Table 3: Water Quality Parameters in Selected Monitoring Spots in the Sanjiang Plain in 2007

Name of River Section	Water Class	Main Pollutant Exceeding the Standard
Hongqiling Station	V	COD, Mn
Wanjinshan Canal Head	V	COD, Mn
Xiaojiahe	IV	COD, Mn
Hamotong Bayou	IV	COD, Mn
Confluence at Baoqing	IV	COD, Mn
No. 4 Team of Hongqiling	IV	COD, Mn
Xiaojiahe Township	IV	COD, Mn
Fulitun	Inferior to Class V	NH_3-N, COD, Mn
Hongqi	Inferior to Class V	NH_3-N, COD, Mn
Confluence at Qianjingou	Inferior to Class V	NH_3-N, COD, Mn
Hongqi Forestry Center	IV	COD, Mn
Sanguliu	Inferior to Class V	NH_3-N, COD, Mn
Longtouqiao Reservoir (Upstream)	IV	COD, Mn
Longtouqiao Reservoir (Middle reaches)	IV	COD, Mn
Longtouqiao Reservoir (Downstream)	IV	COD, Mn
Hamatong Reservoir (Upstream)	IV	COD, Mn
Hamatong Reservoir (Middle reaches)	IV	COD, Mn
Hamatong Reservoir (Downstream)	V	COD, Mn

COD = chemical oxygen demand, Mn = manganese, NH_3-N = ammonia-nitrogen.
Source: Landell-Mills. 2012. *Reviving Lakes and Wetlands: Lessons Learned from the Sanjiang Plain. Sanjiang Plain Wetlands Protection Project: Harbin, China.* Trowbridge, UK.

Project data based on water quality testing at various sites in the Sanjiang Plain wetlands in 2007, documents this critical situation.

One of the most obvious effects of pollution of surface waters from agricultural runoff is eutrophication, or increased nutrient levels (mostly from fertilizers) within the water column. This leads to rapid growth, or "blooms" of microscopic algae, which in turn can cause reduced oxygen levels in the water, resulting in the die-off of large numbers of fish and other aquatic species. Because of eutrophication, fish die-offs are regularly observed in the rivers, lakes, and ponds of the Sanjiang Plain. A recent fish die-off is shown in Figure 8.

Pollution affecting the Sanjiang Plain wetlands also results from the lack of treatment of domestic wastewater and solid waste in nearby villages. Future investment in environmental infrastructure in villages, under existing government policies, could contribute to significant improvement in water quality in the nearby wetlands.

Reliable data on the quantity and quality of water pollution reaching wetlands in the Sanjiang Plain are difficult to access. A clear knowledge and understanding of the pollutants reaching the wetlands would provide the basis for improved watershed management plans

Figure 8: Fish Die-Off in the Sanjiang Plain

Due to heavy eutrophication in this water body, hundreds of dead and dying fish are floating on the water surface.

Source: Dajiahe Nature Reserve.

and the development of associated water quality management plans. Such plans should incorporate measures to address point source pollution by better management of urban and domestic wastewater and stormwater systems, and nonpoint source pollution by better land-use management practices.

Destructive or Illegal Harvesting of Natural Products

Rural communities in and around protected areas traditionally have depended upon the indigenous flora and fauna of the area for food, medicine, fuel, building materials, and other uses. While in the past, harvesting of traditional products has usually been ecologically sustainable, with growing populations and the large-scale commercialization of traditional subsistence products, resource extraction levels often became unsustainable.[26]

Recent investigations in the Sanjiang Plain suggest that unsustainable resource extraction, including fishing, reed gathering, and egg collection, is no longer a serious threat. These activities, while widespread in the past, are now only practiced occasionally, and on a small scale. While there is still anecdotal evidence of illegal fishing, hunting, and gathering of eggs and reeds,[27] overall, illegal exploitation of natural products from within the Sanjiang Plain NRs seems to be relatively minimal, with only minor impacts.

[26] A. Mittelman et al. 1997. *Non-Wood Forest Products Outlook Study: Towards 2010. Bangkok: FAO Regional Office for Asia and the Pacific.*

[27] Other types of resource overexploitation have been reported from this region. For example, the overexploitation of high-value sturgeon and salmonid fish in the area's rivers and waterways by legal commercial operations has led to population declines in recent years (Gao Ruirui, Green Longjiang Foundation, November 2014, personnel communication).

Earning good livelihoods from farming, the vast majority of the residents of the Sanjiang Plain no longer are heavily dependent on extractive activities. Larger per capita land availability in Heilongjiang Province, compared with elsewhere in the PRC, has made farmers in the Sanjiang Plain comparatively better off.[28] Effective public awareness campaigns, that highlight the ecological importance of the flora and fauna of the Sanjiang Plain, in conjunction with satisfactory incomes obtained from farming, have contributed to the reduction of illegal resource extraction.

In some cases, insufficient funding for annual NR operations has led the reserves to lease harvest rights to area residents (e.g., for catching fish and harvesting reeds) and outside commercial interests (e.g., for sturgeon and salmonid fishing). More research is required to determine the impacts this is having on species diversity and populations, and on the overall ecological health of the NRs.

But as mentioned in preceding sections of this report, it is primarily the extensive conversion of wetlands for agriculture, and the resultant water diversion and agrochemical pollution, that pose the greatest current threats to the ecology of the Sanjiang Plain.

[28] Landell-Mills. 2012. *Reviving Lakes and Wetlands: Lessons Learned from the Sanjiang Plain. Sanjiang Plain Wetlands Protection Project: Harbin, China.* Trowbridge, UK.

IV. Lessons from the Sanjiang Plain

The preceding sections have been devoted to discussing the current situation in the Sanjiang Plain wetlands, and key issues and problems being confronted in wetlands management have been highlighted. This section discusses some of the steps that have been taken to address the problems and issues, and takes a close look at the important "lessons learned" that have emerged as a result of these efforts.

The lessons presented here derive mainly from experience gained during the recently completed Sanjiang Plain Wetland Protection Project (SPWPP). The lessons are grouped according to the main components of that project—(i) watershed management, (ii) wetland nature reserve (NR) management, (iii) alternative livelihoods, and (iv) education and capacity raising.

Lessons on Watershed Management

Watershed management featured as a key element of the SPWPP, and several important lessons emerged from this component. Some of the key lessons relating to watershed management are briefly presented here.

Lesson: Water Resource Management Planning and Policy

A major achievement of the Asian Development Bank SPWPP was that plans and policies were formulated that allowed wetlands to be regarded as a "water user" and given due consideration in the water allocation decision-making process.

The Heilongjiang Provincial Water Resources Department and water departments under the city and county governments are responsible for water management at the watershed level. Under the SPWPP, water resources allocation modeling was conducted, and water resources management plans were finalized for six NRs. The NR master plans were revised to incorporate the water resources management plans. As a result of these initiatives, each NR has a plan to improve water management at the local level, and data from these plans have been fed into two river basin master plans (the Sanjiang Plain Water Resources Master Plan and the Songhua River Master Plan). In addition, river water allocation for preservation of wetlands has been included in the Heilongjiang Province's Eleventh Five-Year Plan for the first time. The lesson to emerge from these findings is that such plans provide a mechanism for ensuring that water allocation requirements are accounted for at the broader provincial and basin level, and that measures are mandated to address water demand at the watershed and NR level.

Despite these advances, water allocation for wetlands is still given a lower priority than for domestic consumption and for agriculture, and full supply can only be expected 50% of the time.[29] Whether this is adequate to ensure wetland functionality still remains to be seen.

Lesson: Forestry Management

Maintaining ecological functions of forested lands in the upper watershed areas can yield many significant benefits. The maintenance or establishment of healthy forest cover minimizes soil erosion and sediment runoff while promoting water infiltration to subsurface aquifers, which ensures sustained water availability downstream. Forestry investments under the SPWPP, which included 11,900 hectares (ha) of reforestation, successfully enhanced watershed rehabilitation. As the forestry component activities were completed, the project evaluated and quantified the effects of the new forestry plantations and how forestry practices affected wetlands protection.[30]

Three key outcomes that were reported as a result of improved forest management were

(i) increase of water retention capacity in upstream areas; delay in release of water from the upstream areas to wetlands; increase of ratio of water supplied to wetlands, relative to amount of rainfall; and increase in water volume in wetlands;
(ii) flood prevention benefits; and
(iii) reduced soil erosion in the upstream areas and reduced sedimentation in wetlands.

Forests play an important role in water conservation. Several biophysical characteristics enable forests to function as natural reservoirs. For example, thick layers of leaf litter and porous soils prevent runoff of rainwater and improve water retention; extensive root systems rapidly capture water from the soil and facilitate uptake into plant tissue; and tree crowns form dense canopies that limit loss of water to the atmosphere through evapotranspiration. Hence, the water conservation capacity of forests is significant: 10%–20% of precipitation can be intercepted and of that amount, 50%–80% can penetrate into the soil. Each hectare of forest in the Sanjiang Plain is estimated to conserve 500–2,000 cubic meters (m^3) of water.

Surface runoff can be reduced to a minimum by the forest litter layer. The forest areas in the Sanjiang Plain can conserve some 80% more water than areas without forests. Conversely, deforestation can make the peak runoff flow increase by 1.5 times.

Common practice in the People's Republic of China (PRC) has been to construct dams and reservoirs for flood control. The total fiscal benefit of dams and reservoirs, for the 40-year period after the founding of the PRC, has been estimated at CNY 12.7 billion. According to the evaluation done for SPWPP, the economic value of existing forest lands in Heilongjiang

[29] Standards for securing the water supply for various uses are set within a 100-year timeframe. Within the benchmark 100-year period, the standards are intended to ensure (i) a 95-year water supply for domestic use; (ii) a 75-year supply for agriculture; and (iii) a 50-year supply for wetlands. The standard for wetlands represents a minimum ecological flow. ADB Consultant Team discussions with Institute of Water Resources Design, Harbin, 11 November 2014.

[30] Based on Heilongjiang Provincial Forestry Department. 2013. Sanjiang Plain Wetlands Protection Project. Completion Report, Project Implementation Office. Harbin (Appendix 3). The results of the analysis are regarded as preliminary and requiring further validation.

Province for flood control is more than CNY 2 billion. Concurrent with flood prevention benefits are benefits of reduced soil erosion. The SPWPP estimated that the value of surface soil loss reduction by forest land in the Sanjiang Plain is CNY 117.5 million.

Finally, it was determined by the SPWPP evaluation that different types of trees were not equally effective in their water capture and water retention capacities—the species composition of the forest has a significant impact on how much water is absorbed and conserved within the watershed, and thus this factor will contribute to determining how much water will be available to recharge wetland areas. Soils and their water absorption characteristics are affected differently by different species of trees—this is based on such considerations as to how leaf litter influences soil porosity, how tree root structure affects water capillarity, and how trees contribute to nutrient formation.

According to the SPWPP analysis, it was concluded that (i) water storage capacity by the litter layer of larch and white willow was the greatest, (ii) soil water conservation capacity of coniferous forest and mixed forest was the strongest, and (iii) soil improvement effect of mixed forest was the best, and its soil infiltration capacity was better than for pure (unmixed) forest. It was suggested that forest plantations comprising coniferous forest or mixed forest would be the most effective at improving hydrological and soil function in the watershed—ultimately ensuring that more water, of higher quality, would be available for recharge of wetland areas.

Lesson: Integrated Water Resources Management

A number of significant steps were taken in the SPWPP to introduce and strengthen the concept and practice of integrated water resources management (IWRM). These actions especially focused on institutional, planning, and policy reform. For example, integrated watershed-level and local-level NR water resource planning and water management schemes were formulated. Practical water allocation and management schemes for promotion of water efficiency were put into operation, and implementation of new rural policies was improved.

Out of this experience, a valuable lesson emerged—that water allocation for NRs is absolutely vital to the sustainability of wetlands. However, despite the importance of this component, it received the lowest level of technical assistance under the project. Future wetland protection projects should note the importance of local and basin-wide water planning and management and provide appropriate resources for this to be achieved (footnote 28).

In addition, it was also learned that administration of wetlands in the Sanjiang Plain is complex; simplification, and improved coordination, could enhance effectiveness and efficiency. Although roles of the various institutions are defined (in the June 2003 *Regulations on Wetland Conservation of Heilongjiang Province*), the fact that different agencies are involved, often with relatively low levels of coordination and communication between them, means that often consensus is not achieved and best practice is not transferred between them. Involvement of a number of agencies in the same reserve may also result in contradictory direction or conflicts among different departments because of divergent management goals or departmental interests, thus hindering integrated

management of the reserves and of their wetland resources. Effective mechanisms for coordination, established at a higher level—such as at the provincial level or watershed level—can help to resolve some of the conflicts. Creation of an interagency provincial NR working group, with representation from all the key government agencies, would help to ensure dissemination of lessons learned throughout all NRs and improve coordination. A water resources coordination leading group was established under the project, with representation from each of the six NRs. Such a mechanism could be replicated and enlarged at the provincial level. *NR working groups at the watershed level* would also be advantageous. Such watershed-level working groups can be based on the water resources coordination leading group, which is established under the project with representation from each of the six NRs.

Although progress was made under the SPWPP to introduce a workable IWRM system, one persistent weakness is the emphasis on "top-down" stakeholder consultation. Best practice for IWRM envisages both "top-down" and "bottom-up" stakeholder consultation processes to ensure that downstream communities and other interest groups have a fair and adequate input into the stakeholder consultation process.

Significant lessons emerged from the IWRM component of the SPWPP, especially relating to the loss of hydrological function, water quality issues, low level of awareness of water-saving practices, and wetland fragmentation:

(i) The effectiveness of conserving wetland resources inside NRs is determined not only by the relative success of applying management measures within the reserves but also by the hydrological status outside the reserves. In order to ensure that wetlands can be managed effectively, the entire zone of hydrological influence that affects the wetland must also be managed.

(ii) The de facto Class IV water quality standard for P and N is unsatisfactory, as there is no buffer against further deterioration of water quality. This represents a high level of risk to the wetlands. It would be far preferable if the mandated Class III standard could be more strictly followed. This would provide a buffer against future deterioration in water quality and protect the habitat values of the wetlands, both for migratory waterfowl and for fisheries. Current water quality monitoring is inadequate for effective management purposes. General monitoring results showing a static Class IV water quality are not useful because they give no indication of trends in wetland water quality (however, based on the occurrence of significant fish kills, it is suspected that water quality in many wetland areas is continuing to deteriorate). Trend-line monitoring needs to be embedded as a best practice into water quality work programs.

(iii) Agricultural use accounts for more than 80% of total water use in the Sanjiang Plain and is expected to continue to increase in the future, because of expected increases in irrigated paddy acreage. There is a concern that installed irrigation infrastructure is not being utilized for greatest water efficiency. In addition, public awareness of the need to conserve water resources, and of the ecological consequences of water overuse and ways to prevent it, must be improved. Therefore, public investment in irrigation infrastructure needs to be coupled with public/farmer education to raise awareness of these critical water resource issues.

(iv) Another hydrological risk is posed by the physical fragmentation of the wetlands in the Sanjiang Plain. Smaller, more isolated wetlands are more at risk of being affected by droughts during dry spells than if they were part of a larger, more connected hydrological system. Therefore, hydrological functionality can be improved if wetland areas can be linked together within a more connected system.

Lessons on Wetland Nature Reserve Management

In the PRC, a primary approach employed in biodiversity conservation is the establishment and management of NRs. This approach has manifested in the National Program for Nature Reserves (1996–2010), which set a target that

(i) by 2010, the total number of NRs will reach about 1,200 (including 160–170 national NRs), and the area of NRs will occupy 10% of the PRC's land area;
(ii) by 2030, there will be 2,000 NRs in the PRC, taking up 16.8% of the PRC's land area, and populations of 60% of the wildlife species under special state protection will be restored and increased; and
(iii) by 2050, the number of NRs will reach 2,500, and their area will account for 18% of the national land area, populations of 85% of the wildlife species under special state protection will be restored and increased, and the priorities for rescue, population restoration, and maintenance will include 15 endangered and threatened species (e.g., giant panda, tiger, Tibetan antelope).

The initial targets have been exceeded—by the end of 2007, the PRC had established 2,531 NRs covering a total land area of 151.88 million hectares. The coverage of terrestrial reserves accounted for about 15.2% of the PRC's land area. From 1999 to 2007, the number and coverage of NRs in the PRC increased significantly, with the coverage exceeding the world average. Despite some existing weaknesses, a national NR system has basically taken shape.

The situation in Heilongjiang Province is no different. By the end of 1997, Heilongjiang Province had established 90 NRs protecting 25,327 square kilometers (km^2), or approximately 5.3% of the provincial land area of 454,800 km^2. By the end of 2001, the total number had increased to 142 NRs protecting 34,873 km^2, or 7.3% of the province. By the end of 2005, the province had 170 NRs covering a total area of 46,890 km^2, or 9.8%. However, in spite of the impressive gains in numbers and area of NRs, implementation and management gaps remain (as discussed in the Situation Analysis in Section III).

The SPWPP undertook to address some of the key challenges for more effective management of wetland NRs of the Sanjiang Plain. This component of the project was multidimensional and covered a wide array of activities, including wetland restoration, wildlife species protection and recovery, and habitat restoration. Reform of conservation regulations and strengthening of enforcement activities was undertaken. Sustainable utilization of natural resources, including such uses inside NRs, according to NR regulations, was initiated. Field investigations were conducted in NRs, including targeted

surveys and monitoring of endangered species. Practices for NR financing were reformed. Integrated planning was conducted for NRs, including the preparation of management plans. Institutional systems for nature conservation were strengthened, and assistance was provided for capacity building in wetland management and restoration. Pilot and demonstration projects for wetland restoration and species recovery were conducted.

Several useful lessons that have emerged with regard to management of wetland NRs are presented below.

Lesson: Returning Farmland to Wetland—Policy and Implementation

Under the SPWPP, pilot farmland-to-wetland restoration was implemented in the six model NR sites, and 3,441 ha of farmlands were restored to wetlands, against the target of 3,433 ha set at appraisal. Drawing on the experience of the pilot restoration, a wetland restoration manual was prepared and disseminated to all NRs in the Sanjiang Plain. Using the manual, NR staff conducted wetland restoration in six additional reserves. In the six model reserves, wetland restoration continued after the pilot, and the coverage of wetland areas increased.

Five main approaches were prescribed for returning farmland to wetland:[31]

(i) **Water storage in wetland areas**. With the use of heavy equipment, abandoned drainage channels, roads, farmland furrows, and dikes were graded and leveled for gradual restoration to natural wetlands. Dams and sluice gates were built to prevent the replenished water and the surface catchment from running off, and to ensure that appropriate water volume could be retained in wetland areas.
(ii) **Water replenishment**. According to the status of water resources and water conservancy projects in the region, the local surface water resources and existing water conservancy projects are fully leveraged to build necessary projects of water replenishment and restore the natural water environment.
(iii) **Restoring wetland vegetation**. Two methods, that is, natural restoration and artificial planting, were employed to restore marsh vegetation in the region. The species that could better adapt to local conditions were selected (e.g., *Deyeuxia langsdorffii, Deyeuxia angustifolia, Phragmites communis, Rubia cordifolia*, and *Carex tristachya*). The method of random sowing or turf transplanting was used.
(iv) **Afforestation**. Forest shelterbelts that are 20-m wide are built on the downstream slopes of dikes that are located at the boundaries of the project areas.
(v) **Wetland conservation**. Effective ecological monitoring system and technical support system are put in place to conserve the wetland areas in the region.

During the SPWPP, although the reconversion of farmland back to wetland was generally successful, the methodologies employed could be further improved. To yield better results in terms of creating habitat for waterfowl that more closely approximates the former natural state of the wetlands, a number of best practice options for improvement are presented later in this report.

[31] H. Li and W. Wang. 2005. The Significance of Returning Cropland to Wetland Programme in Sanjiang Plain, China. (2). pp.1–3 (in Chinese).

The Heilongjiang provincial government has formulated a series of policies to protect the wetland area in the Sanjiang Plain, including designation of specific tracts of agricultural land for gradual restoration to a condition that approximates a more natural wetland environment. The lesson to emerge from the past interventions of the SPWPP for reconversion of farmland to wetland is that such reconversion can not only help restore and protect the integrity, ecological characteristics, and diversity of the regional ecosystem but also improve its fragile eco-environment and contribute to enhanced natural conditions at local, national, and global scales.

Lesson: Community-Based Management Approach

Comanagement committees, involving local stakeholders (agencies and other bureaus), have been developed at many NRs, but these are largely reactive committees dealing with problems and conflicts and not proactive committees having inputs to planning and decision making. Furthermore, in reality, local stakeholders (individuals such as farmers, fishermen, etc.) have very little or no input to NR planning and management decision making. Future initiatives should make an effort to engage with stakeholders at the community level and involve them directly in planning and decision making.

Lesson: Sustainable Financing

While funding levels for NRs have increased, particularly for capital investments, these are still not enough to cover running costs. This forces the NRs to sell or lease natural resources (such as land to farmers for agricultural production) to fund conservation operations. Thus, some of the threats to the NRs do not necessarily originate from surrounding communities, but can also originate from practices within the NRs themselves. This suggests that other solutions are needed to identify sustainable financing mechanisms that can support the operations of the NRs in an ecologically sustainable manner. One such response, piloted in the SPWPP, was the introduction of ecotourism. This has provided a more sustainable source of revenue at Zhenbaodao and Xingkaihu NRs. Several options for sustainable livelihood, which can be linked to supporting the NRs, are discussed in the section on alternative livelihoods which follows.

Lesson: Species Recovery Strategies

Some interesting lessons were learned as an outcome of pilot testing of species recovery strategies. These included, among others, construction of artificial nests for storks and provision of nest materials and artificial feeding programs for cranes. To highlight a specific example, artificial nests (Figure 9) were constructed and deployed for the oriental white stork at Xingkaihu NR, Dajiahe NR, Naolihe NR, and Qixinghe NR. The program was most successful at Xingkaihu but less so at the other NRs. Reasons for the lack of nests at other NRs probably included:

(i) Close proximity of nests (e.g., in Zhenbaodao where the mean distance between nests = 1.54 meters),
(ii) fragmentation of habitat (e.g., Naolihe),

Figure 9: Construction of Artificial Nests for Oriental White Storks, Xingkaihu Nature Reserve

Source: Landell-Mills. 2012. *Reviving Lakes and Wetlands: Lessons Learned from the Sanjiang Plain. Sanjiang Plain Wetlands Protection Project: Harbin, China*. Trowbridge, UK.

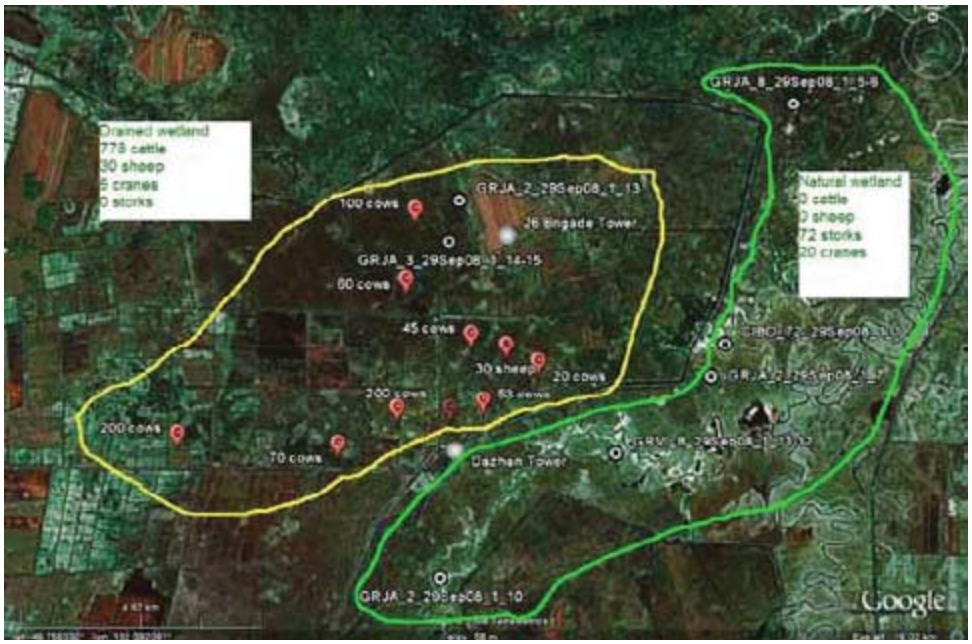
(iii) lack of trees (e.g., Qixinghe), and
(iv) disturbance from cattle or human activity.

From this experience, it was learned that the location of artificial stork nests is of particular importance. Large, unfragmented, unpopulated expanses of wetlands and wetland forests are by far preferable, with adequate spacing between nests. The nests were significantly more successful when separated from areas where cattle grazing and other potential disturbances occurred. Placing nests in more natural wetland areas, rather than in drained wetlands, also resulted in a higher percentage of successful nests. This is well illustrated in Figure 10. The figure shows how, in Naolihe NR, a lower frequency of nesting of cranes and storks occurred in drained wetlands used for grazing versus the relatively higher frequency of nesting that occurred in more natural wetland areas that were undisturbed by livestock. These simple, common-sense lessons can be applied when species recovery activities are being planned for future projects.

Lesson: Need for Greater Coordination in Wetland Nature Reserve Management

Past efforts by Asian Development Bank and its partners have resulted in many improvements for the management of wetlands in the Sanjiang Plain, as highlighted throughout this report. However, despite these accomplishments, the management of the wetland NRs of the Sanjiang Plain has been carried out in a somewhat fragmented manner. This is true in several important respects: the NRs operate largely in isolation—

Figure 10: Nesting Sites of Storks and Cranes at Naolihe Nature Reserve



The figure shows the higher frequency of nesting of cranes and storks in natural wetland areas (green boundary) compared with lower frequency of nesting within drained wetland areas (yellow boundary) that are used for grazing.

Photo source: Landell-Mills. 2012. *Reviving Lakes and Wetlands: Lessons Learned from the Sanjiang Plain. Sanjiang Plain Wetlands Protection Project: Harbin, China*. Trowbridge, UK.

conceptually, physically, administratively, and institutionally.[32] Although the wetland system of the Sanjiang Plain is a critical biodiversity corridor that is needed to support large, globally important populations of migratory waterfowl and other animal life, the NRs of the Sanjiang Plain, as currently operated, are protecting only isolated wetland areas—once contiguous wetlands have become fragments. In addition, there has not been much opportunity to coordinate the management mechanisms that are in place within the NRs to achieve more uniform and consistent management (as one very basic example, standardized methods for monitoring bird populations, applied uniformly across all the NRs, could provide more accurate data about bird populations to better inform management planning and decision making). There has also been no institutional entity having responsibility and authority to factor into decisions, the wide range of considerations that must be taken into account to harmonize land use, area developments, sustainable resource management, and conservation. Sharing of knowledge and resources among NRs, which could lead to further strengthening of management within these sites, has also been limited. Clearly, there is scope for improvement in these areas, which in turn could lead to significantly better

[32] There was success under the SPWPP in establishing water resources coordination lead groups at each of the six pilot NRs that were covered under the project. These lead groups represented all stakeholders and functioned as stakeholder working groups to coordinate the inclusion of water resources management plans into NR master plans. However, there was no umbrella entity established to ensure coordination between them.

results with respect to the management of the NRs, and the wetlands as a whole, for the preservation of biodiversity.[33]

Lesson: Enactment of Regulation for Wetland Conservation and Management

As noted earlier in this report, in 2003, the *Regulation about Conservation of Wetlands in Heilongjiang Province*, which required a halt to reclamation of wetland areas in Heilongjiang Province, was passed as the first law of its kind in the PRC. At the same time, the fact that this regulation was not harmonized with other laws, and the problems which continue to arise as a result, has also been pointed out. For example, while core protection zones of the NRs are meant to be strictly conserved, in reality, significant areas of land within these zones are under the ownership and management discretion of state farm enterprises, thus often being used for agricultural production, and therefore not consistent with the conservation and protection objective. While the enactment of the wetland conservation law can be considered as a milestone achievement for strengthening wetland protection and management, in preparing future enactments or amendments, greater attention needs to be given to actual enforcement of the law, eliminating conflicts and inconsistencies with other legal instruments, and reconciling the jurisdictions of different agencies for more harmonious land use.

Lessons on Alternative Livelihoods

In terms of both the number of species and the populations of individual species supported by the Sanjiang Plains prior to their extensive conversion, the Sanjiang Plain's ecosystems and their original ecological carrying capacity have been significantly degraded. Habitat conversion and fragmentation, and the introduction of environmental pollutants from a range of human activities, have been the principal causal factors. The potential for conflict between boosting agricultural and economic production while preserving ecologically important land areas has been extensively covered in this report. Yet, as proven through the work of the SPWPP and similar projects elsewhere in the PRC and in other countries worldwide, increasing the economic productive value of land per unit area through the use of environmentally sustainable technologies can reduce these potential conflicts and also enhance an area's ecological carrying capacity.[34] This is in line with the "green growth" and "green economy" principles and policies that have been introduced in recent years by the World Bank, the Organisation for Economic Co-operation and Development, the United Nations Economic and Social Commission for Asia and the Pacific, and other multinational entities. Wider-scale adoption of environment-friendly technologies to replace those that cause degradation of environmental parameters presents substantial scope for enhancing

[33] It should be noted that subsequent to the completion of the SPWPP, a new provincial office, the Heilongjiang Wetland Conservation Center, has been established. It seems appropriate that this office might be the logical choice to be assigned to handle the functions of integrating and coordinating activities for wetland management at the many NRs and other wetland sites throughout the Sanjiang Plain.

[34] In the context of sustainability, the ecological carrying capacity of a given area is defined as the size of the population that can be supported indefinitely upon the available resources and services of supporting natural, social, human, and built capital (Sustainable Measures. 2010. *Sustainability 101*. West Hartford, CT. http://www.sustainablemeasures.com/node/33) A larger number of people can be supported on a smaller area of land, enabling some land previously used for production to be taken out of production and restoring natural habitat.

carrying capacity for a range of rare and endangered species. In this way, the wise use of the environment and natural resources can concurrently achieve the goals of economic development and environmental conservation.[35]

The main objective of the livelihood component of the SPWPP was to pilot alternative livelihood activities in order to reduce pressure on natural systems, enabling the restoration of a certain percentage of converted wetland back to its natural state. Through the project, the Heilongjiang Provincial Forest Department enabled local people to earn improved incomes on reduced areas of land, while releasing portions of the farming area (in critical ecological zones) back to their natural state as forest or wetland. An area totaling 3,441 ha of land used for agricultural production was restored as wetland, while an additional 4,300 ha of farmland within the NRs were converted back to forest, thereby improving the overall ecological and hydrological profile of the area.[36]

The alternative livelihood demonstration activities of the SPWPP clearly highlighted the close interdependence between economic productivity and environmental sustainability—both the economic production systems and the ecology of the Sanjiang Plain were supported. While economic objectives were achieved, these activities also led to improved ecosystem capacity to deliver environmental services, including flood and drought control, water storage and pollution mitigation, and improvement and expansion of the region's key biodiversity habitats.

The development of environment-friendly alternative livelihoods supported by the SPWPP also succeeded in improving the incomes of local farmers, compared with their incomes prior to the conversion of farm lands back to wetlands. Average per capita annual net income among participants increased by more than 20%, from CNY 7,776 before conversion in 2005 to CNY 9,473 in 2008.[37]

Among the keys to the success of these initiatives was the diversification of income streams. Program participants assisted by the project no longer depended only on one activity for their livelihood but were able to derive income from a range of activities, including, for example, forest maintenance, forest intercropping with nontimber forest products (NTFPs), patrolling of wetland areas, and jobs at ecotourism sites. This helped to overcome the possibility that a single alternative income-generating activity might not be able to match the income earned previously from farming and therefore prove unattractive for farmers. In addition to the improved income earned by the program's farmer participants, there was also an appreciation that their resilience to change was improved because of access to diverse income streams.[38]

The pilot alternative livelihood activities were tested to determine their feasibility, providing a basis for possible scaling-up in the future. The sections below contain short descriptions

[35] A larger number of people can be supported on a smaller area of land, enabling some land previously used for production to be taken out of production and restoring natural habitat.

[36] Heilongjiang Provincial Forestry Department. 2013. Sanjiang Plain Wetlands Protection Project. Completion Report, Project Implementation Office. Harbin. pp. 14, 16.

[37] See S. de Silva and S. Senaratna Sellamuttu. 2010. *Balancing Wetlands Conservation and Development in the Sanjiang Plain. A Review of Current Status and Options*. Colombo, Sri Lanka: International Water Management Institute. Section 3.1 Annex 2.

[38] Diversifying income streams creates the possibility that when one activity falters in a given year, it can be compensated for by income from the other livelihood activities.

of these important results and how they were achieved. The lessons learned provide examples that could be expanded to increase future beneficial impacts in the Sanjiang Plain and replicated in other similar ecosystems in the PRC and beyond.

Lesson: Agroforestry and domestication of nontimber forest products

As part of the SPWPP, agroforestry development and forest intercropping were linked to farmland-to-forest restoration. These income-generating activities successfully offset negative impacts on the livelihoods of farmers whose lands in the wetland core zones were slated for reconversion to their original forest or wetland status.

Carefully selected NTFPs, including *Schisandra chinesis* and other Chinese medicinal herbs, mushrooms and other fungi, black currant, grapes, and soy and kidney beans, were intercropped on 923 ha of forest land. Other types of activities based on NTFPs, such as beekeeping and honey production, were also introduced. Wages earned by farmers from tree planting and forest maintenance offset their income lost during the initial year as a result of foregone agricultural harvest. Since the conclusion of the project, the intercrops are being harvested and other wage-earning opportunities have been provided for the agroforestry program participants. Farmers are now earning more, compared with their original incomes from farming.[39] Figures 11–13 illustrate several of the successful agroforestry and intercropping demonstration projects.

Figure 11: Beekeeping as an Alternative Livelihood

Li Yuanwen earns an increased annual income since relinquishing his farm in the Zhenbaodao Nature Reserve. He has been hired by the Reserve as a custodian of an ecotourism area and was assisted by the SPWPP to raise bees and produce honey.

Source: Yoshiaki Kobayashi, ADB.

[39] S. de Silva and S. Senaratna Sellamuttu 2010. *Balancing Wetlands Conservation and Development in the Sanjiang Plain. A Review of Current Status and Options*. Colombo, Sri Lanka: International Water Management Institute.

Figure 12: Forest Intercropping as an Alternative Livelihood

Preparing NTFP seedlings for forest intercropping.
Source: Project Management Office, Heilongjiang Forestry Department.

Figure 13: Grape Cultivation as an Alternative Livelihood

Grape vineyard planted on a deforested plot of state forest land. Grape production offers a higher value alternative to grain production, thus providing higher incomes for farmers on smaller plots of land.
Source: Yoshiaki Kobayashi, ADB.

Lesson: Environmentally friendly greenhouses

The SPWPP supported the construction of 50 greenhouses on 10 ha of land in the Qixinghe NR. Each greenhouse is able to produce 15,000 kilograms of vegetables per year.[40] Economic production per unit area of land has increased substantially compared with extensive grain farming. This has allowed the farm lands relinquished by farmers (that had been located within the NR core zone) to be converted back to wetlands.

To yield comparable economic benefits, the land required for intensive greenhouse cultivation of market vegetables, using mostly biological as opposed to chemical inputs, is only one-fortieth of that required for extensive field-crop cultivation. As a consequence, for each hectare of greenhouse area established, 39 ha of land have been released back to the NR for habitat rehabilitation and restoration.

Total income from the greenhouses is estimated at CNY 1 million, providing considerably higher economic returns to farmers than extensive field cultivation. This pilot project illustrates the substantial potential of greenhouse agriculture to provide economically and environmentally sustainable alternative livelihoods.

Greenhouse cultivation also requires less water than field cultivation. Water consumption for the prior farmland areas, for example, was 2,200 cubic meters per hectare (m^3/ha) and rose up to 2,400 m^3/ha in dry years. Water consumption for the greenhouses is 1,500 m^3/ha. The greenhouses are heated by burning renewable biomass and agricultural waste sourced from nearby areas. By using biological cultivation methods, and through reduction of cultivation area, there has been a significant decrease of chemically contaminated runoff adjacent to the critically important NR core zone habitats, as well as a decrease in the demand on groundwater resources. Monitoring of the restored habitats for prevalence of endangered bird species since the establishment of the greenhouses indicates trends of increasing numbers of birds and numbers of species sighted, and increased occurrences of successful nesting.[41]

The greenhouses used for vegetable production are climate controlled and yield several crops per year. They also enable early start of rice seedlings. Rice seedling stock from the greenhouses is widely reported to be stronger and of higher quality, making the rice crop more resilient. This has increased the overall seedling survival rate and made the rice crop more resistant to pests and diseases. Greenhouse rice seedlings have improved both the quality and productivity of the rice crop. Overall, greenhouse farming compared with the alternative of extensive field-crop farming represents a win–win situation for farmers and the protection of the environment.

Further information on the achievements of the SPWPP pilot project for greenhouse cultivation is presented in Box 5.

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[40] Footnote 39, p.18.

[41] Heilongjiang Provincial Forestry Department. 2013. Sanjiang Plain Wetlands Protection Project. Completion Report, Project Implementation Office. Harbin.

Box 5: Ecofriendly Greenhouse Cultivation as an Alternative to Field-Grown Crops

The farmers in Dongxian and Sipai villages grow rice seedlings in greenhouses prior to planting them in the fields. The transplanted rice is reportedly more robust and productive with survival rates and grain set considerably higher than for field-broadcast rice. Rice yields per unit area have increased by as much as 50%. The higher profits from reduced areas of land have prompted the farmers to give up rice cultivation in the wetland areas.

Source: Yoshiaki Kobayashi, ADB.

Zhang Liang (above) is a 56-year-old farmer living in the Qixinghe Nature Reserve. Prior to the ADB Sanjiang Plain Wetland Protection Project, Zhang grew corn on a 10-hectare plot within the reserve. The project offered him the opportunity to shift his farming to a 350 square meter area of greenhouse if he was willing to relinquish his farmland in the nature reserve to enable its restoration to wetland. Although he was initially reluctant, project staff eventually convinced Zhang of the comparative economic benefits and labor savings of greenhouse farming. Zhang Liang's annual income from his single corn crop was CNY 27,000. After taking up greenhouse farming, he was able to earn RMB 42,000 from two crops of greenhouse tomatoes. Zhang now plans to introduce a third crop of tomatoes and expects to earn CNY 63,000 annually.

Lesson: Ecotourism

With support from the Heilongjiang Provincial Tourism Department, the SPWPP implemented pilot ecotourism projects in the Xingkaihu NR and Zhenbaodao NR. Ecotourism has provided an alternative source of income for farmers, allowing a large area of farmland to be restored to wetlands. It is also providing much-needed income for the reserves to cover their annual operating costs, thereby relieving pressure to generate income from fishing and reed harvest leases. The pilot project in Xingkaihu is expected to generate a profit of CNY 2.73 million annually, amounting to an annual rate of return on investment of 14.4%. In Zhenbaodao, the estimated annual net profit of CNY 2.33 million amounts to an annual rate of return of 21.6% (footnote 41). The income has been used for wetland restoration, procurement of vehicles and materials for the NRs, and for strengthening knowledge and skills of staff. Generating income from ecotourism will enable the NRs to reduce fishing and farming leases otherwise required to cover their annual operating costs.

Xingkaihu NR has been proposed as one among 13 focal ecotourism sites for Heilongjiang Province now incorporated into the master plan of Jixi City. Ecotourism facilities constructed at Xingkaiku include facilities for lodging and conferences, greenhouses and other farm buildings, production area for growing organic foods for tourists, facility for biomass and biogas heating and sewage treatment. Tourists can now enjoy bird watching,

fishing, boating, hiking, camping, skiing, and learning about wetland ecology and ecofarming. Annual tourist arrivals have increased from 525,000 before the project, to over 900,000.

More than 400 farmers changed their livelihoods to engage in ecotourism, resulting in the return of 525 ha of farmland, with 427 ha converted to wetland. Annual fish harvest has been reduced by nearly 1 million tons.

The shift from fossil fuel to biomass reduced fossil fuel usage by 75%–80% while also enabling local farmers to earn additional income from the sale of straw and waste biomass to the NR. It is estimated that pollutant emissions have been reduced by 88%.

In Zhenbaodao NR, 50 farmers and fishermen changed their livelihoods to ecotourism. Farming and fishing intensity have been reduced with 3,490 mu of abandoned farmland converted to wetlands.

Ecotourism facilities constructed include buildings for lodging, catering, conferences, and indoor entertainment; greenhouses; cattle barns and hen houses; organic gardens; biomass heating and sewage treatment facilities; and facilities for boating, hiking, camping, skiing, and demonstration of farming practices. Tourist arrivals to Zhenbaodao have increased fourfold.

A Wetlands Demonstration and Education Center has been established and will enable tourists to learn about the ecology, function, and significance of wetlands and why their protection is an urgent priority.

A nature interpretation center was also established at Qixinghe NR. A brief case study describing that activity is presented in Box 6.

Box 6: Nature Interpretation Center at Anbanghe Nature Reserve

Zhu Ranghua teaches primary school students about wetlands ecology at the nature interpretation center established as part of the ecotourism pilot project developed at the Anbanghe Nature Reserve
Source: Yoshiaki Kobayashi, ADB.

"Before, students knew little about wetlands, did not have the chance to visit the wetlands, and had never actually seen them. Through wetland education, students now have opportunities to visit and learn about wetlands. As a result, their knowledge of what wetlands actually are, and therefore, their sense of the importance of environmental protection have been enhanced. They have become very interested in wetlands and when they see learning materials and photos of the local plants and birds, I feel that they are happy and excited to learn about them. Wetland education is having a significant local impact on social development."

— Zhu Ranghua, teacher, Education Center, Anbanghe Nature Reserve.

Lessons on Education and Capacity Raising

Education and capacity raising is a crosscutting element that in fact is integral to, and supportive of, all other activities designed to strengthen and improve wetland management. The SPWPP was very successful in increasing knowledge, raising awareness, and improving the capabilities of stakeholders at various levels and for a wide range of functions. Among the many knowledge, awareness-raising, and capacity-building activities that were included in the past project were the following:

(i) A conservation education master plan was produced, and a pilot wetland protection education program was included in the curriculum of eight elementary and four secondary schools around four NR sites. Teachers received instruction in conservation education and gave lectures on wetlands protection to more than 6,000 students.
(ii) A range of educational materials were produced in various media, including wildlife handbooks, video CDs for wetlands protection, and a printed public awareness manual and profile of the project, posters.
(iii) Support was provided for conservation education centers at Anbanghe NR, Qixinghe NR, and Xingkaihu NR.
(iv) Courses were conducted in six NRs to improve the conservation awareness of more than 500 community and state farm residents.
(v) A special television program was developed and broadcast on CCTV about Qixinghe NR, Xingkaihu NR, and Zhenbaodao NR.
(vi) Various courses were conducted on sustainable alternative livelihoods, wetlands protection, forestry management, and NR management, including courses on biodiversity monitoring and environmental assessment.[42]

Through these activities, knowledge, awareness, and skills were strengthened across a broad spectrum of stakeholders, including top decision makers, managers in the NRs, and local community members alike. By taking such a multipronged approach to capacity building, a more substantial base of knowledge and skills was built, which could provide a stronger foundation for positive change over the long term.

Among the *key lessons* that emerged from the SPWPP with respect to awareness raising and capacity building, were the following:

(i) Children are the carriers of knowledge for the future. Thus, increasing the awareness of children and youth (through the inclusion of conservation education subjects in primary and secondary school curricula, organizing youth conservation programs, etc.) is a powerful force for promoting the conservation of biodiversity and protecting fragile environments over the long term.
(ii) Respect for peers, based on shared common experiences, creates a strong foundation for the effective transfer of knowledge. Therefore, programs such as seminars where farmers advise other farmers, and cross visits to sites where conservation managers can exchange ideas and discuss problems with others who

[42] ADB. 2013. *Completion Report: Sanjiang Plain Wetland Protection Project.* Harbin, China.

have similar responsibilities, are among the most effective means for increasing awareness and building capacity.

(iii) Nature interpretation, wherein visitors to natural areas are provided with opportunities to learn about the historical, socioeconomic, and biophysical aspects of the environment that they are observing and experiencing, is an essential element that can help to increase awareness and appreciation of the importance of environmental conservation. Nature interpretation needs to be supported through regular financial mechanisms that ensure that facilities and programs for interpretation (nature interpretive centers, salaries of naturalists, construction and upkeep of walkways and interpretive signage, etc.) can be maintained sustainably.

V. Recommendations: The Way Forward

The previous chapters have outlined in some detail the existing situation in the Sanjiang Plain, including the challenges for the continued sustainable management of valuable wetland areas. Lessons from the Sanjiang Plain experience, that have shown promising results, and which could be replicated and continued, have also been identified. This chapter goes a step further, in presenting recommendations for strengthening wetlands conservation, watershed management, and livelihood development. The recommendations have relevance not only for the Sanjiang Plain but also for other wetlands sites in the People's Republic of China (PRC), and in other country contexts as well.

The recommendations presented here can be grouped within two main categories. In the first group are those practices and approaches that could be considered to be *sustainability guidelines*. These are broad, fundamental principles and practices that will need to be followed in order to ensure that future economic development on the Sanjiang Plain and conservation and restoration of valuable wetland areas can both proceed harmoniously, on sustainable parallel tracks.

The sustainability guidelines provide a basis for integrating sustainable land and natural resource management and conservation with continuing economic development in the Sanjiang Plain. They are also relevant for a wide range of settings where the objective is to balance sustainable development with environmentally sound management of natural resources by capitalizing on rigorous scientific analysis as well as opportunities to mobilize the active collaboration and participation of key stakeholders. The sustainability guidelines are not limited specifically therefore to the Sanjiang Plain wetlands but are suitable for general application in the wetlands and ecosystems in the PRC and beyond. The guidelines provide a basis for comprehensive area assessment/situation analysis and for multisector integrated planning. They are equally applicable for progress monitoring, project adaptation, optimization, and fine-tuning in response to lessons being derived from project implementation experience.

The second group of recommendations being presented are a set of best practices, termed here as "options for action," that defines a range of activities on the ground, and which can contribute to improved wetland management on the Sanjiang Plain. These best practices have been drawn both from experience on the Sanjiang Plain and from other examples from around the globe. These options include ideas for more effective management of watersheds, better planning and execution of conservation programs in nature reserves (NRs), and development of livelihood options that do not conflict with environmental sustainability. Many of these best practices may not be applicable in all situations—they will need to be tailored to meet the specific requirements of each individual location and

situation. This set of best practices constitutes a "how-to" guide for practical solutions that could be applied to achieve more effective management and better sustainability.

Taken collectively, the *sustainability guidelines* and the *options for action* presented here comprise a set of clear recommendations for future action. These can help decision makers and managers chart a path that ensures both economic sustainability and biological viability in the Sanjiang Plain. In addition to the descriptions of best practices found in this section, a comprehensive listing that presents the main features of more than 30 best practices for improved watershed management, wetland ecosystem management, and sustainable livelihood development is found in Appendix 3.

Sustainability Guidelines

The Precautionary Approach

When addressing matters that involve protecting, preserving, or restoring ecosystems or other important features of the natural environment, it is critical to bear in mind that, once significant adverse environmental impacts occur, the damage done may be irreversible, and the impacts may cause irretrievable loss of globally important biodiversity or other significant resources. For this reason, there is general consensus among environmental scientists regarding the need to adopt a *precautionary approach*, when considering actions that may affect the natural ecosystem.

One of the cornerstones of U.S. environmental law is the Clean Water Act (CWA), which was first passed into law in 1972. This act sets forth requirements that are intended to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The act goes on to state that "the adverse impacts to *wetlands*, streams and other aquatic resources **must be *avoided* and *minimized* to the extent practicable.** For unavoidable impacts, **compensatory mitigation is required to replace the loss of wetland and aquatic resource functions in the watershed"** [emphasis added].[43] This is a clear example of the precautionary approach being applied, since the CWA requires (i) that all reasonable effort must be made to avoid adverse impacts; (ii) if impacts are unavoidable, that impacts are minimized; and (iii) that compensatory measures are undertaken to make up for losses of natural functions in wetlands and other aquatic systems. "avoid, minimize, compensate" is the "mantra" that guides wetlands management practice in the United States.

Another manifestation of the precautionary approach, and one which is perhaps broader and more generally applicable than the US CWA, is found in Principle 15 of the Rio Declaration of 1992. Principle 15, which codified the precautionary approach for the first time at the global level, states that "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation."[44] So, in addition to avoiding,

[43] U.S. Army Corps of Engineers. 2008. 33 CFR PART 332, Compensatory mitigation for losses of aquatic resources. Authority: 33 U.S.C. 401 et seq.;33 U.S.C. 1344; and Pub. L. 108–136. Source: 73 FR 19670, Apr. 10, 2008, unless otherwise noted.

[44] Similar applications of the precautionary principle are found in other international agreements such as the Convention on Biological Diversity and the UN Convention on Climate Change.

minimizing, and compensating adverse impacts, Rio Principle 15 also mandates measures to prevent possible future environmental degradation to be put in place, even when full scientific data may not be available.

The precautionary approach, as embodied in laws and agreements such as the US CWA and Rio Principle 15, certainly has universal relevance and is especially applicable in the case of the Sanjiang Plain wetlands—a fragile and irreplaceable natural system of high environmental, biological, cultural, and economic value and significance.

Ecosystem-Based Management and Integrated Water Resources Management

Given the fact that there is a complex range of socioeconomic and biophysical factors at play in the Sanjiang Plain, a carefully tailored, integrated set of approaches is required to respond to the attendant set of challenges, constraints, and opportunities that characterize this important region.

Identifying optimal means to achieve integrated sustainable environment management and economic development requires attention to the biological, hydrological, socioeconomic, policy, and regulatory conditions that in combination, define the situation. To optimize the potential for success, an approach that minimizes incompatibilities among the *various sector objectives, and instead creates synergies among them, is required.*

Ecosystem-based management (EBM) is an approach that seems to fill this need. EBM can be described very simply as "an integrated area management approach that considers the entire ecosystem, including humans."[45] EBM is not a static approach. It requires continual fine-tuning and adaptation to remain relevant in the context of changing socioeconomic demands and values, policy constraints and opportunities, at the same time responding to dynamic changes in hydrology and water quality, habitats and species. To achieve this responsiveness, ecosystem management is linked practically to an adaptive management framework, through a cyclical process of planning, implementation, and periodic reassessment of conditions and results, which facilitates response to socioeconomic and demographic shifts, climate change, and the impacts of ongoing activities and interventions. Iterative planning and adaptive management respond to these ongoing changes and uncertainties.

Because wetlands typically occur in low-lying areas, they are often at the "receiving end" of impacts that are brought about by activities occurring on more elevated lands that lie outside the wetlands themselves, within the greater watershed. In this context, the application of an EBM approach becomes all the more critical. This principle is clearly recognized by wetland scientists and has been adopted and promoted under the Ramsar Convention. Box 7 presents a discussion that explains how an EBM approach is fundamental to the methodologies being promoted through the Ramsar Convention. Additional information about the EBM approach, which is regarded as a critical element

[45] Further information can be found at N. L. Christensen et al. 1996. The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management. *Ecological Applications.* 6. pp. 665–691.

Box 7: Wise Use of Wetlands Resources

Under Article 3.1 of the Ramsar Convention, parties commit themselves to national planning for the "wise use" of the wetlands in their territory. This core concept of "wise use" was pioneering when the convention was developed—it makes clear that human use of natural resources on a sustainable basis are entirely compatible with Ramsar principles, and wetland conservation in general. The Ramsar "wise use" concept applies to all wetlands and water resources in a contracting party's territory, not only to those sites designated as wetlands of international importance. Its application is crucial in ensuring that wetlands can continue their vital role in supporting the maintenance of ecosystem services, biological diversity, and human well-being for future generations.

As the term "wise use" gained currency within the Ramsar community and elsewhere, the Conference of the Parties recognized the need for greater precision and adopted a clear definition in 1987, which was subsequently updated in 2005: "Wise use of wetlands is the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development." These definitions and the thinking that went with them established a congruence between Ramsar "wise use" and the terminology of the World Conservation Strategy, developed by the World Wildlife Fund, the International Union for the Conservation of Nature, and the United Nations Environment Programme in 1980 to link human well-being and our dependence upon nature as integral parts of a whole, of the 1987 UN World Commission on Environment and Development definition of "sustainable development," and subsequently of the Millennium Ecosystem Assessment (2001–2005), with its focus upon "ecosystem services."

Source: Ramsar. 2012. *Liquid Assets: 40 Years of the Convention on Wetlands*. Gland, Switzerland: The Ramsar Secretariat.

for the successful continuation and strengthening of wetland conservation efforts in the Sanjiang Plain, is provided in Appendix 5.

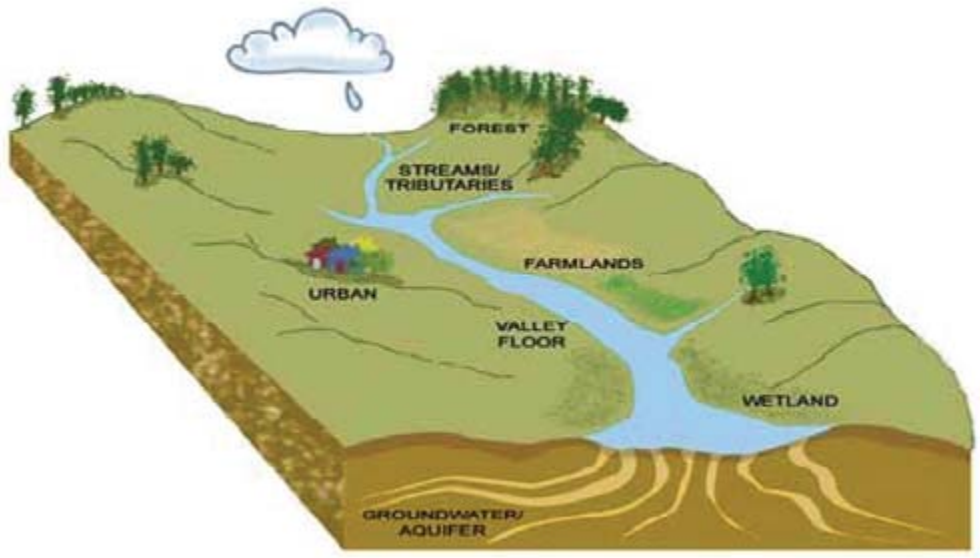
As is the case with EBM, *integrated water resources management* (IWRM) applies an integrated approach to the management of water resources, incorporating consideration and response to a range of closely interrelated factors, including domestic water use, water resources for agriculture and industry, and preservation of the integrity of nature and ecosystems. *IWRM is envisioned as a "win–win" approach, wherein natural ecosystems can be protected, while essential economic activities can be carried out in a sustainable manner.*

Effectively integrating sustainable water management and land use in the context of the broader ecosystem presents both an overarching challenge and opportunity. Historically, ad hoc development of activities in river basins and watersheds has led to unsatisfactory physical, environmental, and social conditions in many countries, including the PRC. Today, through stronger policy development and best practice, IWRM in large-scale catchment basins and ecosystems is delivering vastly improved results compared with prior and less holistic approaches.

At the heart of the IWRM approach is recognition that *actions in upstream areas have a significant influence and impact on the downstream environment*. The interrelationship

between upper and lower watershed areas and groundwater resources is illustrated in Figure 14. Accordingly, it can be appreciated that the low-lying wetland areas of the Sanjiang Plain are at risk from the impacts caused by harmful land-use practices at higher elevations. There is a need to raise awareness among land users (e.g., farmers or land managers) as well as policy makers regarding land uses that result in nonpoint source pollution, including soil erosion and water pollution, and to advocate for the use of improved land use and agricultural production practices that will have both on-site and off-site benefits. This is a cost-effective mechanism for changing poor land-use practices and for reducing their adverse impacts.

Figure 14: Schematic Representation of a Typical Watershed



Source: East-West Gateway Council of Governments. St. Louis, MO. http://www.ewgateway.org/environment/waterresources/Watersheds/WatershedDiagram/WatershedDiagram.htm

River basins and their constituent watersheds provide an appropriate scale for organizing and *planning* effective land and water management actions. Integrating water resource and ecosystem-based planning can help to avoid, minimize, or remedy potential conflicts between users and ensure that natural hydrological and ecological functionality are protected within the watershed. On the contrary, *actions* need to be carried out at local scale, for example, within designated water bodies, stretches of rivers, wetlands, or areas defined by administrative boundaries, such as towns or counties. Local governments, local communities, farmers, and other land users are the key actors who will be involved in carrying out the required interventions.

At the watershed level, better integration of policy objectives by the various administrative organizations in the watersheds of the Sanjiang Plain is needed to harmonize and reconcile potentially disparate regulations, policies, and practices. The establishment of a *basin-wide policy advisory group* is suggested to achieve this, with expert members of the group drawn from various levels of government, communities, and the private sector. A more

integrated policy and implementation framework formulated by the advisory group can then become the vehicle to promote efficient water use, conservation, and recycling; to introduce measures to protect and improve water supply and water quality; to ensure that the ecological and biodiversity resources in the forests, rivers, streams, lakes, and wetlands of the Sanjiang Plain are adequately protected; and to promote economic and livelihood activities that are environmentally sustainable.

An ecosystem-based watershed management approach centers on effective stakeholder engagement. It involves describing issues using language that people understand and connecting them with solutions where they can appreciate the benefits. By considering a wide range of issues across the ecosystem, river basins, and watersheds, and by explaining the benefits of action, more innovative and collaborative solutions can be explored and more economic and social benefits can be identified. Through working with the local people, communities and governments can take ownership of problems and commit to appropriate action.

Adequate ongoing budgets should be provided by provincial and local governments to highlight their commitment to EBM–IRWM and to ensure that watershed as well as larger basin-wide management partnerships can be established. Budgetary costs will likely be offset by financial benefits achieved by fostering closer collaboration between key stakeholders, and ultimately self-sustaining partnerships over time. In addition, the private sector should be engaged (e.g., using the "corporate social responsibility" model) as partners for development of sustainable financing. Water demand management, raw water pricing for wastewater treatment, and other economic instruments should all be considered when determining mechanisms for covering the costs of maintaining the ecosystem goods and services that the watersheds provide.

The Asian Development Bank has developed a guideline for 25 essential elements for effective IWRM.[46] In a recent analysis, it has been determined that, through past Asian Development Bank and government initiatives, agencies and professionals working in the Sanjiang Plain have successfully embraced 15 of these key principles. Thus, added focus is needed to strengthen capacity on the remaining 10 elements, which are not yet fully embedded into agency work practices and programs in the Sanjiang Plain, and these 10 key elements are mentioned in Table 4.

Designation of headwater forest areas as forest reserves, in line with the PRC's forest classification system, to complement the Sanjiang Plain's wetland NRs, is one critical element that should be part of the integrated ecosystem, water resource, and watershed management framework. Forestry improvement needs to embrace the whole forestry cycle from initial forest establishment through growth phases to maturity and harvesting. For the forestry sector, the key performance indicators are demonstrating that forests are slowing down water runoff in flood times but maximizing water yield at other times.

To access the best available scientific knowledge and information, there are several key stakeholders who need to be involved in the planning process for IWRM in the Sanjiang Plain. These include the State Forestry Administration, Northeast Forestry University and

[46] ADB. 2006. *Innovations and Advances in Basin Management in Asia.* Appendix A: ADB's 25 Elements of IWRM in River Basins. Manila.

Table 4: Ten Key Elements for Implementing Integrated Ecosystem and Water Resources Management in the Sanjiang Plain
(Based on ADB's 25 IWRM Elements)

ADB IWRM Element (#)	Typical Interventions/ Criteria (From ADB's 25 Elements)	Further Analysis and Suggestions
Private sector contribution (12)	Introduce or increase private sector participation in integrated water resources management (IWRM) through corporate social responsibility-type contributions	Forest and nature reserve practitioners, administrators, and decision makers must begin to engage with the private sector industries, businesses, and services whose operations may be impacting on the overall environmental health of the watersheds of the Sanjiang Plain.
IWRM financing (8)	Institutionalize models whereby government agencies at all levels contribute to the IWRM budget	Establish an appropriate advisory group of experts from within the government sector to advise on the setting up of a collaborative financial model for IWRM for the watersheds of the Sanjiang Plain.
Economic instruments (9)	Introduce raw water pricing and/or other economic instruments to share the IWRM costs, stimulate water demand management and conservation, protect the environment, and pay for environmental services	A difficult challenge for provincial and local governments. In 2011, a Greentech review (China Greentech Initiative, April 2011. The China Greentech Report 2011: China's Emergence as a Global Greentech Leader. Greentech Networks, Hong Kong, China.) of market water pricing across 600 cities in the People's Republic of China showed little support for increasing the water price. However, the same review noted better acceptance of price increases for wastewater treatment than water supply; therefore, the administrators will need to carefully word the business case for water pricing. Water supply prices are set locally with no national pricing policy or directive. However, market water pricing is vital; if water is free or undervalued, there is wastage. Adequate clean water means children are healthy and go to school; parents are healthy and go to work; social and environmental benefits multiply. The drivers for change in waste water treatment in the People's Republic of China are to: (i) use less land for treatment, (ii) use less energy in treatment, (iii) produce energy from treatment processes, (iv) recover other resources such as phosphates from treatment processes, (v) produce reusable water after waste water treatment, and (vi) meet higher standards of river quality being set at the national level.

continued on next page

Table 4 *continued*

ADB IWRM Element (#)	Typical Interventions/ Criteria (From ADB's 25 Elements)	Further Analysis and Suggestions
Water education (13)	Introduce IWRM into school programs to increase water knowledge and develop leadership among the youth, including responsibility for water monitoring in local water bodies	Water and environmental education is key to raising awareness of the complex environmental and social interactions within watersheds that need to be managed for the well-being of the present and future generations. Local water monitoring is a proven means of creating new stakeholders and reporting local water issues.
Watershed management (14)	Invest to protect and rehabilitate upper watersheds in collaboration with local communities and civil society organizations	The overall health of the upper watersheds is fundamental to protecting the health of the nature reserves. There is a case for establishing equivalent upper catchment reserves to reinforce their importance relative to wetlands.
Water quality improvement (20)	Invest in structural and nonstructural interventions that reduce point and nonpoint water pollution	There is significant point and nonpoint pollution from flooding events into the nature reserves. The development of management plans and adoption of agricultural best management practices to avoid, mitigate, and remedy water pollution is suggested.
Wetland conservation (21)	Invest to conserve and improve wetlands as integral part of the river basin ecosystems	This advocates responsible agencies follow best practice and integrate the management of the wetlands into overall IWRM.
Fisheries (22)	Introduce measures to protect and improve fisheries in the river	The intervention should extend into streams, lakes, and wetlands.
Water conservation (24)	Institutionalize a policy and implementation framework to promote efficiency of water use, conservation, and recycling	The development of more integrated policy objectives by the various administering organizations in the Sanjiang watersheds is needed to achieve a situation whereby the water policies of individual organizations are not inconsistent with each other. The setting up of a basin-wide policy advisory group is suggested.
Decision support information (25)	Improve online publicly available river basin information systems to support IWRM policy, planning, and decision making, including dissemination of "tool boxes" and good practices	The continuum of data, information sharing, knowledge, and wisdom is best promoted through electronic real-time systems, to reach and engage the widest possible audience of practitioners, stakeholders, and administrators.

Source: ADB. 2006. *Innovations and Advances in Basin Management in Asia*. Appendix A: ADB's 25 Elements of IWRM in River Basins. Manila.

other academic institutions, national and international nongovernment organizations with experience and proven competence in sustainable environment and wetlands management and conservation, and the Heilongjiang Provincial Forestry Department, among others. In addition, local government agencies, NR authorities, water and wastewater companies, highway authorities, the private sector, farmers, tourism operators, tourists, wildlife enthusiasts, the general public, and students constitute another group of stakeholders who are in essence the "customers" of the ecosystem stewards, who are dependent upon the ecological goods and services provided by the natural ecosystem.

In summary, the introduction of the EBM–IWRM management approach signifies a major change to land and water management. It is a key step in the right direction but fulfilling its potential will take determination, imagination, and careful monitoring and review. For the Sanjiang Plain, a functional EBM–IWRM framework is imperative for the long-term survival of the wetlands and the ecological services they support. Some additional guidelines to support the development of such a framework are provided in Appendix 4.

Supporting Sustainable Livelihoods

Environmentally sustainable livelihoods complement conservation efforts by reducing pressures on natural resources.

In a global survey conducted by Wetlands International, best practices in sustainable livelihood development have been identified, and these could be applied in future efforts to expand on progress made during the Sanjiang Plain Wetland Protection Project (SPWPP). The practices include

(i) local situational analysis, for a preliminary determination of the feasibility of various livelihood improvement options;
(ii) collaborative planning, involving local stakeholders and prospective adopters of the livelihood alternatives, to determine their priorities and potential interests, giving them a sense of ownership in the process of selecting the best alternatives;
(iii) multiple-use zoning, in which livelihood development strategies are matched with the land capability and conservation values of particular microsites within the protected area estate;
(iv) microfinance, revolving funds, and payment for ecosystem services, to provide the necessary financial supports and start-up costs for farmers interested in developing selected livelihood alternatives;
(v) marketing assessment and assistance, identifying the demand and market potential for various products to be produced by participants in the alternative livelihood development initiative and assisting producers to get their products to market efficiently and effectively;
(vi) support for pilot and demonstration projects, so that tangible examples of the alternative livelihood options are available for local scrutiny, and so that lessons from successes can be applied for effective scaling-up of pilot initiatives;
(vii) farmer-to-farmer knowledge exchange and extension, enabling the managers of successful pilot and demonstration activities to serve as mentors to guide other interested parties;

(viii) stakeholder mobilization, to encourage a larger group of new adopters of the sustainable livelihoods approaches to multiply both the income and environmental conservation benefits as a result of their wider-scale implementation; and
(ix) monitoring and evaluation, enabling identification and overcoming of problems and constraints in a timely manner, and iterative adaptation and improvement of implementation based upon applying lessons learned, so that the greatest possible level of success is achieved.[47]

Many of the support mechanisms required to promote sustainable livelihoods are listed above. Specific examples of sustainable livelihood opportunities and best practices are provided in the "options for action" section which follows these "sustainability guidelines."

Stakeholder Participatory Planning

In the rural development field, in recent decades, local communities and stakeholders have become increasingly involved in decision-making processes. This experience has shown that when community stakeholders are directly involved in considering natural resources and ecosystem management options, or evaluating potential livelihood development alternatives, the likelihood for successful outcomes is increased. There are various reasons for this:

(i) Involving local stakeholders in project planning enables local knowledge to be incorporated into the plans. Based on improved overall understanding of the local situation, the design of technical options tends to be more compatible with local conditions, priorities, and concerns.
(ii) Tailoring project designs to align with local preferences, objectives, and aspirations generates local enthusiasm and a perception among people that they will be getting what they really want and need from a project, rather than what outsiders consider best.
(iii) Creating space for local people to contribute to project planning builds up their sense of personal ownership, leading to a desire to participate in helping to make the project a success, and to sustain and further build upon that success after the project has been completed.

In contrast, conventional "expert-led" planning approaches undervalue the relevance of local stakeholder knowledge and capacity to contribute meaningfully to project planning and decision making. Projects planned exclusively by outside experts often overlook important information about the local social, cultural, economic, and natural systems often leading to their failure, or at least to a failure to fully capitalize on the actual potential. Instead of galvanizing the interest, enthusiasm, and participation of local stakeholders, expert-driven projects can alienate local communities when they perceive that project designers do not value their opinions or respect their concerns.

[47] Ramsar Convention Secretariat. 2010. Managing Wetlands: Frameworks for Managing Wetlands of International Importance and Other Wetland Sites. *Ramsar Handbooks for the Wise Use of Wetlands*, 4th ed., Vol. 18. Gland, Switzerland: Ramsar Convention Secretariat.

For these reasons, projects that have empowered stakeholders and communities with a substantive role in problem assessment, priority setting, and project planning have delivered better project designs, public participation, and benefits.

The enthusiasm and interest generated by stakeholder participatory planning can make its facilitation an exhilarating process. Participants' energies are freed up to brainstorm, present ideas, and to have their ideas taken seriously. But, skilled hands are required to ensure that the process is well organized, engaging, and enables all views to be heard and considered. It is widely acknowledged that stakeholder participatory planning is most successful when it is supported by experienced rural planning facilitators. To ensure that stakeholder participatory planning will be an effective catalyst for promoting sustainable development and resources management objectives, it is also essential that sufficient funding is committed to support the early implementation of stakeholders' selected priority development options.

In general, strong participation in the planning phase will also lead to increased participation of local stakeholders during implementation. Local community members, including farmers, business people, resource managers, and civil society members, are very often the most knowledgeable about local socioeconomic and biophysical conditions. At the same time, they have the greatest interest and stake in ensuring that proper decisions are made and appropriate actions are taken. Thus, they are the most qualified to participate in the decision making and implementation processes, so that the desired outcomes are achieved, whether they be for fulfilling conservation objectives, livelihood development, or enhancing knowledge and awareness. Thus, reliance on local stakeholders, operating in close cooperation with representatives of concerned government agencies through a carefully considered **comanagement** approach, is usually the best way to proceed in attaining these multiple objectives.

Awareness Raising, Education, and Capacity Building

One of the most important lessons that emerged from the SPWPP was recognition of the fact that awareness raising, education, and capacity building are essential to support efforts to conserve wetlands and watersheds. Because it is considered important to further disseminate lessons from past experience to promote further improvement in wetlands management in the Sanjiang Plain, continuing education, awareness-raising, and capacity-building activities will be required.

As demonstrated by past projects in the Sanjiang Plain and elsewhere, among the most effective means for expanding knowledge and awareness are the following:

(i) inclusion of wetland protection and conservation education programs in primary and secondary school curricula;
(ii) dissemination of printed materials (posters, brochures, guidebooks, etc.) that can further spread messages about the importance of wetland protection;
(iii) development of centers dedicated to promoting public education about wetland conservation; and

(iv) using various electronic media (e.g., TV and radio, internet, DVDs, social media) to reach a broader audience and provide information about the importance of conserving natural resources and respecting the environment.

Applying a wide-reaching and multifaceted approach in developing educational, awareness-raising, and capacity-building programs will strengthen the likelihood that behaviors and attitudes of important groups of stakeholders, including decision makers, children and youth, and grassroots community members, will be positively influenced in recognizing that the preservation of natural habitats, ecosystems, and biodiversity is a fundamental moral and social obligation.

Best Practices: "Options for Action"

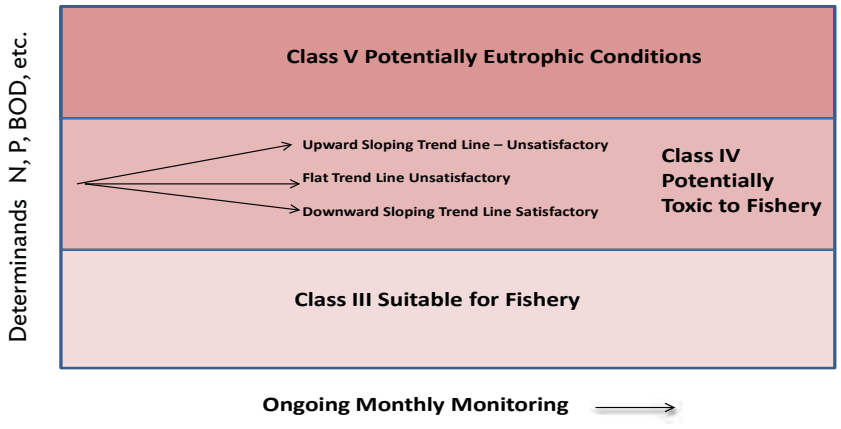
Strengthening Water Quality Monitoring Programs and Improvement Plans

A weakness that is evident in current water resources practices on the Sanjiang Plain is the absence of Water Quality Improvement Plans or Water Quality Management Plans to accompany the Water Allocation Plans for water quantity. Normal best practice would see these as "twin" plans, to be prepared and implemented together.

Current water quality monitoring practice in the Sanjiang Plain is not sensitive enough to measure trends or gradual changes in water quality. The results of recent monitoring, showing static Class IV water quality conditions, give no indication of trends, which need to be known for effective management. This principle is illustrated in Figure 15.

Monthly monitoring at each wetland NR for the normal water quality parameters (N, P, biochemical oxygen demand [BOD], etc.) would give a series of points that would

Figure 15: Establishing Trend Lines for Water Quality Monitoring in Wetlands



Source: TA 8541-PRC consultants.

enable water quality trend lines to be established. Upward-sloping or flat trend lines are unsatisfactory, as the risk of water quality deterioration to Class V standard is present, and there is no buffer against this happening.

Conversely, downward-sloping trend lines are satisfactory, since the risk of water quality deterioration to Class V standard is moderated as the downward-sloping trend lines themselves form a buffer against the risk of water quality falling to Class V standard. While an improvement from Class IV to Class III standard is a challenging target, it could be achieved in time, provided the existing nonpoint pollution issues on the Sanjiang Plain are addressed. The important point to be kept in mind is that regular, reliable, time-series water quality monitoring data are an absolute prerequisite to addressing the issue of deteriorating water quality in the Sanjiang Plain wetlands.

Plantation Forestry

Forests, natural or planted, provide ecosystem services that prevent the effects of pastoral and other agricultural activities involving high nutrient input. Trees require little or no fertilizer, store carbon, slow water runoff and mitigate flooding, prevent erosion, enhance biodiversity, and improve landscape aesthetics. However, forest plantations can generate negative environmental effects if not properly designed or if appropriate management practices are not in place. It is important that best practices are applied throughout the planting cycle, including the planning, design, grow-out, harvest, and postharvest phases. Some of the most important best practices are briefly presented below:

(i) Cutting of trees may involve leaving large areas of soil exposed and can generate large volumes of wood waste. Wood waste dumped into streams can clog the waterways, and cleared areas are subject to erosion and sediment runoff. These effects can be avoided by applying accepted forestry best practice. Proper placement of waste wood in streams (using larger-sized logs and branches) can actually be beneficial, by slowing stream flows to attenuate flooding (without clogging), and creating shaded areas that serve as shelter for fishes and other aquatic or semiaquatic animals.

(ii) After harvesting, it is important to replant as soon as possible, to restabilize soils, and to quickly reestablish the forest cover. It will typically take 3 years–4 years to recover the watershed benefits of the new planting.

(iii) Weed control during the early years after planting will promote more rapid tree growth, facilitate higher survival rates, and ensure better timber yield.

(iv) Sites that are sensitive should be avoided as plantation areas. These may include sites with important historical or archaeological values, or natural areas where indigenous vegetation is growing.

(v) Adequate setbacks from wetlands, rivers, streams, or lakes are required to avoid excess water capture by trees, which could reduce the availability of water to maintain the functionality of nearby aquatic systems. Recommended minimum setbacks are: 5 meters (m) from perennial streams and rivers with a channel width <3 m; 5 m from the "landward extent of wetland vegetation" for wetlands; 10 m from perennial rivers and streams with a channel width >3 m; 10 m from lakes >0.25 ha; and 20 m from locally significant wetlands, lakes, or rivers.

(vi) Choosing the right tree species for the right location is vital before any replanting is carried out. Any of the following—"the right tree in the wrong place, the wrong tree in the right place, or the wrong tree in the wrong place"—can lead to poor planting results, more potential land disturbance, and poor economic returns. Apart from economic consideration, characteristics of particular importance when deciding on appropriate tree species to be planted in sites near wetlands include the water demand characteristics, root structure and capacity to bind soils, and potential contribution to soil enrichment through nitrogen fixation, leaf litter production, etc. Forestry experts in Heilongjiang Province have identified the following trees as being generally suitable for plantations in the Sanjiang Plain: for softwoods—Spruce (*Picea* spp.) and Dahurian larch (*Larix* spp.); for hardwoods—Poplar (*Populus* spp.) and Birch (*Betula* spp.).

(vii) Phased planting and attention to the total areal coverage of the plantation relative to the size of the watershed are important considerations that can help ensure that the area of land that is exposed following harvest is kept to a minimum.

In summary, it is suggested that new forest planting should be implemented under a farm forestry or agroforestry approach, rather than as broad watershed or landscape-scale plantations that can impact water yields. Management practice needs to phase plantings to give a spread of age classes and a good mix of species to avoid risk of die-off within single-species plantings. The use of indigenous (native) species is recommended in areas set aside for providing wildlife habitat, riparian planting, biodiversity corridors, and buffers from adjacent nonforested land uses. In general, native species, which are adapted to local microclimates, will not put undue demand on groundwater resources. Finally, the 2014–2015 State Council ban on commercial logging in natural forests in Heilongjiang Province provides further assurance that plantings of native species will be secure and protected.

Applying Technologies for Improved Management of Agricultural Lands

In the situation analysis, it was noted that nonpoint source pollution from agricultural runoff is the largest contributor to water pollution in the PRC (and in the Sanjiang Plain). As pointed out in the previous discussion, such pollutants are impairing water quality in sensitive wetland areas. Agricultural activities that cause nonpoint source pollution include poorly located or managed animal feeding operations; overgrazing; plowing too often or at the wrong time; and improper, excessive, or poorly timed application of pesticides, irrigation water, and fertilizer. Pollutants that result from farming include sediments, nutrients, pathogens, pesticides, metals, and salts.[48]

Conventional, field-based crop farming in the Sanjiang Plain does not yet apply international state-of-the-art conservation farming technologies. Many practices designed to reduce pollution also can save water. Thus, such improvements could result in the provision of more reliable water supplies, both for maintaining minimum ecological flows in wetland areas, and also, to provide water for farming and other economic activities. Significant improvements could result, both in terms of water quantity and water quality.

[48] U.S. Environmental Protection Agency website. March 2005. Agricultural Nonpoint Source Fact Sheet. EPA 841-F-05-001. http://water.epa.gov/polwaste/nps/agriculture_facts.cfm

Impacts from agricultural activities on surface water and groundwater can be minimized by using management practices that are adapted to local conditions. Technologies such as soil and water conservation, drip irrigation, larger-scale and decentralized agricultural runoff and sewage treatment facilities, computerized soil moisture and fertility monitoring and delivery systems, and laser field leveling and other such technologies could substantially increase production while reducing contaminated runoff, chemical use, and water diversion, all of which will reduce adverse impacts on the protected wetland ecosystems.

Developing and Strengthening Management Plans for Nature Reserves

In the course of conducting research about the management of NRs in the Sanjiang Plain, it was discovered that there were *master plans* prepared for the NRs but that *management plans* were weak or absent. The distinction here is a significant one—while master plans might chart out a vision for the establishment of an NR, the management plan is intended specifically to present the management objectives for the facility, and to serve as a handbook that guides day-to-day operations and management.

In other countries and in other natural areas, management plans are the standard primary reference used to provide a "road map" for the management of the area. Typically, best practice for the development of the management plan includes several key steps or elements:[49]

(i) statement of the biodiversity or natural significance of the site, and development of a vision for its management;
(ii) description of the legal authority under which management of the site will be conducted;
(iii) gathering of comprehensive data about the site—its natural resources, management constraints and opportunities, and socioeconomic context;
(iv) identification of requirements for management—staffing, budget, involved partners, and affected people;
(v) definition of the site boundaries, zoning and mapping, and description of permitted and prohibited uses;
(vi) description of expected interventions or actions for management, including monitoring, research, enforcement, development and maintenance of physical facilities, and public outreach and awareness programs (among others);
(vii) definition of timeframe—period to implement required actions, and period of validity of the management plan, with requirements for regular revision and updating; and
(viii) employment of a participatory process throughout the development (and implementation) of the plan.

[49] Numerous references are available that present guidelines for the development of management plans for protected areas and natural areas. One good example is provided here: L. Thomas and J. Middleton. 2003. Guidelines for Management Planning of Protected Areas. World Commission on Protected Areas (WCPA). *Best Practice Protected Area Guidelines. Series No. 10*, P. Adrian, Series Editor. IUCN—The World Conservation Union. Gland, Switzerland.

Following these basic steps can ensure that the management of the NR has adequate resources, is well planned, addresses all priority issues and concerns, and takes into account the interests of all concerned parties. It is imperative that the NRs of the Sanjiang Plain each have a comprehensive management plan that can be referred to by managers on a regular basis, and which is updated according to a regular schedule.

Identifying Ecological Hotspots: Establishing Biodiversity Corridors and Nature Reserve Networks

Given the quantity of food required to feed the population of the PRC, and the key contributing role played by the Sanjiang Plain in meeting national targets for grain production and food security, it is unlikely that restoring large areas of the Sanjiang Plain to their original ecological condition will be pursued as a policy. As an alternative, carefully designed "ecological hotspot" projects can be located in scientifically selected areas that have a particularly important role in preserving and maintaining the region's globally important biodiversity, critical ecological services, and habitats, and in protecting vital water resources. Restoring these "ecological hotspots" will help to ensure improved and sustained delivery of the ecological services provided by the Sanjiang Plain's wetlands and watersheds.

Ecological hotspots will include primarily

(i) selected areas of watershed forest,
(ii) riparian zones that provide habitat for threatened and endangered species, and
(iii) sites selected to restore habitat and ecosystem connectivity or "biodiversity corridors" to remedy the current fragmentation of the ecosystem.

The concept of biodiversity corridor is important. To the extent possible, sites should be identified for protection, which will enable physical connections, or corridors, to be established between important segments of habitat that might otherwise be fragmented and isolated. One good example is found in the Naoli River watershed. Here, the existing NRs in the watershed—which include the Qixinghe NR, Sanhuanpao NR, Naolihe NR, and Dajiahe NR—could form the core areas along the corridor. Extending protection to the riparian zones that link these sites could ensure that various species of wildlife would be able to move freely within and between suitable habitat areas, thereby having access to sufficient territory (and the resources that are contained therein, food, nesting sites, etc.) to ensure that their needs for feeding, shelter, and reproduction can be met. Protection and enhancement of riparian corridors will be especially important in the Sanjiang Plain, as the riparian corridors are natural connectors between wetlands that might otherwise remain isolated. Enhancement of riparian protection zones might involve planting of suitable native species of vegetation that could serve to stabilize river banks, minimize erosion, absorb nutrients, and provide habitat for waterfowl and other species. Other important sites for management and protection along corridors may be identified by studying the major flyways that are used by migratory waterfowl for breeding, feeding, and staging, and locating the wetlands that lie along the same paths.

The fragmented nature of wetland protection that is currently in place in the Sanjiang Plain has been mentioned in the "Lessons" section—up to the present, each NR has operated

more or less autonomously from the others. Treating the NRs conceptually as a *network* of protected areas that are working together to achieve greater biological connectivity as well as efficiency in operations—rather than as separate NRs operating quite independently of each other—would be an important step to advance the biodiversity corridor concept. Also, there has not been an institutional structure or administrative mechanism in place to help coordinate the conservation management practices and activities across all the NRs in the area. This shortcoming has limited the opportunities for sharing information and pooling resources. The recently established Heilongjiang Wetland Conservation Center could possibly serve in the role of a coordination body, to help to advance networking among the Sanjiang Plain NRs, both in a conceptual and an applied, practical sense.

One final element that could help promote more holistic management of the Sanjiang Plain wetlands would be to establish a common data repository for all the NRs and other wetland areas of the Sanjiang Plain. The core of such a repository should be a comprehensive geographic information system database that is easily accessed by NR managers and easily updated to accommodate the input of new information. Such a database would help facilitate planning and management at both local and regional scale.

The ultimate objective of these various integrative actions would be to maintain, enhance, and effectively manage biodiversity corridors that are needed to support viable populations of migratory waterfowl and other valuable species requiring large connected habitat areas for their survival.

Creating Improved Waterfowl Habitat

If environmental conditions overall are made more suitable for waterfowl, then survival of sensitive species could also be improved. One example, derived from lessons learned in the SPWPP, was the deployment of artificial nests for storks. Several other options for improving conditions to support waterfowl are presented here:

(i) **Protecting nest sites from predators or competitors**. This can be accomplished in several different ways, including (a) use of fences (e.g., to exclude grazing animals), (b) building of small islands, which would offer more protection from predators, and (c) cultivating or encouraging the growth of tall grasses and reeds to hide nesting sites. Closely related to this would be to provide nesting sites that are slightly elevated, to protect nests from flooding.[50]

(ii) **Providing more food resources**. In addition to direct feeding (which was done under the SPWPP), this can be accomplished by planting preferred species of food plants, and by providing conditions under which other food resources, including fish, insects, crustaceans, and snails and worms, will flourish.

(iii) **Regulating water flow**. Many of the NRs already have in place irrigation structures that enable the regulation of water flow within their boundaries. Irrigation structures also are in use on lands surrounding the NRs. Minimum environmental

[50] Further information about improving survivorship of waterbirds through habitat manipulation can be found in: C. L. White et al. 2005. *Nesting Island Creation for Wading Birds.* CIR1473, Wildlife Ecology and Conservation Department, University of Florida/IFAS Extension. Gainesville, Florida USA. http://edis.ifas.ufl.edu/uw223; and R. A. Rounds et al. 2004. Nest-Site Selection and Hatching Success of Waterbirds in Coastal Virginia: Some Results of Habitat Manipulation. *Journal of Field Ornithology*. 75 (4). pp. 317–329.

water flows to the wetlands could be systematically determined, planned, and regulated, by reducing water diversion, particularly at critical life cycle periods for endemic, rare, and endangered species of migratory avifauna. Flooding, which has caused failure of nests in the past, could also be better controlled. These measures could be achieved in conjunction with investments in water conservation agriculture in terms of both irrigation management and crop selection.

(iv) **Improving water quality**. The existing unsatisfactory water quality in wetland areas within the NRs has already been noted. By applying measures to improve water quality, waterfowl will benefit in several ways. These include (a) less susceptibility to disease (e.g., waterborne pathogens) or nest failure (through weakening of eggshells) and (b) increasing populations of fish and other aquatic animals that are available as food sources. One interesting option for improving water quality involves the use of "artificial wetlands" or "constructed wetlands." In such applications, species of wetland plants are identified that are capable of absorbing large quantities of nutrients and other chemicals (e.g., pollutants such as fertilizers and heavy metals). By growing these plants in areas where water quality is below accepted standards, the pollutants are withdrawn from the water column, and it is possible that significant improvements in water quality could be achieved. While this method is typically used for water purification in constructed settings (wastewater treatment plants, oxidation ponds, etc.), using suitable plant species could, in a similar manner, contribute to improved water quality in natural wetland settings.

The measures described above would need to be tailored to the specific requirements at different sites. They could be pilot tested, and if proven successful, expanded to cover larger areas or other similar sites, as appropriate.

Improving Wetland Restoration Results[51]

In the section on "lessons learned," the techniques that were applied in the SPWPP for reconversion of farmlands to wetlands in the Sanjiang Plain were discussed. There are a range of other technologies that could be applied to enhance the restoration process, both in terms of restoring wetlands to a more natural state and shortening the amount of time required to reestablish wetland vegetation. Several of these methods are presented here.

(i) **Establishing a germplasm bank and related technologies**. Seed germination and physical separation methods are used to screen wetland soils to develop a germplasm bank and floral seed resources. These methods also help in characterizing the pioneer and dominant species of wetland vegetation that occur under varied environmental conditions. This knowledge is helpful in developing effective protocols for wetland restoration. In addition, seeds of common wetland plants, such as reeds and cattails, can be effectively germinated by soaking in a solution of potassium nitrate. Appropriate field procedures (e.g., controlling water levels, proper soil contouring and leveling) can promote more

[51] This best practice is contributed by Shouzheng Tong, Northeast Institute of Geography and Agricultural Ecology, Chinese Academy of Sciences; and see also G. Wang et al. 2015. Effects of Farming on the Soil Seed Banks and Wetland Restoration Potential in Sanjiang Plain, Northeastern China. *Ecological Engineering*. 77. pp. 265–274.

rapid seed germination and rooting, to quickly restore the reed wetland. The technologies have already been extensively applied in restoration of wetlands of the Sanjiang Plain.

(ii) **Vegetative propagation of sedges**. The sedge, *Carex heterolepis*, can be propagated by root splitting and leaf cutting. Growth of offsets can be stimulated, to rapidly multiply the plants. The technique has been applied in the construction of Harbin Sun Island Park and in wetland restoration on the Sanjiang Plain.

(iii) **Propagation methods for lotus and water lily**. Based on seasonal growth patterns, tuberous roots of lotus (*Nelumbo nucifera*) and water lilies (*Nymphaea* spp.) can be collected during dormancy, before new leaves emerge. In this state, they can be easily stored and transported without dehydration.

(iv) **Restoration of rosemary willow**. The rosemary willow (*Salix rosmarinifolia var. brachypoda*) can be planted in dense rows that quickly reestablish a favorable substrate that enhances restoration of degraded wetland areas.

(v) **Prolonging viability of cattails**. As a typical wetland species, the cattail, *Typha orientalis*, generally takes 3–4 years before it reaches the period of its most rapid growth. After 6–8 years, it starts to enter a senescent "withering period," during which it grows more slowly, and may die off completely in spring. A method involving treatment of the roots can help prevent the plants from entering the withering phase, and enable a more rapid restoration of cattail wetlands.

High-Tech Applications for Monitoring Migratory Waterfowl

During the implementation of the SPWPP, a number of modern, state-of-the-art technologies were utilized to facilitate monitoring of waterbirds. In Xingkaihu NR, monitoring of migratory bird and breeding habitat by satellite remote sensing was used to record migration patterns. Innovative real-time video monitoring proved invaluable in establishing a baseline and a means of demonstrating progress with work programs. Monitoring of species in Xingkaihu NR was improved through (i) the provision of monitoring equipment and instruction on operation and methodology; (ii) the establishment of permanent monitoring stations, a geographic information system, and a database; and (iii) the development of a monitoring method and manual. At Dajiahe NR, remote-controlled video cameras were used to monitor and record activity and behavior that had never been witnessed before, in the nests of spoonbills. The clear lesson from these experiences is that advanced technologies can greatly enhance the effectiveness of monitoring of waterfowl being carried out by the NRs.

One other technology that has found application in bird monitoring activities, which could also be applied on the Sanjiang Plain, is the use of unmanned aerial vehicles (UAVs), or "drones" (Figure 16). Drones and the cameras that they carry onboard can be remotely controlled by scientists from distances up to several hundred meters. This enables researchers to obtain aerial views of nesting birds that would otherwise be hidden from them (Figure 17) and allows for more accurate counts of resident and migratory species to be performed. An organization known as ConservationDrones.org is promoting a range of conservation uses for drones. The Nature Conservancy has used drones in monitoring populations of Sandhill cranes in California.

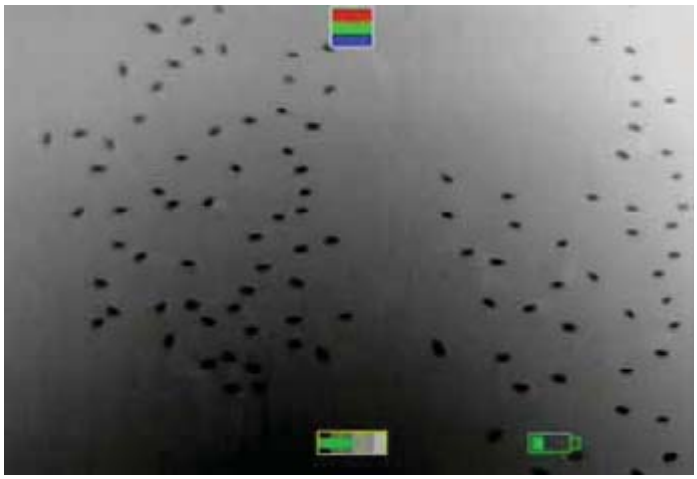
Figure 16: Unmanned Aerial Vehicle for Use in Bird Monitoring

(a) UAV "quad" kit

(b) Preparing a drone for bird monitoring

Source: (a) 3D Robotics website. https://store.3drobotics.com/; (b) Nature Conservancy website—use of drones for monitoring of Sandhill crane populations. blog.nature.org/science/2014/03/06/drones-uav-sandhill-cranes-california-wetlands/

Figure 17: Crane Monitoring Using an Unmanned Aerial Vehicle



This still frame, taken from a video shot at night in infrared light, shows nesting Sandhill cranes in California.

Source: Nature Conservancy website—use of drones for monitoring of Sandhill crane populations. blog.nature.org/science/2014/03/06/drones-uav-sandhill-cranes-california-wetlands/

Costs for purchasing high-quality UAVs have come down dramatically in recent years; depending on the type of camera equipment, the size and power of the unit, and other included features, a drone suitable for use in bird monitoring will cost in the range of several hundred to several thousand dollars.

In addition to the direct advantages of using drones for monitoring of birds, this technology potentially offers other important benefits for NR managers, including early warning capability for detecting brush fires and detection of unauthorized or illegal activities.

Advocacy for Recognition of Wetlands of International Importance

Six NRs in the Sanjiang Plain—Honghe NR, Sanjiang NR, Xingkaihu NR, Qixinghe NR, Dongfanghong NR, and Zhenbaodao NR—already are recognized as Ramsar sites, or Wetlands of International Importance. This status brings with it global recognition of the importance of these sites, especially in terms of their biodiversity significance. With increased recognition, comes the potential to attract greater support—in terms of funding, publicity, and scientific interest—for the conservation of the area. Thus, pursuing the inclusion of a wetland on the list of recognized Ramsar sites can have substantial benefits for improving the management of the site and its resources.

In order to qualify as a Ramsar site, the area must be shown to meet one or more of nine criteria. For example, a wetland that supports 20,000 or more waterbirds, or 1% of the global population of a particular species or subspecies of waterbird, would qualify to be listed as a Ramsar site. These and the other criteria highlight the importance of having good monitoring data, upon which the determination is based. The full Ramsar site criteria are shown in Table 5.

Table 5: Criteria for Identifying Wetlands of International Importance

Group A of the criteria. Sites containing representative, rare, or unique wetland types.
Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
Group B of the criteria. Sites of international importance for conserving biological diversity.
Criteria based on **species and ecological communities**
Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles or provides refuge during adverse conditions.
Specific criteria based on **waterbirds**
Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.
Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.
Specific criteria based on **fish**
Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species, or families; life-history stages; species interactions; and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, a spawning ground, a nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
Specific criteria based on **other taxa**
Criterion 9: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent nonavian animal species.

Source: Ramsar Convention on Wetlands. http://www.ramsar.org/sites/default/files/documents/library/ramsarsites_criteria_eng.pdf

There are 25 NRs in the Sanjiang Plain. Nine of these are national nature reserves (NNRs), while 16 are provincial nature reserves (PNRs). Given the presence of these many important wetland locations, there is ample scope to increase the number of sites in the Sanjiang Plain that might be included on the Ramsar list. Since the requirements for classification of NNRs are more stringent than for PNRs, this might involve two separate paths: (i) NNRs might be directly considered for Ramsar designation and (ii) PNRs might first be elevated to NNR status, before being submitted as potential Ramsar candidate sites.

Using Economic Valuation and Payment for Ecosystem Services as Foundations for Sustainable Financing of Conservation

It is a fact that the wetlands and watersheds of the Sanjiang Plain provide significant ecosystem services values, or ESVs, but that these have been declining over the years, as ecosystems have deteriorated. Well-designed and well-executed *economic valuation studies* are an effective way to highlight the values that ecosystems provide for human populations, many of which may be intangible and "hidden," but nonetheless significant. These ESVs include such elements as access to clean air and water, access to resources for food and other essential commodities, resiliency to climate change, hydrological regulation, moderation of erosion, waste reduction, maintenance of biodiversity, and opportunities for tourism and recreation. Once decision makers become fully aware of the economic importance that these ESVs represent, they are often compelled to put into place measures to protect the ecosystems that provide them.

Similarly, *payment for ecosystem services* is a methodology that has been gaining attention in recent years[52] as a way to effectively compensate the caretakers of natural areas—often the communities living in close proximity to them—for the effort involved or for opportunity costs incurred in maintaining them. For example, by protecting forested areas and keeping them intact, water supplies within watersheds are made more secure. The stewards in the upper watershed areas who protect these forests (instead of cutting trees to sell as lumber) are entitled to receive financial compensation from water users downstream for their efforts.

As explained here, economic valuation studies and payment for ecosystem services schemes are effective tools that can be used to bring much-needed financial and institutional support for the conservation of critical natural areas.

[52] See Q. Zhang et al. 2010. *An Eco-Compensation Policy Framework for the People's Republic of China: Challenges and Opportunities. Mandaluyong City, Philippines: ADB;* Q. Zhang et al. 2010. Payments for Ecological Services and Eco-Compensation: Practices and Innovations in the People's Republic of China. *Proceedings from the International Conference on Payments for Ecological Services, Ningxia Hui Autonomous Region, People's Republic of China.* 6–7 September 2009. Mandaluyong City, Philippines: ADB.

Sustainable Livelihood Opportunities

As discussed earlier (in Section V.A.3), sustainable alternative livelihoods can complement other initiatives that are aimed at improving ecosystem management. Most residents of the Sanjiang Plain depend on a single occupation or crop for their livelihood. If their income streams were diversified, incomes could be raised and the economic resiliency of households would be improved.

State and community farms have been producing the same crops in similar ways for some time. Without proper support and insurance, it is risky to alter their current production patterns even if doing so promises to provide additional income. On-farm demonstration and piloting of alternative production systems; conventional and on-farm demonstrations of alternatives; provision of technical and farmer-to-farmer extension support, in combination with subsidies (e.g., for conservation farming); and insurance to protect against risk would help relieve constraints on investing in sustainable alternatives.

In order to promote a more diversified economic base, and to increase economic resiliency, it is suggested that a comprehensive list of potential sustainable livelihood options be developed. Cost–benefit analyses for existing alternative livelihood activities can help to identify their potential for expansion based on proven return on investment and beneficial impacts in terms of wetlands restoration and conservation.

In the previous section (Section V.A.3), promoting sustainable livelihoods has already been highlighted as a broad guideline for sustainability. In Section V.B., Best Practices: "Options for Action," a number of promising options for environmentally sustainable livelihood alternatives for the Sanjiang Plain have been highlighted. These include ecotourism, agroforestry and production of nontimber forest products (NTFPs), cultivation in greenhouses, handicraft production, fisheries, and composting. All the sustainable livelihood opportunities presented in this report are also included in the list of recommended best practices in Appendix 3.

Sustainable Livelihood Opportunity: Ecotourism

The Sanjiang Plain offers tourists some of the most stunning landscape vistas in the world (Figures 18 and 19). During the peak seasons when large numbers of migratory birds are present, the area becomes a breathtaking natural wonder almost without parallel (Figure 20). Some of the earlier constraints to tourism have been remedied in recent years, with improvement of the Heilongjiang provincial road network and availability of accommodation at a number of NRs that meet the requirements of most tourists. As a result, tourist arrivals have increased substantially. For example, arrivals at Xingkaihu NR and Zhenbaodao NR now total well over one million visitors annually. As tourist arrivals continue to grow, the greater the potential contribution of tourism to the effective management, conservation, and restoration of the Sanjiang Plain wetlands' NRs, and to the area's economy. However, increases in visitor arrivals need to be monitored closely, and due consideration needs to be given to the carrying capacity of area facilities to support the large numbers of tourists visiting the area.

Figures 18–20: Scenic Views of the Sanjiang Plain

Figure 18. Mist rising over the wetlands of Dajiahe NR.
Source: Dajiahe NR.

Figure 19. Zhenbaodao NR in summertime.
Source: Landell-Mills. 2012. *Reviving Lakes and Wetlands: Lessons Learned from the Sanjiang Plain. Sanjiang Plain Wetlands Protection Project: Harbin, China*. Trowbridge, UK.

Figure 20. During the peak of the migration season, large numbers of cranes, storks, and other endangered waterfowl, such as hooded cranes (*Grus monacha*) shown in the figure, can fill the skies over the Sanjiang Plain.
Source: Dajiahe NR.

As demonstrated by activities carried out as part of the SPWPP, ecotourism presents the NRs with options to hire local residents, providing them with alternative livelihoods. Farmlands previously cultivated by the newly employed ecotourism staff can then be returned to the NRs for wetlands restoration, as the jobs created by ecotourism provide former farmers with higher incomes.

The following principles can be applied in ensuring that future ecotourism development in the Sanjiang Plain will grow in a sustainable way:

(i) "Build with nature:" While tourists require adequate facilities for transportation, accommodation, eating, and recreation, the main attraction for ecotourists is nature itself. Structures built within the NRs to provide these services should be designed in a manner that is in harmony with the natural environment, complementing it as much as possible, rather than detracting from it. Several examples of "building with nature" are illustrated in Figure 21.

(ii) Involve local communities and nongovernment organizations in helping to design, plan for, and participate in ecotourism activities, building up the local constituency in support of local environmental conservation. Ensure that adequate guidance is provided to build the capacity, knowledge, and skills of local residents, so that they can serve as effective ecotourism service providers.

(iii) Make the local culture and area history a part of ecotourism: involve local people and elders to explain and demonstrate local culture and history for tourists.

(iv) Augment income-earning opportunities for local communities by enabling residents to sell local products, screened to ensure high quality standards, on site. Provide handicrafts instruction to local communities to enable them increase the range of products available for sale.

(v) Ensure that sewage and waste disposal capacity for hotels and other tourism facilities are adequate for preventing negative environmental impacts. Facilitate waste recycling and utilize renewable energy sources.

(vi) Ensure sufficient investment in nature interpretive facilities so that visitors can learn in detail about the area's ecology and its wildlife. Include visual aids and activities that will be of interest to children.

(vii) Provide tour operators with environmental awareness brochures that include "dos and don'ts for tourists," helping both tour operators and tourists to be better informed prior to their arrival at the site. In addition to simple brochures, the preparation of a more detailed ecotourism manual, designed for use primarily by NR managers, could help ensure consistency in ecotourism operations and standards throughout the NRs of the Sanjiang Plain. Such a manual could serve as a valuable guide to accepted ecotourism procedures and best practices for managers of the Sanjiang Plain wetlands' NRs.

(viii) Provide well-marked paths and "hides" within NRs. Limit numbers of visitors and access to sensitive areas as may be required to prevent damage to the environment and negative impacts on plants and animals.

(ix) Monitor the impacts of tourism on the site, and adapt management guidelines as required based on monitoring feedback.

Figure 21: Examples of "Building with Nature"

The examples shown here illustrate harmonious design of constructed facilities at various wetland parks and reserves from around the world

a. Suncheon Wetlands, Republic of Korea

b. Great Fen Visitor Center, UK

c. Green Cay Wetlands, USA

d. Wetland boardwalk, Qixinghe nature reserve, Sanjiang Plain, People's Republic of China

e. Main building, Sun Island Nature Park Wetland Center, Harbin, People's Republic of China

f. Raised walkway and interpretive signage, Sungei Buloh Wetland Park, Singapore

Sources:

a. Suncheon: Inhabitat website: Suncheon Wetland Visitor Center; http://inhabitat.com/green-roofed-suncheon-wetlands-center-flows-with-the-tides/suncheon-wetland-visitor-center-egg_38042/
b. Green Cay: South Florida Green News: Green Cay Nature Center and Wetlands; http://southfloridagreennews.com/author/ellen-mee/
c. Great Fen: detail-online blog: Great Fen Visitor Centre; http://www.detail-online.com/blog-article/great-fen-visitor-centre-uk-by-cmjn-24897/
d. Qixinghe: James T. Berdach.
e. Sun Island: James T. Berdach.
f. Sungei Buloh: James T. Berdach

Sustainable Livelihood Opportunity: Agroforestry and Nontimber Forest Products

The various interfaces created by the juxtaposition of natural and plantation forests and farmlands create different habitats for a range of plant species, which can be intercropped in and around these forests. By doing so, an area's biological diversity is increased, while economically valuable species provide incentives for communities to protect forests, as local people benefit financially from the intercrops.

Otherwise known as *agroforestry*, tree–crop mixtures and mosaics provide additional income, improve food security (e.g., fruit, nut, medicinal plant, and edible oil production), and produce fuelwood and construction materials, while reducing deforestation and helping to stabilize soil and water resources. Agroforestry helps to buffer against the expected impacts of climate change by increasing the diversity and thereby the resilience of agricultural landscapes. Many trees and crops in agroforestry systems are multipurpose, providing a range of the aforementioned benefits.[53]

Several types of agroforestry systems were promoted and supported by the SPWPP, and these could be replicated elsewhere in the Sanjiang Plain. They include intercropping of medicinal herbs, field crops, grape vines and other berries and fruits in forest openings and on young plantations, as well as beekeeping and mushroom cultivation.

Cultivation of high-value NTFPs, including traditional Chinese medicinal herbs and fungi, offers opportunities for generating higher incomes for farm households on relatively smaller parcels of land, when compared with the cultivation of conventional grain crops. This would enable farmers to release a portion of their lands for rehabilitation of wetlands.

The PRC has a long history of cultivating NTFPs on farms. Among the most common of these are medicinal herbs and fungi. Because of its extensive phyto-pharmacopoeia, in-depth traditional knowledge, and long history of growing medicinal herbs, the country enjoys a distinct comparative market advantage.[54]

In 2010, the annual output value of traditional Chinese medicine was more than $50 billion, and this is expected to rise to nearly $150 billion by 2025.[55] The total size of the current global market for medicinal and cosmetic herbs has been estimated to already exceed $62 billion. Production of materials for use in natural cosmetics holds even greater potential, with the current value of worldwide cosmetics forecast to total an additional $265 billion by 2017.[56]

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53 Secretariat of the Convention on Biological Diversity. 2009. *Sustainable Forest Management, Biodiversity and Livelihoods: A Good Practice Guide*. Montreal, Canada: SCBD.

54 See, for example: Institute of Chinese Materia Medica. 1997. Medicinal Plants in China: A Selection of 150 Commonly Used Species. *WHO Regional Publications, Western Pacific Series No. 2: China Academy of Traditional Medicine*. Geneva, Switzerland: World Health Organization.

55 360° Consultancy, Helmut Kaiser Consultancy, China Kaiser Consultancy; http://www.hkc22.com/ChineseMedicine.html

56 Michelle Yeomans, 7 November 2012. "Global beauty market to reach 265 billion in 2017 due to an increase in GDP". http://www.cosmeticsdesign.com/Market-Trends/Global-beauty-market-to-reach-265-billion-in-2017-due-to-an-increase-in-GDP

While the existing market is already considerable and is growing rapidly, increasing awareness throughout most parts of the world of the potential dangers and side effects of synthetic pharmaceuticals and chemically based cosmetic preparations is driving an ongoing shift to the use of phytoherbal preparations for preventive medicines and cosmetics. With increasing global demand, prices are increasing accordingly. In 2010, for example, prices of certain bulk raw materials (such as dried leaves, flowers, roots, and barks) increased by as much as a factor of 3 within a single year.[57] As these trends continue, it is forecast that markets for medicinal and cosmetic formulas based on natural phytoherbals could reach as high as $5 trillion by 2050.[58,59]

The present medicinal and cosmetic herb and plants market is essentially a "sellers' market," with decreasing supply and increasing demand. But it is currently the middlemen—vendors, traders, and exporters—who get increasingly more of the profits compared with the farmer-producers. This is mainly because of the poorly developed sorting, grading, packaging, and marketing skills of rural producers. Better marketing skills, market information systems, and processing and packaging technologies could change this, enabling rural communities to capitalize on these significant market opportunities.[60]

For the reasons explained above, careful selection of high-value NTFPs with established market demand could provide high returns to farmers in the Sanjiang Plain, while reducing pressures on land and water resources. The strategy is promoted in the PRC's National Biodiversity Action Plan (2011–2030) through its call for the "introduction and domestication of rare and endangered wild medicinal species and development of alternatives."[61]

Sustainable Livelihood Opportunity: Ecogreenhouses

Ecologically managed greenhouses or "ecogreenhouses" utilize a variety of environment-friendly management techniques to maximize crop production while minimizing adverse environmental impacts. Ecogreenhouse production techniques include (i) integrated or biological pest management reducing or eliminating the use of chemical pesticides, (ii) organic fertility management or minimization of chemical fertility inputs, (iii) composting of crop residues or using them as biofuel, (iv) use of biofuel for greenhouse heating, (v) use of solar power to operate greenhouse ventilation systems, (vi) water conservation and water recycling, and, from a broader land-use perspective, (vii) reduction

[57] American Botanical Council. 2011. http://cms.herbalgram.org/heg/volume8/02February/TCMpricesrising.html?t=1296580896

[58] J. D. H. Lambert, P. A. Ryden, and E. E. Esikuri. 2005. *Capitalizing on the Bio-Economic Value of Multi-Purpose Medicinal Plants for the Rehabilitation of Drylands in Sub-Saharan Africa*. Global Environment Facility Program. Washington, DC: World Bank.

[59] Government of India, Ministry of Science and Technology, Department of Scientific and Industrial Research. http://www.dsir.gov.in/reports/ittp_tedo/ism/ISM_AS_Market.pdf; http://www.cosmeticsdesign.com/Market-Trends/Global-beauty-market-to-reach-265-billion-in-2017-due-to-an-increase-in-GDP

[60] J. D. H. Lambert, P. A. Ryden, and E. E. Esikuri. 2005. *Capitalizing on the Bio-Economic Value of Multi-Purpose Medicinal Plants for the Rehabilitation of Drylands in Sub-Saharan Africa*. Global Environment Facility Program. World Bank, Washington, DC.

[61] Refer to Ministry of Environmental Protection (MEP). 2010. *China National Biodiversity Conservation Strategy and Action Plan (2011–2030)*. Beijing; Ministry of Environmental Protection (MEP). 2010. China National Biodiversity Conservation Strategy and Action Plan (2011–2030): p. 48. Beijing. Project 31, "Introduction and domestication of rare and endangered wild medical species and development of alternatives."

of cultivated area based on higher unit area production from ecogreenhouses, enabling rehabilitation and restoration of natural ecosystems on abandoned fields.

The development of ecogreenhouses during implementation of the SPWPP proved to be highly successful both for improving farmers' incomes and releasing former wetland areas for restoration. There remains considerable potential to expand and build upon the initial success of the ecogreenhouse strategy, and to capitalize on its proven capacity to increase agricultural income per unit area of land, enabling restoration of much larger areas of the Sanjiang Plain wetlands to functional natural habitat for waterfowl and other biodiversity.

Other state-of-the-art horticultural practices can be incorporated, together with greenhouse culture, to enhance revenue and ensure environmental sustainability. Currently, there is growing awareness among Chinese consumers about the dangers of pesticides and the comparative health benefits of organically grown food. As part of the possible expanded use of greenhouses, organic production methods, such as integrated pest management (biological pest control) and organic fertilizers could be employed. In addition, soilless hydroponic farming could also increase productivity and profitability of greenhouse cultivation (Figure 22).[62]

Figure 22: Hydroponic Cultivation in Greenhouses

Hydroponic tomato production in greenhouses. The vegetables are grown in a soil-less environment. Aerated re-circulated water can be injected with liquid organic fertilizers produced on-farm, reducing production costs and increasing profitability.

Photo: Agratech Greenhouses http://www.agratech.com/gallery-commercial-greenhouse-manufacturer.html

[62] More information on hydroponic greenhouse farming is available at Diver, Steve: http://www.agrisk.umn.edu/cache/arl01481.htm, http://www.hydroponics.com.au/issue-98-greenhouse-production-in-japan/, http://www.extension.umn.edu/rsdp/community-and-local-food/production-resources/docs/cold-climate-greenhouse-resource.pdf, http://extension.umass.edu/floriculture/fact-sheets/hydroponic-greenhouse-production-resources

Sustainable Livelihood Opportunity: Value Adding through Postharvest Processing, Branding, and Certification

Several major strategies are available, by which the market value of products from the Sanjiang Plain could be boosted substantially. Three of these strategies are **postharvest processing**, **branding,** and **certification**. Since the products from the Sanjiang Plain are primarily based on agriculture or natural resources, the higher the unit value of the goods being produced, the lesser the land and resources required for production. Overall, this leads to production streams that are more ecofriendly, and thus, more sustainable. Each of these strategies is discussed briefly in the following sections.

Value Adding: Postharvest Processing

There is a diverse range of agricultural products already being produced, along with others that could be produced in the Sanjiang Plain wetlands and environs, including (among others) grains, a wide variety of fruits, vegetables, berries, and mushrooms. While some processing of these products is already taking place, considerable scope remains for adding further value, particularly through postharvest processing. Among the options for various products to be considered are canned and frozen juices, extracts, concentrates, purees, dried and sugar-coated or salted and preserved fruits and vegetables, pulps, jams, and confections.

Development of value-added products for the Sanjiang Plain would require instruction and capacity building, as well as development of appropriate infrastructure. Although there have been some recent improvements in transportation systems,[63] long distances still hinder access to many urban markets, especially those outside Heilongjiang Province. Cold storage, cold transport, and processing facilities are currently limited. Development of such facilities would reduce constraints on production of high-value perishable products. Targeted subsidies, preferential loans, and tax reductions would provide a stimulus for the development of improved facilities.

Value Adding: Branding

Branding is a process whereby a link is established that enables a particular brand (name of product) to be associated with higher quality, thus leading to higher volume sales, or justifying higher pricing (or both). One clear example of branding is in the organic foods market. In the PRC, this market is relatively new, but growing rapidly. A steadily increasing number of people worldwide, including in Asia and in the PRC, are becoming aware of the comparative health benefits of organically grown foods. Many of them are more willing to accept the additional cost of buying organic products, in order to avoid the potential risks posed by foods that could be tainted with toxic chemical.

Organic foods normally command a price premium of around 33%, compared with the ones that have been produced conventionally using chemical fertilizers and pesticides. In other

[63] Projects are already underway to improve transport linkages within Heilongjiang Province, and between Heilongjiang Province and the rest of the PRC. http://www.worldbank.org/projects/P133114/heilongjiang-cold-weather-smart-public-transportation-system?lang=en; http://www.adb.org/news/200-million-loan-help-improve-heilongjiang-provincial-highway-prc

words, successful organic farmers can generate the same level of profit from a reduced area of land, and with less costly inputs (fertilizers, insecticides).

With continuing economic growth, the market for organically produced agricultural products in the PRC is also likely to continue to expand, as more people can afford to buy these products.[64] While some organic produce is already being grown in Heilongjiang Province, demand is outpacing supply, creating potential for the successful expansion of organic production of virtually all of the crops being grown, including rice.

Another interesting example of branding relies on the labeling of food products as being "locally produced" or originating from specific, well-known production locations. Both in the perception of consumers, and in reality, locally produced foods have the potential of being fresher (and thus healthier) than foods shipped from great distances, and the sale of locally produced goods supports the local economy. In other cases, foods from particular localities are recognized to be more nutritious, or better tasting (e.g., French wine). Many consumers prefer to purchase such products, as they feel confident about the high quality of products that they are buying.

One specific example of location-based branding for the Sanjiang Plain is that of "Heilongjiang rice." Heilongjiang rice is already well-known throughout the PRC for its high quality. Its popularity with consumers increased markedly in 2013 after rice from the southern provinces was found to be tainted with high levels of the toxic heavy metal cadmium. While the demand for Thai rice increased in the aftermath of this incident, this demand was somewhat limited because of the fact that Thai rice can cost as much as nine times the price of local rice. However, in response to the tainted-rice scare, in May 2013, the price of Heilongjiang rice also rose by 2.6% in a single month.[65]

The province has not yet capitalized on the full potential of special branding of its well-known rice, nor on the potential for producing a range of rice-based products which could be similarly marketed, including, rice bran oil, rice noodles, rice cakes, puffed rice and rice crackers, rice milk, rice vinegar, and rice wine. There is also a growing market for unpolished brown rice among an increasing number of health-conscious consumers, as well as for rice-based cosmetics.[66]

Cumulatively, all these products could add significant value to rice production in Heilongjiang, and increase the economic output per unit area of farmland.

Value Adding: "Green Marketing" and Eco-Certification

In the recent decades, there has been a growing awareness among consumers of the importance of the environment for public health, and the overall future quality of life, both for local communities and the extended "global community." Alongside this growing

[64] See for example, Little, Amanda. 31 July 2014. "Building the Whole Foods of China." Bloomberg Business website. http://www.businessweek.com/articles/2014-07-31/tonys-farm-organic-food-provider-to-chinas-elite

[65] Bloomberg News. 2013. "Cadmium scare boosts appeal of North China rice, Thai imports." 27 May. http://www.bloomberg.com/news/2013-05-27/cadmium-scare-boosts-appeal-of-north-china-rice-thai-imports.html

[66] For example, soap, shampoo, hair conditioner, and skin cream.

awareness, there has been a concurrent increase in the number and value of products that are marketed as contributing in some way to environmental conservation. As such, these products are following a "green marketing" approach.

Green marketing could be applied as a strategy for improving the value of various products from the Sanjiang Plain. A product labeling and ecocertification system could be developed that has as its focus conservation of the Sanjiang Plain wetlands, whereby sales of eco-certified products would contribute to conserving the wetland environment. Eco-certification logos could be used to identify products and programs that are verified to be "ecofriendly" (examples are shown in Figure 23).

Labeling for the eco-certification program might also convey a message similar to the following:

> The majestic Sanjiang Plain wetlands provide northeast PRC with critical protection from droughts and floods and assure stable water supplies for

Figure 23: Eco-Certification Labels

Logos such as these, for several well-known certification programs, are displayed on products, or advertise services that indicate to consumers that the products or programs contribute to environmental conservation.

Source: Eco-certification images: https://www.google.com/search?q=eco+certification&sa=X&biw=1366&bih=657&tbm=isch&tbo=u&source=univ&ved=0CC0QsARqFQoTCNu2xJPU8cYCFQTVgAod3uIF5w

> 5% of PRC's agricultural production and 10% of our population. The plain is home to a large number of endangered migratory waterbird species, and even the world's last remaining Siberian tigers. Your purchase of this product will contribute directly to efforts aimed at restoring and conserving this exceptional natural heritage, which is important not only to PRC but to the entire world. Ten percent of the profit from the sale of this product will be used to support environmental conservation projects in the Sanjiang Plain.

This strategy could be linked to various products, for which potential scenarios have been outlined in other sections of this report.

The key to success of the eco-certification scheme is to establish the trustworthiness of the brand. This would require (i) agreement on the standards for products to be considered as having been produced in an environmentally sustainable manner (e.g., which contribute to conserving the Sanjiang Plain wetlands ecology); and (ii) implementation of a monitoring system, employing third-party inspectors, to ensure impartiality in verifying if production methods and quality conform to the standards that have been established for the product.[67]

Sustainable Livelihood Opportunity: Handicrafts

The likelihood of continued increases in tourist arrivals to the Sanjiang Plain creates opportunities to increase economic benefits to local communities through production and sale of handicrafts. The quality and diversity of handicrafts presently produced within the Sanjiang Plain communities is limited. By increasing the incomes of farm families through handicraft production and sales, reliance on field agriculture as a sole income stream would be reduced, and could facilitate conversion of farm lands back to wetlands.

In Baiyangdian Lake in Hebei Province, local households are actively involved in producing "reed paintings" made out of the reeds growing in the wetlands (Figure 24). This is but one of many examples of products that could also be developed in the Sanjiang Plain. As long as the raw materials for handicraft production are harvested in a sustainable manner, this can create "win–win" opportunities that could support both economic growth and environmental sustainability.

Sustainable Livelihood Opportunity: Fisheries/Aquaculture/ Recreational Fishing Management

Besides supporting large numbers of migratory waterfowl, the wetlands of the Sanjiang Plain provide habitat for 80 native species of fish.[68] Overfishing, however, caused fish catches

[67] For examples of certification programs and guidelines, see: http://www.rainforest-alliance.org/forestry/documents/ntfp-addendum-generic-guidelines.pdf and http://www.sureharvest.com/product/4/Protected_Harvest.html

[68] H.-Y. Liu, X.-G. Lu, and Z.-Q. Liu. 2000. Landscape Planning and Ecology Construction of Wetland Comprehensive Protected Area System in the Sanjiang Plain. *Journal of Environmental Sciences*. 12 (3). pp. 361–366.

Figure 24: Reed Paintings from Baiyangdian Lake, PRC

Source: James T. Berdach.

to decline dramatically between 1960 and 1970, from 22,000 tons to only 3,200 tons, including 1,100 tons accounted for by aquaculture.[69]

Current fish populations and catch levels seem to have leveled off,[70] although additional monitoring and research are required to scientifically determine how best to improve the overall management of the freshwater fishery of the Sanjiang Plain to optimize and sustain its productivity.

The environment of the Sanjiang Plain wetlands presents considerable potential for increasing small- and medium-size aquaculture of native fish species as a way to increase annual economic output.[71] Fish resources could also be utilized for recreational fishing.

Sustainable Livelihood Opportunity: Composting

The PRC is plagued by severe air pollution, most of which originates from industrial and coal-fired power plant emissions, and from vehicle emissions in urban areas. While industrial air pollution in Heilongjiang Province is much less serious than in other parts of the country, widespread burning of rice stubble and agricultural wastes in Heilongjiang regularly causes serious air quality problems.

[69] X. Liu et al. (n.d.). *The Wetlands of Heilongjiang Province, North-East China. United Nations University website.* http://archive.unu.edu/unupress/unupbooks/80349e/80349E06.htm

[70] With the possible exception of chum salmon and huso sturgeon. Personal communication, Gao Ruirui, Project Director, Green Longjiang (NGO), Harbin. November 2014.

[71] However, extreme caution must be exercised in introducing nonnative fish species into the ecosystem. See, for example: R. I. Arthur et al. 2010. Assessing Impacts of Introduced Aquaculture Species on Native Fish Communities: Nile Tilapia and Major Carps in SE Asian Freshwaters. *Aquaculture*. 299. pp. 81–88.

Agricultural wastes, in addition to being used for biomass energy production, can be composted and used for organic crop production or bagged as garden compost marketed through farm and nursery suppliers. Creating a demand for these raw materials by developing the capacity of garden compost production in the Sanjiang Plain would reduce the amount of rice straw and other crop residues being burned, thereby reducing air pollution. Similarly, processing of livestock manure could also significantly reduce waste materials left to wash into wetland areas, resulting in reduced pollution of groundwater and surface waters.

Capacity Development: A Prerequisite for Sustainable Livelihood Introduction in the Sanjiang Plain

A key element of support for developing new livelihood opportunities in the Sanjiang Plain will relate to building the capacity of farmers and other local stakeholders to adopt new livelihoods. Skills development and capacity building will contribute to the potential for various alternative livelihood initiatives to be successfully implemented. In Table 6, a range of capacity-building activities are presented. These activities should also include peer-to-peer mentorship programs, so that the knowledge, skills, and capabilities being transferred can be disseminated to a broader audience, over a longer (sustained) timeframe.

Table 6. Suggested Educational and Capacity-Building Activities for Sustainable Livelihoods in the Sanjiang Plain

Subject Area/Topic	Purpose	Methods to Be Applied	Participants
Participatory needs, opportunities, and constraints assessment for alternative eco-livelihoods	Provide methods enabling survey, assessment, and selection of ecologically sound and potentially successful income generating alternatives.	Classroom sessions on the underlying rationale and methods for conducting participatory livelihood opportunities assessment Practical training in the field using the methods which have been taught	Township staff, reserve staff, farmer, and local occupational group leaders
Meaning of "eco-livelihoods" and their contribution to integrated conservation and development	Clearly understand: Which alternative livelihood options are ecologically sound, which are not, and why? How will various eco-livelihoods contribute directly or indirectly to sustainable environmental management and wetlands restoration?	Classroom sessions Local field study and participant evaluation of lessons learned Study tours	Provincial staff, municipality staff, township staff, reserve staff, farmer, and local occupational group leaders
Technical instruction for selected alternative livelihoods options	Provide interested potential adopters of the various selected alternative livelihoods options with the skills required to implement them successfully.	Classroom sessions Field visits to learn about ecologically sound livelihoods and how they contribute to Sanjiang Plain's conservation and rehabilitation objectives, as well as to livelihoods which are antithetical to achieving these objectives	Alternative livelihoods extension personnel. Persons interested in adopting the various alternatives

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Table 6 *continued*

Subject Area/Topic	Purpose	Methods to Be Applied	Participants
Agro- and community forestry and nontimber forest products (NTFPs)	Review the environmental and economic benefits of tree planting and various methods to realize these benefits, including intercropping with trees, and on-farm cultivation of high-value NTFPs.	Classroom sessions on key principles and best practices Presentations by best practice agroforestry and NTFP projects in similar ecozones in the People's Republic of China Learning visits to best practice sites	Provincial staff, municipality staff, township staff, reserve staff, and farmer leaders
Ecogreenhouse agriculture	Capacity building on advances in ecogreenhouse agriculture, including solar heating and water heating for hydroponic vegetable production in cold climates, state-of-the art organic production, production and use of organic fertilizers/pesticides, integrated and biological pest management.	Classroom sessions Presentations by ecogreenhouse managers. Field learning visits to best practice sites	Provincial staff, municipality staff, township staff, reserve staff, and farmer leaders
Living softly on Earth: eco-alternatives for sustainable agriculture in ecologically sensitive areas	Introduce alternatives to high input chemical-intensive crop production, including organic meat, poultry, fish, and crop production.	Classroom sessions Interactive discussions Field visits to best practice sites Presentations and demonstrations by subject matter specialists	Provincial staff, municipality staff, township staff, reserve staff, and farmer leaders
Crafts production and handicraft raw materials production	Enable interested craftspeople to produce raw handicraft materials, diversify local crafts production, and improve product quality and marketing.	Classroom sessions on handicraft and raw materials production Hands-on training by production specialists Session on product marketing	Residents in and around nature reserves
Monitoring and evaluation for adaptive management	Enable systematic progress monitoring of developing livelihoods alternatives, problem identification and problem solving, to improve the success potential of new initiatives. Identify factors contributing for effective scaling up.	Classroom sessions Hands-on practice	Provincial staff, municipality staff, township staff, reserve staff, and farmer leaders
Ensuring benefits for disadvantaged groups	Impart knowledge, skills, and behaviors which will help ensure that disadvantaged groups, including women, the poor, and ethnic minorities, can be specially targeted to ensure that livelihood development activities are tailored to their needs and interests.	Classroom sessions Infield practical application of methods learned in the classroom	Provincial staff, municipality staff, township staff, reserve staff, women's federation, youth federation, ethnic minorities federation, federation of the elderly, and farmer leaders
Networking	Enhance potential for networking among farmers, farmers groups, and stakeholder organizations, enhancing potential for information sharing and collaboration, contributing thereby to improved livelihood development and environmental conservation outcomes.	Lessons learned from successful stakeholder engagement and networking Effective networking methods Creating and implementing an effective networking plan Hands-on network planning	Provincial, municipal and township staff, nature reserve staff, local farmer leaders, nongovernment organizations, and other civil society organization representatives

VI. Conclusions

The Sanjiang Plain will continue to provide indispensable contributions to agricultural output in Heilongjiang Province, and to the food security of all of the People's Republic of China. For this reason, large-scale restoration of the Sanjiang Plain wetlands to their original ecological state is unlikely in the foreseeable future. But careful identification of the most sensitive ecological areas through scientific means, and restoration of these "hotspots," will enhance critical habitats and can improve ecosystem connectivity within biodiversity corridors. This will have a significant positive impact on the overall ecological profile of the Sanjiang Plain wetlands and the capacity of the wetlands to provide a host of vital ecological services.

The previous project, the Sanjiang Plain Wetland Protection Project, had many notable successes. These successes were made possible through extensive capacity building and educational programs, which gave practitioners the knowledge and tools needed to address and progressively resolve many of the issues threatening the sustainability of the wetlands and nature reserves (NRs).

However, the project activities were confined to just six of the 24 NRs within the Sanjiang Plain. Thus, there is clear scope to expand and replicate the successful actions of the past project, to the other NRs. In addition, more attention needs to be paid to interventions that address issues outside the NRs, in the broader watershed. By doing so, potential adverse impacts that originate outside the NRs, but which nonetheless affect the sensitive wetlands within the NRs, could be avoided or minimized.

This knowledge product has provided background to inform readers about the history of environmental change on the Sanjiang Plain. More importantly, it has identified the key lessons learned from the past Sanjiang Plain Wetland Protection Project that could be applied for more effective management of wetlands in the future. And perhaps, most important of all, the knowledge product has also presented a set of detailed recommendations—key guiding principles and a range of novel best practices, or "options for action"—that could further strengthen efforts for conserving, protecting, restoring, and managing the Sanjiang Plain wetlands and their attendant biodiversity resources in the future.

Among the main *sustainability guidelines* that will be essential for successfully integrating wetlands conservation initiatives and sustainable economic development in the Sanjiang Plain are the following: (i) applying a precautionary approach; (ii) adopting ecosystem-based management and integrated water resources management as a means for coordinating management across multiple sectors, throughout the entire watershed,

especially taking into consideration how upstream action can cause impacts that are felt in the wetlands downstream; (iii) promoting sustainable livelihoods; (iv) using participatory planning methods, that give a wide range of stakeholders a voice in planning and decision making, and tapping local community stakeholders to participate in comanagement during implementation; and (v) maintaining a strong program of awareness raising, education, and capacity building.

Specific "options for action" that have been identified for application in the Sanjiang Plain include the following: (i) strengthening water quality monitoring and improvement plans, (ii) improving land management and other practices related to plantation forestry, (iii) applying environmental principles in farming; (iv) developing comprehensive management plans to guide the operations of NRs; (v) identifying ecological hotspots and establishing biodiversity corridors and NR networks, (vi) improving waterfowl habitat, (vii) improving wetland restoration results, (viii) applying new technologies to improve monitoring of waterbirds, (ix) supporting applications for wetland sites to be classified as Ramsar Wetlands of International Importance, (x) using economic valuation studies and payment for ecosystem services schemes as tools to provide institutional support and sustainable financing for conservation initiatives, and (xi) supporting development of a wide range of sustainable livelihood options.

The promotion of alternative livelihood options is especially important, since the livelihoods of the large majority of farmers and others living on the Sanjiang Plain are inextricably linked to the land. By reducing the amount of land required to support households who currently depend on farming relatively large land areas, more land could be freed up for reconversion back to natural wetland habitat. The specific opportunities for fully capitalizing on the potential for developing new livelihood alternatives have been discussed in detail in this report.

Given the global significance of the biodiversity and all living resources that depend on the wetlands of the Sanjiang Plain for their survival, and the critical ecological services that they provide, further support is needed and should be made available by the government, the private sector, the civil society, and the development partners for the continued protection and sustainable management of these vital ecosystems. It is envisioned that providing such support can produce a "win–win" result, whereby the vital natural functions of wetland areas are protected, while at the same time, priority economic development objectives are achieved in an environmentally sustainable manner.

APPENDIX 1
Nature Reserves of the Sanjiang Plain

No.	Name of Nature Reserve	Location	Area (ha)	General Site Description and Conservation Target	Level	Year Approved	Management Authority
1	Bachadao NNR	Tongjiang City	32,014	Wetland ecosystem and rare wildlife	NNR	1 October 1999	Environmental protection authority
2	Sanjiang NNR	Fuyuan County	198,089	Wetlands consist of a mixture of rivers, open bogs, seasonally flooded meadows, and sedge marshes, the largest area of freshwater wetland in the country; site is internationally important for waterbirds, including endangered *Ciconia boyciana, Mergus squamatus,* and *Anser cygnoides*; important habitat and breeding area for several commercial fish species and serves as a natural reservoir for the Sanjiang Plain, providing vital flood control. (listed as Ramsar site No.1152 in 2002)	NNR	19 September 1994	Forestry authority
3	Honghe NNR	Tongjiang City	21,835	Marsh ecosystem with a large variety of wetland types, providing support for six endangered and rare species of flora and three species of avifauna; main breeding site for the oriental stork (*Ciconia ciconia*), with 200 individuals in autumn, as well as black stork, red-crowned and white-napped cranes, whooper swan, and mandarin duck; overuse of groundwater and intensive agriculture are viewed as potential threats. (listed as Ramsar site No. 1149 in 2002)	NNR	11 January 1988	Environmental protection authority
4	Naolihe NNR	Fujin City, Raohe County	160,595	Wetland and aquatic ecosystems formed with aquatic and terrestrial life and their habitats	NNR	4 December 1998	Environmental protection authority
5	Sanhuanpao NNR	Fujin City	25,075	Wetland ecosystem and red-crowned crane, swan, and *Cinnamomum brevipedunculatum*	NNR	1 July 1997	Other

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Appendix 1 Table *continued*

No.	Name of Nature Reserve	Location	Area (ha)	General Site Description and Conservation Target	Level	Year Approved	Management Authority
6	Qixinghe NNR	Baoqing County	20,000	Representative of the inland freshwater marsh type in Northeast Asia; recognized as one of the best preserved natural wetland areas in the People's Republic of China; large-scale reed marshes are among the most important in the Sanjiang Plain and have remarkable abilities of water storage and flood control; site supports 29 threatened species of which three are mammals and 26 are birds, such as siberian crane, oriental stork, red-crowned crane, scaly-sided merganser, and baer's Pochard; wetland habitat supports 388 plant species, 201 birds (including 80 waterbirds), 35 mammals, 10 amphibians and reptiles, and 18 fish species. More than 1% of the population of nine waterbirds species is present at the site. (listed as Ramsar site No. 1977 in 2011)	NNR	17 October 1991	Environmental protection authority
7	Dongfanghong NNR	Hulin City	31,516	Natural freshwater marshland ecosystem; habitat supports critically endangered baer's pochard *Aythya baeri*, endangered oriental stork *Ciconia boyciana* and *tiger panthera tigris*. (listed as Ramsar site No. 2185 in 2013)	NNR	19 April 2005	Forestry authority
8	Zhenbaodao NNR	Hulin City	44,364	Site supports a diversity of freshwater wetland types, mainly river and floodplain wetlands, as well as permanent and seasonal freshwater marshes/pools, herb marshes, shrub marshes, and forest marshes; 13 threatened species found here, of which 8 are birds and 5 are mammals; total of 393 plant species, 171 birds, 61 fish, 16 amphibians and reptiles, and 40 mammals; site supports more than 100,000 individuals and more than 1% of the population of 12 waterbird species; beautiful landscapes of the Ussuri River and diverse wetlands offer great potential value for ecotourism. (listed as Ramsar site No. 1978 in 2011)	NNR	15 April 2002	Forestry authority

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Appendix 1 Table *continued*

No.	Name of Nature Reserve	Location	Area (ha)	General Site Description and Conservation Target	Level	Year Approved	Management Authority
9	Xingkai Lake NNR	Mishan City	222,488	Site is a UNESCO biosphere reserve, with a complex wetland system, including grassland, marshes, lakes, and forests; situated at the northern end of the large lake, provides important breeding habitat for a number of globally threatened species, including the endangered *Grus japonensis*, and some 65 fish species and more than 460 higher plant species; typically approximately 1,200 cranes of five species stop over annually at the site during spring migration; transboundary nature reserve agreement (including joint training) established in 1992 with the Khanka Nature Reserve in Russia. (listed as a Ramsar site No. 1155 in 2002)	NNR	5 April 1986	Forestry authority
10	Heixiazidao NNR	Fuyuan County	12,417	Wetland ecosystem, rare and endangered plants and animals	NNR	Not available	
11	Qindeli PNR	Tongjiang City	36,663	Amur sturgeon, Darcy's kaluga, rare fish and their habitat	PNR	4 December 1998	Environmental protection authority
12	Ussuri River PNR	Fuyuan County	39,668	Inland wetland ecosystem	PNR	2001	Environmental protection authority
13	Xilinhe PNR	Hegang City	20,617	Forest and wetland ecosystems, rare animals	PNR	2 September 2004	Forestry authority
14	Heilongjiang shuilian PNR	Luobei County	8,952	Inland wetland ecosystem	PNR	16 September 2003	Environmental protection authority
15	Shuibin Liangjiang PNR	Hegang City	55,490	Inland wetland ecosystem	PNR	8 June 2007	Forestry authority
16	Duluhe PNR	Luobei County	199,673	Wetland ecosystem, red-crowned cranes, and erne	PNR	1 August 2000	Forestry authority
17	Fujin Yanjiang PNR	Fujin City	26,336	Inland wetland ecosystem and rare waterfowl	PNR	12 May 2008	Other
18	Huachuan Songhuajiang PNR	Huachuan County	26,119	Inland wetland ecosystem and rare waterfowl	PNR	1 September 2004	Other
19	Heiyupao PNR	Tangyuan County	22,401	Wetland ecosystem and rare waterfowl	PNR	8 June 2007	Forestry authority
20	Anbanghe PNR	Jixian County	10,295	Inland wetland, aquatic ecosystems, and rare waterfowl	PNR	1 March 1993	Other

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Appendix 1 Table *continued*

No.	Name of Nature Reserve	Location	Area (ha)	General Site Description and Conservation Target	Level	Year Approved	Management Authority
21	Jiamusi Yanjiang PNR	Jiamusi City	11,267	Wetland ecosystem and rare waterfowl	PNR	13 August 2007	Forestry authority
22	Dajiahe PNR	Raohe County	72,604	Natural ecosystem, inland wetland, aquatic ecosystems, rare wild animals and plants	PNR	1 September 2004	Other
23	Dongsheng PNR	Baoqing County	19,244	Inland wetland and aquatic ecosystems	PNR	1 September 2004	Other
24	Wokenhe PNR	Qitaihe City	7,363	Wetland ecosystem	PNR	23 December 2011	Forestry authority
25	Hukou PNR	Hulin City	15,000	Inland wetland ecosystem	PNR	4 February 1997	Forestry authority

ha = hectare, NNR = national nature reserve, PNR = provincial nature reserve.

APPENDIX 2
Globally Threatened Species at Six Nature Reserves in the Sanjiang Plain

Globally threatened species recorded at six nature reserves (SPWPP sites), listed by IUCN Red List category (yellow indicates waterfowl)

Common Name	Scientific Name	Anbanghe	Dajiahe	Naolihe	Qixing he	Xingkaihu	Zhenbao dao
IUCN Status: Critically Endangered							
Siberian crane	*Grus leucogeranus*	1	1		1	1	
IUCN Status: Endangered							
Amur sturgeon	*Acipenser schrenckii*			1			
Kaluga sturgeon	*Huso dauricus*		1	1		1	
Scaly-sided merganser	*Mergus squamatus*	1	1	1	1		
Swan goose	*Anser cygnoides*	1	1	1	1	1	1
Oriental stork	*Ciconia boyciana*		1	1	1	1	1
Red-crowned crane	*Grus japonensis*	1	1	1	1	1	1
Tiger	*Panthera tigris*		1	1			1
IUCN Status: Vulnerable							
Chinese soft-shell turtle	*Pelodiscus sinensis*		1	1		1	1
Chinese egret	*Egretta eulophotes*				1	1	
Lesser white-fronted goose	*Anser erythropus*		1	1	1	1	
Baikal teal	*Anas formosa*		1	1		1	
Baer's pochard	*Aythya baeri*	1	1	1		1	1
Greater spotted eagle	*Aquila clanga*		1				
Pallas's sea eagle	*Haliaeetus leucoryphus*						
Steller's sea eagle	*Haliaeetus pelagicus*		1			1	
Swinhoe's rail	*Coturnicops exquisitus*					1	
Hooded crane	*Grus monacha*	1	1	1	1		
White-naped crane	*Grus vipio*	1	1	1	1	1	1
Saunders's gull	*Larus saundersi*					1	
Manchurian reed warbler	*Acrocephalus tangorum*					1	
Rufous-backed bunting	*Emberiza jankowskii*					1	
Asiatic black bear	*Ursus thibetanus*		1	1		1	1
23 species total	**Total**	**7**	**17**	**15**	**10**	**18**	**9**

IUCN = International Union for Conservation of Nature, SPWPP = Sanjiang Plain Wetlands Protection Project.

Source: Landell-Mills. 2012. *Reviving Lakes and Wetlands: Lessons Learned from the Sanjiang Plain.* Harbin, China: Sanjiang Plain Wetlands Protection Project.

APPENDIX 3
Best Practices to Improve Wetlands Management in the Sanjiang Plain

SECTION I: WATERSHEDS/INTEGRATED WATER RESOURCES MANAGEMENT

1	Name/Title	The Asian Development Bank's 25 Elements of IWRM in River Basins
	Location	The Sanjiang Watersheds
	Implementers/ Partners	Forestry agencies, water resources agencies, policy developers and decision makers, land-use administrators and practitioners, nature reserve managers.
	Description of the Best Practice	These 25 elements are widely accepted to be important in introducing integrated water resources management (IWRM) in river basins. Incorporating these elements into institutional reforms, development strategies, and investment projects will make a significant difference for IWRM in the basin. To date, 15 of these elements are complete in the watersheds. Attention can now focus on implementing the remaining 10 elements.
	Ease or Difficulty	Relatively difficult but essential to address the remaining weaknesses in IWRM in the watersheds.
	Relevance to Sanjiang Plain	Highly relevant.
	Resources Required	Existing staff resources, capacity building for all practitioners in the Sanjiang Plain. Financing and investment. Policy development and integration. Linking data, information, knowledge, and wisdom.
	Reference	ADB. 2006. *Innovations and Advances in Basin Management in Asia*. Appendix A: ADB's 25 Elements of IWRM in River Basins. Manila.

2	Name/Title	"Upstream Thinking"
	Location	Originally from South West Region of the United Kingdom, but applicable internationally.
	Implementers/ Partners	Forestry agencies, water resources agencies, policy developers and decision makers, land-use administrators and practitioners, nature reserve managers.
	Description of the Best Practice	In this referenced case study, the innovators believe that water consumers will be better served, and in a more cost-effective manner, if the administering agencies spend money raised from water charges on catchment restoration in the short term rather than on ever advancing treatment processes in the long term. They anticipate that, through this proactive rather than reactive approach, they may be able to reduce the future additional costs of water purification by a factor of 50. The entire "Upstream Thinking" initiative will cost each water consumer in the South West Region of England the equivalent of around $1 per year.

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Appendix 3 Table *continued*

	Ease or Difficulty	Straightforward.
	Relevance to Sanjiang Plain	Highly relevant.
	Resources Required	Existing staff resources, capacity building for all practitioners in the Sanjiang Plain.
	Reference	CIWEM. 2013. Policy Position Statement. *The Catchment Based Approach in England*. The Chartered Institution of Water and Environmental Management. London, UK and University of Exeter website: "Upstream Thinking".

3	**Name/Title**	**Forest Classification**
	Location	Headwaters.
	Implementers/ Partners	Heilongjiang Provincial Forestry Department.
	Description of the Best Practice	Implementation and use of the People's Republic of China forest classification system. Needs to be more widely used, referenced, and valued as a capacity-building tool. Water conservation forests should be "administratively linked" to wetland nature reserves.
	Ease or Difficulty	Easy and straightforward.
	Relevance to Sanjiang Plain	Headwater forests provide the first level of protection for the wetlands and deliver the basic water yield.
	Resources Required	Existing staff resources.
	Reference	In late November 2009, the People's Republic of China's State Forestry Administration (SFA) released the Seventh National Forest Resource Inventory Report. This report covers the period from 2004 to 2008.

4	**Name/Title**	**Awareness Raising on Hydrology and Hydrological Function**
	Location	The Sanjiang Plain headwaters, wetlands, and nature reserves.
	Implementers/ Partners	The water resource agencies.
	Description of the Best Practice	More awareness of hydrological functions and interrelationships within watersheds is needed among policy makers, key decision makers, and nature reserve managers. With such awareness will come a better understanding of the ongoing issues concerning water availability and water use in the watersheds. This can lead quite naturally to better resolution of water-use conflicts and improvements in water resources management.
	Ease or Difficulty	Straightforward, needs advocacy and capacity building for its use in day-to-day work practices.
	Relevance to Sanjiang Plain	Highly relevant.
	Resources Required	Existing staff resources and capacity building.
	Reference	J. Chen et al. 2014. Land Use Changes and their Effects on the Value of Ecosystem Services in the Small Sanjiang Plain in China. *The Scientific World Journal*. 2014, 752846.

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Appendix 3 Table *continued*

5	Name/Title	Wise Water Use
	Location	The Sanjiang Plain.
	Implementers/ Partners	Water resources agencies, policy developers and decision makers, land-use administrators and practitioners, nature reserve managers.
	Description of the Best Practice	Developing and implementing water-saving policies and practices in agricultural use. Water saving in agriculture must be elevated to a higher priority in the overall water resources policy and management.
	Ease or Difficulty	Easy to understand the need, policy initiatives and implementation will need advocacy, influence and commitment.
	Relevance to Sanjiang Plain	Highly relevant, agriculture has the highest potential for saving water.
	Resources Required	Existing staff resources, capacity building for water-use professionals.
	Reference	J. Wu et al. 2012. Securing Water for Wetland Conservation: A Comparative Analysis of Policy Options to Protect a National Nature Reserve in China. *Journal of Environmental Management*. 94. Volume 94, Issue 1, February 2012, pp. 102–111.

6	Name/Title	Water Quality Trend Monitoring
	Location	The Sanjiang Plain and its nature reserves and wetlands.
	Implementers/ Partners	Water resources agencies, policy developers and decision makers, land-use administrators and practitioners, nature reserve managers.
	Description of the Best Practice	There is a critical need to develop and implement procedures to promote water quality improvements. Trend monitoring in all Sanjiang Nature Reserves (described in the main report), and setting of an "aspirational" target of Class III for water quality improvements are among the steps required.
	Ease or Difficulty	Easy to understand the need—policy initiatives and implementation will require advocacy, influence, and commitment.
	Relevance to Sanjiang Plain	Highly relevant: deteriorating water quality is a major threat to the sustainability of wetlands. The small Xingkai Lake is at a tipping point toward Class V and eutrophication.
	Resources Required	Existing staff resources, capacity building for water quality professionals.
	Reference	R. Stone. 2011. On Lake Taihu, China Moves To Battle Massive Algae Blooms. http://e360.yale.edu/feature/on_lake_taihu_china_moves_to_battle_massive_algae_blooms/2429/

7	Name/Title	Promoting Stakeholder Consultation
	Location	The Sanjiang Plain.
	Implementers/ Partners	Water resource agencies.
	Description of the Best Practice	Best practice for integrated water resources management envisages both "top-down" and "bottom-up" stakeholder consultation processes to ensure downstream communities and other interest groups have input

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Appendix 3 Table *continued*

		into decisions affecting water resource allocation and management. "Bottom-up" stakeholder consultation needs to be elevated to a higher priority in overall water resources policy and management.
	Ease or Difficulty	Moderate difficulty, needs advocacy, influencing skills and capacity building.
	Relevance to Sanjiang Plain	Highly relevant.
	Resources Required	Existing staff resources, capacity building for water resources professionals.
	Reference	Chartered Institution of Water and Environmental Management. 2013. Policy Position Statement, *The Catchment Based Approach in England*. London, UK.

8	**Name/Title**	**Water Quality Improvement Planning**
	Location	The Sanjiang Plain.
	Implementers/ Partners	Water resources agencies.
	Description of the Best Practice	Currently there are no water quality improvement plans or water quality management plans to accompany the water allocation plans for water quantity. Normally, best practice would see these plans as "twins" to be prepared and implemented together. Water quality improvement and planning needs to be elevated to a higher priority in overall water resources policy and management.
	Ease or Difficulty	Moderate difficulty, needs advocacy, influencing skills and capacity building.
	Relevance to Sanjiang Plain	Highly relevant.
	Resources Required	Existing staff resources, capacity building for water resources professionals.
	Reference	H.-Y. Liu and Z.-F. Li. 2008. Spatial Characteristics of Wetland Water Quality and Land Use Impacts at Spring (time) in the Small Sanjiang Plain, China. *China Environmental Science*. 28 (10). pp. 933–937.

9	**Name/Title**	**Addressing Nonpoint Source Pollution from Villages and Small Communities**
	Location	The Sanjiang Plain.
	Implementers/ Partners	Water resources agencies, policy developers and decision makers, land-use administrators and practitioners, nature reserve managers.
	Description of the Best Practice	Pollution from nonpoint sources, emanating from the higher areas of the Sanjiang Plain, eventually flows to the wetlands, particularly following flood events. While runoff from agricultural lands is the most significant source of such pollutants, pollutants from untreated domestic wastewater and solid waste in nearby villages are also a major contributor. Best practice would be to implement future investment in environmental infrastructure in villages under existing government policies which could contribute to improved water quality in the nearby wetlands. Provision of wastewater treatment capability to all small towns and all villages without wastewater treatment facilities should be prioritized.

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	Ease or Difficulty	Relatively straightforward, needs planning, application for financing under existing government policies and preparation of ongoing annual work programs to provide adequate wastewater treatment to villages.
	Relevance to Sanjiang Plain	Highly relevant.
	Resources Required	Existing staff resources, capacity building for wastewater professionals.
	Reference	The state council issued a policy document in 2007 on the strengthening of opinion on rural environmental protection. The rural wastewater collection and treatment, solid waste collection and treatment, and animal waste collection and treatment are supported by this national policy.
10	**Name/Title**	**Addressing Nonpoint Source Pollution from Agriculture**
	Location	The Sanjiang Plain.
	Implementers/ Partners	Water resources agencies, policy developers and decision makers, land-use administrators and practitioners, nature reserve managers.
	Description of the Best Practice	Pollution from nonpoint sources, emanating from the higher areas of the Sanjiang Plain, eventually flows to the wetlands, particularly following flood events. The largest source of such pollution is from agricultural runoff. Nonpoint source pollution from agriculture is exacerbated if accepted best practices for appropriate use of agricultural lands are not applied. This includes paying attention to how lands are plowed, irrigated, and planted, and how fertilizers and insecticides are used. Any intervention aimed at reducing nonpoint source pollution from agriculture requires that targets are set and key performance indicators are used to measure progress. The issues associated with nonpoint source pollution from agriculture need to be elevated at a higher priority in overall water resources policy and management, and need to be integrated within annual work programs to reduce nonpoint source pollution. Awareness raising and capacity building among rural communities should be carried out in tandem with policy development and work programs.
	Ease or Difficulty	Moderately difficult, needs an awareness raising initiative for rural land users and state and local farms to explain the issues and the need to improve land-use management practices to avoid, mitigate, and remedy nonpoint pollution.
	Relevance to Sanjiang Plain	Highly relevant.
	Resources Required	Existing staff resources, capacity building for wastewater and land-use professionals.
	Reference	H.-Y. Liu and Z.-F. Li. 2008. Spatial Characteristics of Wetland Water Quality and Land Use Impacts at Spring (time) in the Small Sanjiang Plain, China. China Environmental Science. 28 (10). pp. 933–937.
11	**Name/Title**	**Planting the Right Tree in the Right Place**
	Location	Headwaters.
	Implementers/ Partners	Forestry departments and practitioners.

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	Description of the Best Practice	Extensive work has been done to investigate the types of trees that are appropriate for specific sites and growing conditions. Improvement in the site-specific selection and planting of tree species is a continuing process. In addition to the usual silvicultural considerations, the effects of climate change may also need to be considered—successful planting may require use of species resistant to drought to prevent die-off.
	Ease or Difficulty	Straightforward continuation of current efforts.
	Relevance to Sanjiang Plain	Highly relevant.
	Resources Required	Existing staff resources.
	Reference	I. Aranda et al. 2012. Species-Specific Water Use by Forest Tree Species: From the Tree to the Stand. *Agricultural Water Management*. 114. pp. 67–77.

12	**Name/Title**	**New Scientific Research in the Forestry Sector**
	Location	Harbin.
	Implementers/ Partners	Forestry departments, universities, professionals, and practitioners.
	Description of the Best Practice	Through sound scientific research, many innovations are being developed in the forestry sector. Weaknesses arise when the research is not published in scientific journals, or results are not made accessible to practitioners who can apply the new discoveries. Publication and effective dissemination of validated research findings ensure that policy makers, institutional donors, and other decision makers will have a sound basis for taking action. This best practice is equally applicable to other related sectors such as water resources management, pollution control, and integrated water resources management.
	Ease or Difficulty	Straightforward.
	Relevance to Sanjiang Plain	Highly relevant.
	Resources Required	Existing staff resources.
	Reference	Scion (New Zealand) Forest Science.http://www.scionresearch.com/research/forest-science

SECTION II: WETLANDS AND NATURE RESERVE MANAGEMENT

13	**Name/Title**	**Applying the Precautionary Approach in Practice**
	Location	The United States and other developed western nations.
	Implementers/ Partners	Heilongjiang Provincial Forest Department, Ministry of Environment, State Forestry Administration, Ministry of Agriculture, other national government agencies
	Description of the Best Practice	While environmental protection is codified in the laws of the People's Republic of China, in practice, the letter of the law is not always applied. When environmental protection comes into conflict with other strong policy directives—including economic development, poverty

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		reduction, job creation, and food security—it sometimes happens that environmental protection laws are not rigorously enforced. This can result in significant adverse impacts on the environment, which may go uncompensated. The "precautionary approach" has been presented as a guiding principle in the main text of this report. In the context of the Sanjiang Plain wetlands, such an approach can help to ensure that, to the extent possible, potential adverse environmental impacts from proposed actions are avoided and minimized, and any remaining impacts are appropriately compensated for.
	Ease or Difficulty	Fairly difficult. There are a number of fundamental conflicts at the policy level and within the legal framework that need to be reconciled in order to ensure that the precautionary approach becomes embedded in resource management practices.
	Relevance to Sanjiang Plain	With conflicting land-use interests, especially in the agricultural sector, this best practice is highly relevant.
	Resources Required	A strong cross-sectoral coordination body is required, with key involvement of the Ministry of Environment and State Forest Administration.
	Reference	U.S. Army Corps of Engineers. 2008. 33 CFR Part 332. Compensatory mitigation for losses of aquatic resources. Authority: 33 U.S.C. 401 et seq.; 33 U.S.C. 1344; and Pub. L. 108–136. Source: 73 FR 19670, Apr. 10, 2008, unless otherwise noted. www.nap.usace.army.mil/Portals/39/docs/regulatory/regs/33cfr332.pdf

14	**Name/Title**	**Applying an Ecosystem-Based Management Approach: Measuring Carrying Capacity**
	Location/Source	The People's Republic of China; Ramsar sources.
	Implementers/ Partners	Academic institutions, nature reserves
	Description of the Best Practice	The best practice is intended to provide the information needed to know the limits to which other activities in the watershed can proceed without adverse impact to the wetlands and their biodiversity. This will require a study of the main activities (farming, tourism, etc.) to determine the requirements for water, waste disposal, etc. Once these determinations are made, necessary resources can be allocated and services provided in such a manner that the requirement for maintaining the wetlands can be adhered to.
	Ease or Difficulty	Studies for carrying capacity are relatively straightforward; however, implementation of measures to ensure that sustainability requirements are met will be challenging.
	Relevance to Sanjiang Plain	Highly relevant.
	Resources Required	Consultancy services from technical specialists
	References	R. Li and L. Rong. 2007. Ecotourism Carrying Capacity of Hangzhou Xixi National Wetland Park in China. *Ying Yong Sheng Tai Xue Bao*. 18 (10). pp. 2301–2307. www.ramsar.org

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		Sustainable Measures website: "Sustainability Indicators 101." http://www.sustainablemeasures.com/node/33 Ramsar Convention Secretariat. 2010. (Dave Pritchard, series editor). Managing Wetlands: Frameworks for Managing Wetlands of International Importance and other Wetland Sites. *Ramsar Handbooks for the Wise Use of Wetlands*, 4th ed., Vol. 18. Gland, Switzerland: Ramsar Convention Secretariat.

15	**Name/Title**	**Contiguous Biodiversity Corridors**
	Location	The People's Republic of China and elsewhere.
	Implementers/ Partners	Forestry agencies, water resources agencies, policy developers and decision makers, land-use administrators and practitioners, nature reserve managers.
	Description of the Best Practice	Ecosystem discontinuities exist because of various land uses in the Sanjiang Plain, and many nature reserves are geographically fragmented or isolated. While these nature reserves are "stepping stones" that contain rich biodiversity resources, they need to be physically linked to corridors or networks. It is suggested that riparian planting is used to create a series of contiguous biodiversity corridors from the forest reserves through the middle reaches to the wetlands in the lower reaches. This will mitigate nonpoint source pollution and make the ecosystem from the forest reserves to the wetlands more robust and reduce the vulnerability of biodiversity becoming isolated in fragmented reserves. In addition, it is suggested that wetland "hotspots"—areas not yet within nature reserves but of high biodiversity value—be clearly identified and selected for strengthened protection.
	Ease or Difficulty	Moderately difficult but implementation will be an ongoing and gradual work program.
	Relevance to Sanjiang Plain	Highly relevant.
	Resources Required	Existing staff resources, capacity building for all practitioners in the Sanjiang Plain to advocate and seek policy and financial approval. Labor and planting materials for actual implementation.
	Reference	Ministry of Environmental Protection (MEP). 2010. China National Biodiversity Conservation Strategy and Action Plan (2011–2030). Beijing.

16	**Name/Title**	**Developing and Strengthening Management Plans for Nature Reserves**
	Location	Sanjiang Plain.
	Implementers/ Partners	Heilongjiang Provincial Forestry Department, Heilongjiang Wetland Conservation Center, nature reserves (NRs).
	Description of the Best Practice	Management plans are currently weak or lacking in many of the NRs of the Sanjiang Plain. Such plans are an essential and fundamental tool that can be used to guide the effective operation and management of NRs.
	Ease or Difficulty	Requires concerted effort of multiple stakeholders and strong commitment from NRs and relevant government agencies; however, many excellent models are available from other countries.

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	Relevance to Sanjiang Plain	NR management plans can serve as a road map to guide the day-to-day management and operation of the NRs.
	Resources Required	Volunteered time and labor of concerned stakeholders; staff time of nature reserve managers and staff.
	References	L. Thomas and J. Middleton. 2003. Guidelines for Management Planning of Protected Areas. World Commission on Protected Areas (WCPA). *Best Practice Protected Area Guidelines. Series No. 10*, P. Adrian, Series Editor. IUCN—The World Conservation Union. Gland, Switzerland. A. J. Trently. 2014. Old Forest State Natural Area Management Plan, State of Tennessee. Department of Environment and Conservation, Natural Areas Program. http://www.overtonpark.org/wp-content/uploads/2015/01/OF-Mgmt-Plan-SNA-Nov2014.pdf
17	**Name/Title**	**Advanced Methods for Plant Propagation and Cultivation**
	Location	Sanjiang Plain.
	Implementers/ Partners	Academic research institutions, nature reserves.
	Description of the Best Practice	Recent advances in plant propagation and cultivation techniques have led to the discovery of methods that can accelerate or facilitate the restoration of wetlands that have been degraded or converted to other uses. The techniques include development of germplasm banks and advanced propagation methods for key wetland plant species, including sedges, cattails, water lily, and lotus.
	Ease or Difficulty	Medium difficulty—application of these methods will likely require field testing and refinement of cultivation protocols.
	Relevance to Sanjiang Plain	Highly relevant and ultimately offering great potential to more rapidly restore wetland habitats.
	Resources Required	Technical expertise, laboratory and field testing facilities.
	References	Personal communication, Shouzheng Tong, Northeast Institute of Geography and Agricultural Ecology, Chinese Academy of Sciences. G. Wang et al. 2015. Effects of Farming on the Soil Seed Banks and Wetland Restoration Potential in Sanjiang Plain, Northeastern China. *Ecological Engineering*. 77. pp. 265–274.
18	**Name/Title**	**High-Tech Applications for Field Monitoring of Migratory Birds**
	Location	The United States, New Zealand, Australia.
	Implementers/ Partners	Nature reserve staff, technical specialists.
	Description of the Best Practice	The use of unmanned aerial vehicles, or drones, with onboard cameras that can be remotely controlled by scientists from distances up to several hundred meters. This enables researchers to obtain aerial views of nesting birds that would otherwise be hidden from them and allows for more accurate counts of resident and migratory species.
	Ease or Difficulty	Relatively easy.
	Relevance to Sanjiang Plain	Highly relevant. It is believed that drone technology can greatly improve accuracy in bird census on the Sanjiang Plain.

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	Resources Required	Purchase of unmanned aerial vehicles.
	References	ConservationDrones.org website. http://conservationdrones.org/2015/05/22/publications-page/ 3D Robotics corporate website. https://3drobotics.com/about/ Cool Green Science website. "Of Drones and Cranes: UAV Technology Aids California Bird Conservation." Matt Merrifield and Rodd Kelsey, March 6, 2014. http://blog.nature.org/science/2014/03/06/drones-uav-sandhill-cranes-california-wetlands/#sthash.QEMfil2P.dpuf

19	Name/Title	**Creating Improved Waterfowl Habitat**
	Location	Sanjiang Plain nature reserves, various locations.
	Implementers/ Partners	Heilongjiang Provincial Forest Department, nature reserves.
	Description of the Best Practice	The best practice is intended to explore various options for optimizing habitat for waterfowl, for promoting better success in breeding and nesting. The actions that could be considered include, among others, protecting nesting sites from predators and flooding, providing artificial nests, improving food supplies for waterfowl, and improving water flow and water quality.
	Ease or Difficulty	A range of methods are available, and the most appropriate ones can be selected for specific situations. A number of these are quite simple to execute.
	Relevance to Sanjiang Plain	Very relevant. Various methods of improving habitat for waterbirds can enhance breeding success and survival of vulnerable species.
	Resources Required	Manpower can be provided by existing personnel in the nature reserves. Depending upon the methodology employed, regular budget resources may be sufficient to cover costs, or supplementary funds may be required.
	References	C. L. White et al. 2005. *Nesting Island Creation for Wading Birds.* CIR1473, Wildlife Ecology and Conservation Department, UF/IFAS Extension. http://edis.ifas.ufl.edu/uw223 R. A. Rounds, R. Michael Erwin, and J. H. Porter. 2004. Nest-Site Selection and Hatching Success of Waterbirds in Coastal Virginia: Some Results of Habitat Manipulation. *Journal of Field Ornithology*. 75 (4). pp. 317–329. http://www.bioone.org/doi/full/10.1648/0273-8570%282004%29075%5B0317%3ANSAHSO%5D2.0.CO%3B2 Reports from Sanjiang Plain nature reserves on artificial nests, feeding programs, and other related initiatives.

20	Name/Title	**Advocacy for Ramsar Classification—Wetlands of International Importance**
	Location	Sanjiang Plain and other significant wetland sites worldwide.
	Implementers/ Partners	Ramsar, nongovernment organizations, nature reserves (NRs), academic institutions.
	Description of the Best Practice	To date, six NRs in the Sanjiang Plain—Honghe NR, Sanjiang NR, Xingkaihu NR, Qixinghe NR, Dongfanghong NR, and Zhenbaodao NR—have already been recognized as Ramsar sites, or wetlands of

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		international importance. This status brings with it global recognition of the importance of these sites, especially in terms of their significant biodiversity. With increased recognition, comes the potential to attract greater support—in terms of funding, publicity, and scientific interest—for the conservation of the area. Thus, pursuing the inclusion of a wetland on the list of recognized Ramsar sites can yield great benefits for improving the management of the site and its valuable resources.
	Ease or Difficulty	Relatively straightforward process, dependent upon demonstrating, through acquisition of reliable data, that the site meets the established Ramsar criteria.
	Relevance to Sanjiang Plain	Highly relevant, especially since a number of wetland sites in Sanjiang Plain provide critical habitat for migratory waterfowl.
	Resources Required	Well-documented data that will establish the eligibility of the site for Ramsar classification.
	Reference	Ramsar Convention. 1971. *The Ramsar Sites Criteria, The Nine Criteria for Identifying Wetlands of International Importance*. http://www.ramsar.org/sites/default/files/documents/

21	**Name/Title**	**Using Economic Valuation and Payment for Ecosystem Services as Foundations for Sustainable Financing of Conservation**
	Location	Sanjiang Plain, other natural areas and conservation sites worldwide, especially within watersheds.
	Implementers/ Partners	Natural resources, economists, community groups, private sector, government entities—contractual arrangements executed between resource users and parties responsible for environmental stewardship.
	Description of the Best Practice	Often, key decision makers are not fully aware of the economic value of goods and services that are provided by the natural ecosystem. Once made aware of the importance of the economic contributions made by the natural ecosystem, they are more inclined to lend support for the protection of wetlands, watersheds, and other important natural areas. Successful implementation of payment for ecosystem services schemes can help ensure that resource users are giving appropriate compensation to persons or entities who are working to protect the natural ecosystems that provide important economic benefits.
	Ease or Difficulty	Economic valuation studies are relatively straightforward. Payment for ecosystem services schemes, while easily designed, are difficult to implement successfully.
	Relevance to Sanjiang Plain	Decision makers need to have a comprehensive understanding of the ecosystem goods and services being provided by the wetlands and watersheds of the Sanjiang Plain, in order to realize the greatest economic benefits over the long term and to make wise policy and land-use decisions.
	Resources Required	Funding for studies, human resources.
	References	Zhang et al. eds. 2010. *An Eco-Compensation Policy Framework for the People's Republic of China: Challenges and Opportunities.* Mandaluyong City, Philippines: ADB.

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		Zhang et al. eds. 2010. Payments for Ecological Services and Eco-Compensation: Practices and Innovations in the People's Republic of China. *Proceedings from the International Conference on Payments for Ecological Services, Ningxia Hui Autonomous Region, People's Republic of China*, 6–7 September 2009. Mandaluyong City, Philippines: ADB.

SECTION III: LIVELIHOOD

22	Name/Title	Ecotourism
	Location	Xingkaihu NR and Zhenbaodao NR, Sanjiang Plain, the People's Republic of China; Tonle Sap, Cambodia; Nam Ha National Protected Area, the Lao People's Democratic Republic (Lao PDR).
	Implementers/ Partners	Nature reserve staff, nongovernment organizations, local community organizations, technical specialists.
	Description of the Best Practice	Provides alternative income for local community members reducing pressure on protected environments, raises public awareness about the importance of environmental conservation.
	Ease or Difficulty	Requires careful planning to ensure that visitors are well-accommodated and that visitor numbers do not exceed the ecosystem's carrying capacity; infrastructure should be appropriately designed so as not to detract from the site's natural beauty.
	Relevance to Sanjiang Plain	Could be scaled up in the Sanjiang Plain wetlands based on lessons learned from initial pilot projects and successful ecotourism projects at other sites in the People's Republic of China and elsewhere.
	Resources Required	Sufficient infrastructure to comfortably accommodate ecotourists and provide opportunities for them to enjoy the area's natural beauty without disturbing its ecology; should be systematically planned with assistance from technical experts.
	References	Heilongjiang Provincial Forestry Department. 2013. Sanjiang Plain Wetlands Protection Project. Completion Report, Project Implementation Office. Harbin, PRC. Osmose 2006. "How to protect the environment while reducing poverty? An Osmose-led demonstration is ongoing at Prek Toal." Osmose. Siem Reap, Cambodia.http://www.osmosetonlesap.net/www/english/ intervention.php United Nations Development Programme. 2012. Nam Ha Ecotourism Project, Lao PDR. Equator Initiative Case Study Series. UNDP, New York, NY. http://www.undp.org/content/dam/laopdr/docs/Reports%20and%20publications/Nam%20Ha%20ecotourism%20project.pdf The International Ecotourism Society n.d. "The components of successful ecotourism." IES, Burlington, Vermont, USA (shared by UNEP, Division of Technology, Industry and Economics, Paris, France). http://www.unep.fr/shared/publications/other/WEBx0137xPA/part-two.pdf

23	Name/Title	Ecogreenhouses
	Location	Qixinghe NR, Sanjiang Plain, the People's Republic of China; Japan, the United States, and others.
	Implementers/ Partners	Farmers, technical experts.

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	Description of the Best Practice	Greenhouse cultivation enables farmers to increase income on much smaller areas of land compared with extensive field cropping. Abandoned field crop land can be restored to natural wetlands. Water resources can be conserved.
	Ease or Difficulty	Requires significant initial investment but provides favorable financial rate of return. Maximizing the value of production and producing organically requires technical expertise, but does not exceed the capacity of well-trained greenhouse managers.
	Relevance to Sanjiang Plain	Could be replicated at other sites in the Sanjiang Plain, particularly in areas identified as ecological hotspots, enabling hotspot areas to be restored to wetlands.
	Resources Required	Sufficient investment resources and technical expertise are required.
	References	EGTOP 2013. "Final report on Greenhouse Production (Protected Cropping)." European Commission Directorate-General for Agriculture and Rural Development. Expert Group for Technical Advice on Organic Production (EGTOP). Brussels, Belgium. http://ec.europa.eu/agriculture/organic/eu-policy/expert-advice/documents/final-reports/final_report_egtop_on_greenhouse_production_en.pdf Diver, Steve/ National Center for Appropriate Technology 2004. "Greenhouse and hydroponic vegetable production resources on the internet." NCAT, ATTRA - National Sustainable Agriculture Information Service. Fayetteville, Arkansas, USA. http://www.agrisk.umn.edu/cache/arl01481.htm Nichols, Mike and Bruce Christie 2008. Hydroponics: "Greenhouse production in Japan." *Practical Hydroponics and Greenhouses* Issue 98. Casper Publications, Narabeen, New South Wales, Australia. www.hydroponics.com.au/issue-98-greenhouse-production-in-japan/ University of Minnesota Extension 2013. Cold-climate Greenhouse Resource: A guidebook for building a cold-climate greenhouse. Southeast Regional Sustainable Development Partnership, Minneapolis, Minnesota, USA. http://www.extension.umn.edu/rsdp/community-and-local-food/production-resources/docs/cold-climate-greenhouse-resource.pdf MASS Amherst Center for Agriculture, Food and the Environment 2015. "Greenhouse crops and floriculture factsheets. University of Massachusetts, Amherst, MA, USA. http://extension.umass.edu/floriculture/fact-sheets/hydroponic-greenhouse-production-resources IFOAM EU Group 2012. "Position paper on Organic Greenhouse Production." International Federation of Organic Agriculture Movements, European Regional Group, Brussels, Belgium. http://www.ifoam-eu.org/sites/default/files/page/files/ifoameu_reg_greenhouse_production_position_201201.pdf

24	**Name/Title**	**Nontimber forest products**
	Location	Applicable for Sanjiang Plain wetlands, other locations in PRC, Indonesia, Nepal, Lao PDR, Thailand (among others).
	Implementers/ Partners	Farmers, technical specialists, projects.
	Description of the Best Practice	High-value nontimber forest products can be grown on farms. The income provided from relatively small areas of land enables farmers to abandon extensive farming. Abandoned areas can be restored as natural wetlands.

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	Ease or Difficulty	Requires careful selection of appropriate species depending on environmental as well as market factors.
	Relevance to Sanjiang Plain	A range of high-value nontimber forest products could be grown on farms and in forest plantations. There is significant potential to increase income per unit area cultivated. This will enable land identified as ecologically critical to be restored to forests or wetlands. Water resources can be conserved.
	Resources Required	Technical expertise for crop selection and cultivation requirements. Market research for identifying sales potential. Identification of opportunities to process raw materials to add value.
	References	D. John et al. 2005. *Capitalizing on the Bio-Economic Value of Multi-Purpose Medicinal Plants for the Rehabilitation of Drylands in Sub-Saharan Africa*. Global Environment Facility Program. Washington, DC: World Bank. J. Foppes and S. Phommasane. 2005. Experiences with market development of nontimber forest products in Lao PDR. SNV, The Netherlands Development Organization, Vientiane, Lao PDR. http://search4dev.nl/download/284094/116258.pdf ACIAR 2013. Development of timber and nontimber forest products' production and market strategies for improvement of smallholders' livelihoods in Indonesia. Australian Center for International Agricultural Research, Canberra, Australia. http://aciar.gov.au/project/fst/2012/039 Global NTFP Partnership 2013. About the Global Non-Timber Forest Products Partnership. India coordination unit, New Delhi, India. http://ntfp.inbar.int/wiki/index.php/about FAO. 2014. Non-wood forest products. Food and Agriculture Organization of the United Nations, Rome, Italy. http://www.fao.org/forestry/nwfp/85449/en/

25	**Name/Title**	**Agroforestry**
	Location	Sanjiang Plain, the People's Republic of China, many countries worldwide in association with protected areas management projects.
	Implementers/ Partners	Farmers, technical experts, protected area authorities.
	Description of the Best Practice	Intercropping of a variety of crops and nontimber forest products in natural, plantation, and farm forests increases income per unit area of land, reducing pressure on protected area land and resources. Water resources can be conserved. Contributes to carbon sequestration.
	Ease or Difficulty	Requires technical support for proper crop selection. Easily implemented. Potential profitability depends on astute intercrop selection and marketing. Processing before marketing adds value to products being produced.
	Relevance to Sanjiang Plain	Successfully implemented in five of six counties where Sanjiang Plain Wetlands Protection Project was operational. Significant potential for expansion and for diversification of agroforestry crops. Significant potential for increasing income by crop selection, processing, and marketing. Can contribute to reducing farming area leading to wetlands and forest habitat restoration.
	Resources Required	Technical expertise to identify best crops. Market studies. Processing capacity. Market outlets.

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	References	World Agroforestry Centre n.d. "On-farm productivity: Projects. World Agroforestry Centre, Nairobi, Kenya. http://www.worldagroforestry.org/research/agroforestry-systems/projects S.T. Chew. 1989. "Agroforestry projects for small farmers: A project manager's reference". A.I.D. Evaluation Special Study No. 59. United States Agency for International Development, Washington, D.C., USA. http://pdf.usaid.gov/pdf_docs/PNAAX212.pdf FAO/ Vo Hung 2004. "Agroforestry Research: Systematizing the local ecological knowledge of the M'nongs in Vietnam's central highlands." Asia Pacific Agroforestry Network Newsletter No. 24. Food and Agriculture Organization of the United Nations, Rome, Italy. http://www.fao.org/docrep/008/af336e/af336e02.htm J. Kiuri Muriaki. 2011. "Medicinal trees in smallholder agroforestry systems." World Agroforestry Centre. Nairobi, Kenya. http://www.slideshare.net/agroforestry/jonathan-muriuki-icraf-presntation-25-january-2011

26	Name/Title	Heilongjiang Rice-Based Products
	Location	Various sites worldwide under the classification eco-marketing or green marketing.
	Implementers/ Partners	Technical experts, farmers associations, nongovernment organizations, projects, marketing agencies.
	Description of the Best Practice	The idea is to take environmentally produced products and link their marketing to environmental protection and/or restoration initiatives. Marketing targets to a clientele who wish to support environmental conservation and restoration.
	Ease or Difficulty	Requires professional, technical, and business expertise for product development, value chain management, advertising, designing, and for mounting effective marketing campaigns.
	Relevance to Sanjiang Plain	Could substantially increase the value and diversity of products marketed from Sanjiang Plain in conjunction with arrangements for profit sharing with the protected areas/nature reserves.
	Resources Required	Technical and professional expertise. Innovative design. Collaboration among producers, government agencies and regulators, nature reserves, processors/packagers, and market chain linkages.
	References	IFPRI. 2012. "Branding and agricultural value chains in developing countries." Discussion Paper 01207. International Food Policy Research Institute, Washington, D.C., USA. http://www.ifpri.org/sites/default/files/publications/ifpridp01207.pdf Regional Environment Centre. 2015. "Biodiversity." The Regional Environment Centre for Central and Eastern Europe, Ady Enre, Hungary. http://www.rec.org/topicarea.php?id=9 C. Grandi and A. Triantafyllidis. 2010. "Organic agriculture in Protected areas: The Italian experience." Food and Agriculture Organization of the United Nations (FAO). Rome. Italy. http://www.fao.org/3/a-al412e.pdf T. Golja, S. Dolenc, and V. Marinkovic. 2012. "How to make agriculture production in protective areas profitable? - project idea on the example of Republic of Croatia." From: Economics of

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		Agriculture 2/2012, UDC: 631.147(497.5) http://ageconsearch.umn.edu/bitstream/127118/2/8%20-%20Golja,%20Dolenc,%20Marinkovic.pdf S. de Silva and S. S. Sellamuttu. 2010. Balancing Wetland Conservation and Development in the Sanjiang Plain: A review of current status. Colombo, Sri Lanka: International Water Management Institute. https://cgspace.cgiar.org/handle/10568/39699
27	**Name/Title**	**Green Marketing**
	Location	Various sites worldwide under the classification eco-marketing or green marketing.
	Implementers/ Partners	Technical experts, farmers associations, nongovernment organizations, projects, marketing agencies.
	Description of the Best Practice	Link production, branding, and marketing of products to environmental conservation.
	Ease or Difficulty	Requires professional, technical, and business expertise for product development, value chain management, advertising, designing, and for mounting effective marketing campaigns.
	Relevance to Sanjiang Plain	Could substantially increase the value and diversity of products marketed from Sanjiang Plain in conjunction with arrangements for profit sharing with the protected areas/nature reserves.
	Resources Required	Technical and professional expertise. Innovative design. Collaboration among producers, government agencies and regulators, nature reserves, processors/packagers, and market chain linkages.
	References	IFPRI. 2012. "Branding and agricultural value chains in developing countries." Discussion Paper 01207. International Food Policy Research Institute, Washington, D.C., USA. http://www.ifpri.org/sites/default/files/publications/ifpridp01207.pdf Regional Environment Centre. 2015. "Biodiversity." The Regional Environment Centre for Central and Eastern Europe, Ady Enre, Hungary. http://www.rec.org/topicarea.php?id=9 C. Grandi and A. Triantefyllidis. September 2010. Organic agriculture in protected areas: the Italian experience. Natural resources management and environment department, FAO. Rome. http://www.fao.org/3/a-al412e.pdf T. Golja, S. Dolenc, and V. Marinkovic. 2012. How to Make Agriculture Production in Protective Areas Profitable?—Project Idea on the Example of Republic of Croatia. From: Economics of Agriculture 2/2012, UDC: 631.147(497.5). http://ageconsearch.umn.edu/bitstream/127118/2/8%20-%20Golja,%20Dolenc,%20Marinkovic.pdf S. de Silva and S.S. Sellamuttu. 2010. Balancing Wetland Conservation and Development in the Sanjiang Plain: A review of current status. Colombo, Sri Lanka: International Water Management Institute. https://cgspace.cgiar.org/handle/10568/39699
28	**Name/Title**	**Agricultural Processing**
	Location	Worldwide.
	Implementers/ Partners	Technical experts, producers, processors, project support personnel, farmers' organizations.

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Appendix 3 Table *continued*

	Description of the Best Practice	Processing of agricultural raw materials can increase their market value significantly. There is potential to deliver some of these profits back to farmers. Earning more income from smaller cultivated areas permits some of the cultivated area to be restored to wetlands or forests.
	Ease or Difficulty	Requires careful crop/product selection and establishment of processing facilities; linkages to producer networks and processing plants. Assistance with branding, marketing, and entry to market chains.
	Relevance to Sanjiang Plain	High potential for some crops being grown, or whose cultivation could be expanded, to bring in increased revenues. If part of this added value is delivered to farmers, there is potential for their handing over of some land in wetlands reserves and watersheds for ecological restoration. Conservation of water resources.
	Resources Required	Professional and technical expertise, agricultural extension support, market chain linkages, private–public-producer partnerships.
	References	A. Berk. 2013. "Processor Driven Integration of Small-Scale Farmers into Value Chains in Turkey." Food and Agriculture Organization of the United Nations Regional Office for Europe and Central Asia, Sub-regional Office for Central Asia. Ankara, Turkey. http://www.fao.org/fileadmin/user_upload/Europe/documents/Publications/PDI/Turkey_en.pdf Mekong Institute, Capacity Development for Regional Cooperation and Integration; accessed 26 July 2015, Rural Development for Sustainable Livelihoods. http://www.mekonginstitute.org/rural-tab-menu.html Watson, Bob n.d. "How to Assist the Small-Scale Farmer." Director of the International Assessment of Agricultural Science and Technology for Development, UK Department of Environment, Food and Rural Affairs. London, United Kingdom. http://www.un.org/en/ecosoc/docs/statement08/robert_watson.pdf University of California Cooperative Extension. 2015. "Marketing and Specialty Foods." UC Extension Small Farm Program. Davis, California, USA. http://sfp.ucdavis.edu/marketing/

29	**Name/Title**	**Organic Products**
	Location	Worldwide.
	Implementers/ Partners	Farmers, technical experts, agricultural extension personnel, nongovernment organizations.
	Description of the Best Practice	Agricultural production without the use of chemical inputs that pollute the environment and can be a public health hazard.
	Ease or Difficulty	Requires technical expertise, on-farm demonstration for extension purposes, farmer capacity building.
	Relevance to Sanjiang Plain	Reduces the volume of agrochemical pollutant runoff into the wetlands' core zones. Increases the value of farmers' crops thereby increasing the farmers' income. Potential for cultivation of smaller land areas with same or greater economic return, allowing conversion of some farmland back to wetlands. Conservation of water resources.
	Resources Required	Composting materials and biopesticides can be produced locally. Agricultural extension support for farmers transitioning from chemical-intensive agriculture to organic agriculture.

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Appendix 3 Table *continued*

	References	IFOAM n.d. "Principles of Organic Agriculture." International Federation of Organic Agriculture Movements (IFOAM). Bonn, Germany. http://www.ifoam.org/en/organic-landmarks/principles-organic-agriculture FAO n.d. "Organic Agriculture." Food and Agriculture Organization of the United Nations, Inter-departmental Working Group on Organic Agriculture. Rome, Italy. http://www.fao.org/organicag/oa-faq/oa-faq7/en/ Technology Water. 2013. "UN says organic agriculture only way to feed the world. Technology Water, Blue Planet Environmental, Ontario, Canada. http://www.technologywater.com/post/69995394390/un-report-says-small-scale-organic-farming-only P. Pugliese. 2001. "Organic farming and sustainable rural development: A multi-faceted and promising convergence." *Sociologia Ruralis* Vol. 41. No. 1. Blackwell Publishers, Oxford, U.K. http://www.devab.org/moodle/pluginfile.php/1626/mod_resource/content/1/ABILE_organic_farming_and_sustainable_developpment.pdf

30	Name/Title	Handicrafts
	Location	Various sites worldwide.
	Implementers/ Partners	Farmer-producers, ecotourism authorities, handicrafts production quality experts, marketers.
	Description of the Best Practice	Production of quality handicrafts can significantly improve farm household incomes. Quality handicrafts can be effectively marketed in conjunction with ecotourism activities and at other outlets in urban areas. Can be linked to green marketing schemes.
	Ease or Difficulty	Requires careful product selection. Raw materials should be produced or already available locally. Expert trainers required to raise capacity of producers. Harvesting raw materials from wild sources needs to be managed to ensure sustainability of harvest volumes.
	Relevance to Sanjiang Plain	Increasing farm household incomes through production and sale of handicrafts may help reduce the area of farmed land, thereby enabling restoration of wetlands. Water resources can be conserved.
	Resources Required	Training expertise and longer-term follow-up by expert trainers to ensure quality. Various tools and equipment depending on items to be produced. Raw materials for production readily available, preferably farm grown or from natural source.
	References	S. de Silva and S.S. Sellamuttu 2010. Balancing Wetland Conservation and Development in the Sanjiang Plain: A review of current status. Colombo, Sri Lanka: International Water Management Institute. IUFRO. 2013. "Model Forests in Argentina: Creating place and time for participatory sustainable forest management, In. Forests under pressure: Local responses to global issues." International Union of Forest Research Organizations. Vienna, Austria. http://www.google.co.th/url?sa=t&rct=j&q=&esrc=s&source=web&cd=50&ved=0CE8QFjAJOCg&url=http%3A%2F%2Fwww.iufro.org%2Fdownload%2Ffile%2F11092%2F5581%2Fws32-PII_ch02_Argentina_pdf%2F&ei=qDaaVLvlOJONuASy2YDQCQ&usg=AFQjCNGsw_3HnZOoUaSZcALw9ZiQktNuPA&sig2=hlM3VfID-Jp3Ydw_erssuA Ndenecho, E.M. 2011. Local Livelihoods and Protected Area Management—Biodiversity Conservation Problems in Cameroon. (book synopsis on Project Muse website, John Hopkins University Press: http://muse.jhu.edu/books/9789956717460)

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Appendix 3 Table *continued*

		Scripps Institute of Oceanography. Center for Marine Biodiversity and Conservation. http://cmbc.ucsd.edu/content/1/docs/wunder.pdf
31	**Name/Title**	**Sustainable Aquaculture and Fisheries Management**
	Location	Various sites worldwide; Mai Po Inner Deep Bay, Hong Kong, China.
	Implementers/ Partners	Technical experts, aquaculture farmers, fisher's associations, protected areas management staff, technical extension staff, market chain representatives.
	Description of the Best Practice	Involves development of on-farm ponds for cultivation of high-value native fish species or sustainable fish harvest from natural sources.
	Ease or Difficulty	Requires expertise which can be easily learned. Standards must be applied rigorously to ensure compliance with sustainable production guidelines. Sustainable harvest from natural sources must be carefully monitored.
	Relevance to Sanjiang Plain	Could increase farmer incomes on smaller land areas, enabling reduction of farming in nature reserve core zones. Abandoned areas would be reconverted to natural wetlands. Water resource conservation.
	Resources Required	Ponds and associated equipment, guidelines for sustainable management,
	References	N. Romanowski. 2006. Sustainable freshwater aquaculture : the complete guide from backyard to investor. Sydney, Australia. University of New South Wales Press. World Bank. 2014. "Sustainable Aquaculture." The World Bank, Washington, DC, USA. http://www.worldbank.org/en/topic/environment/brief/sustainable-aquaculture Greenpeace. 2015. "Sustainable aquaculture." Greenpeace, Amsterdam, Netherlands. http://www.greenpeace.org/international/en/campaigns/oceans/sustainable-aquaculture/ A.J.M. Russell, P.A. Grötz, S.K. Kriesemer, and D.E. Pemsl. 2008. Recommendation Domains for Pond Aquaculture. Country Case Study: Development and Status of Freshwater Aquaculture in Malawi. *WorldFish Center Studies and Reviews* No. 1869. The WorldFish Center, Penang, Malaysia. http://www.worldfishcenter.org/resource_centre/WF_1102.pdf W. Wurts. 2015. "Sustainable aquaculture: Concept or practice?" *Biotechnology* Vol. 10. Encyclopedia of Life Support Systems. Wiley and Sons, New Jersey, USA. http://www.eolss.net/Sample-Chapters/C17/E6-58-09-09.pdf USAID MACH Project. (n.d.). Community-Based Wetland Co-management in Bangladesh. Management of Aquatic Ecosystems through Community Husbandry (MACH). USAID, Dhaka, Bangladesh. http://pdf.usaid.gov/pdf_docs/Pnadl272.pdf
32	**Name/Title**	**Composting**
	Location	Worldwide.
	Implementers/ Partners	Farmers, greenhouse managers, agriculture extension officers.

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Appendix 3 Table *continued*

	Description of the Best Practice	Utilizes local resources efficiently. Enables reduction of agricultural chemical usage and thereby contamination of surface water runoff and aquifers. Provides potential new sources of income. Contributes to adoption of organic farming.
	Ease or Difficulty	Easily implemented on a small scale. For commercial operations, requires equipment, easily learned expertise, marketing channels.
	Relevance to Sanjiang Plain	Provides a potential source of income and alternative employment for farmers. Potential contribution to development of organic production. Reduces burning of crop residues. Can reduce dependence for those employed by the production facilities to reduce the area of farmland required to produce adequate livelihoods.
	Resources Required	Farm-scale production does not require special equipment of much expertise. Commercial-scale production requires land, easily acquired expertise, and relatively inexpensive equipment, including shredders and baggers.
	References	R. Sherman. 2014. "Large scale organic materials composting." North Carolina State University, Raleigh, North Carolina, USA. https://www.bae.ncsu.edu/extension/ext-publications/waste/composting/ag593-large-scale-composting.pdf J. Rouse, S. Rothenberger, and C. Zurbrügg. 2008. Marketing Compost: A Guide for Compost Producers in Low and Middle-Income Countries. Sandec: Department of Water and Sanitation in Developing Countries. Swiss Development Cooperation, Zurich, Switzerland. http://www.sswm.info/sites/default/files/reference_attachments/ROUSE%20et%20al%202008%20Marketing%20Compost.pdf M. Ali. (ed.) 2004. "Sustainable composting." Water, Engineering and Development Centre, Loughborough University/ (with Sandec-Eaweg, Zurich Switzerland). http://www.sswm.info/sites/default/files/reference_attachments/ALI%202004%20Sustainable%20Composting.pdf Euro-bagging. 2011. "Compost Bagging Machines, Closed Composting System." Euro-bagging Inc. Průmyslová, Czech Republic. http://www.eurobagging.com/en/composting-technology

33	**Name/Title**	**Stakeholder Participatory Planning**
	Location	Worldwide.
	Implementers/ Partners	Trained facilitators, farmers, nature reserve staff.
	Description of the Best Practice:	Involves stakeholders in project planning and capitalizes on a wide range of knowledge, including local knowledge often unknown to, or poorly understood by, outsiders. It fosters a sense of project ownership among stakeholders, encouraging their active involvement in efforts to achieve project objectives.
	Ease or Difficulty:	The process is simple but the nuances are many. Trained facilitators are required to ensure opportunities for all stakeholders to participate.
	Relevance to Sanjiang Plain:	Participatory planning in Sanjiang Plain wetlands could help create enthusiasm among a wider constituency of knowledgeable and committed actors to contribute to achieving local economic development and environment conservation objectives.
	Resources Required:	Skilled participatory process facilitators to demonstrate the process and provide training for a larger group of local facilitators.

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Appendix 3 Table *continued*

	References	Wheeling Walks. 2003. "Wheeling Walks Training Manual: Benefits of Participatory Planning. Wheeling Walks, West Virginia University, Morgantown, VA, USA. http://www.wheelingwalks.org/WW_TrainingManual/CHPP_TrainingManual/chpp4/chpp4.asp J. Kpierekoh. 2011. "Participatory Planning: Fostering Stakeholder Engagement in Fostering Stakeholder Engagement in Sustainable Land Management." United Nations University Land Restoration Program, Agricultural University of Iceland, Reyjkavik, Iceland. http://www.silc.com.au/wp-content/uploads/2012/04/Presentation-Jonas-18-9-2011-Read-Only.pdf Caribbean Natural Resources Institute (CANARI). 2011. Facilitating participatory natural resource management: a toolkit for Caribbean managers. Laventille, Trinidad and Tobago. http://www.cepf.net/SiteCollectionDocuments/caribbean/CANARI_PNRM_Tooklit.pdf (See also: Convention on Biological Diversity, 2012. "Ensuring Inclusive Societal Engagement in the Development, Implementation and Updating of NBSAPs." CBD: Montreal, Canada. http://www.canari.org/documents/guidelines4-guidelinesforparticipatoryplanning.pdf) Center for International Forestry Research (CIFOR) 2007. "Towards Well-being in Forest Communities: A Sourcebook for Local Government. Why is Participatory Planning Useful." CIFOR, Bogor, Indonesia. http://www.cifor.org/sourcebook/part_two_tools/pp_why_is_pp_useful.html

34	**Name/Title:**	**On-Farm Demonstration/Farmer-to-Farmer Extension**
	Location:	Worldwide.
	Implementers/ Partners:	Farmers, agricultural extension personnel, technical experts, nature reserve staff.
	Description of the Best Practice:	For most farmers introduced to new and unfamiliar practices, "seeing is believing." Demonstration of new production techniques on local farms enables them to see and learn from practical, first-hand experience. Farmers who have implemented the new practices successfully on their farms can show and explain them to others.
	Ease or Difficulty:	On-farm demonstration and farmer-to-farmer extension, although simple overall, require specialized knowledge and experience for proper and successful implementation. These techniques are well-known to many nongovernment organizations and field-experienced academics. Government extension staff in many countries remain relatively unfamiliar with the specialized, systematic approaches involved.
	Relevance to Sanjiang Plain:	Developing new crops and production methods will require testing to confirm their viability. The best way to demonstrate viability and to disseminate successful management techniques is through on-farm demonstration and farmer-to-farmer training and extension.
	Resources Required:	Requires extension personnel or facilitators who have been trained and are experienced with the methods and techniques involved.
	References	J.G. Richardson. 2003. On-farm demonstrations: consideration factors for their success and viability as an extension teaching tool. *South African Journal of Agricultural Extension.* Vol. 32, 2003. Union of South Africa. http://www.ajol.info/index.php/sajae/article/view/3653

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Appendix 3 Table *continued*

		Humanity Development Library 2.0 for Sustainable Development and Basic Human Needs.(n.d.) "On-Farm Demonstrations." New Zealand Digital Library, Wellington, New Zealand. http://www.nzdl.org/gsdlmod?e=d-00000-00---off-0hdl--00-0----0-10-0---0---0direct-10---4-------0-1l--11-en-50---20-help---00-0-1-00-0-0-11-1-0utfZz-8-10&a=d&cl=CL1.1&d=HASH015911c670fb3a86dbfe25c4.5.4 Oakley, P. and C. Garforth 1985. Guide to Extension Training. FAO. Rome. Chapter 5. 'Extension Methods.' accessible online at: http://www.fao.org/docrep/t0060e/t0060e07.htm FAO Corporate Document Repository. FAO Economic and Social Development Department. Rome. E. Anisimova, S. Franzel, and E. Kiptot. 2014. Volunteer farmer trainers change the way we think about extension: A PIM Impact Story. IFPRI Blog, CGIAR Research Program on Policies, Institutions, and Markets (PIM). International Food Policy Research Institute, Washington, DC, USA. http://www.ifpri.org/blog/volunteer-farmer-trainers-change-way-we-think-about-extension

APPENDIX 4
Guidelines for Applying Integrated Water Resources Management

The table presented here includes ideas and suggestions for capacity building in the area of integrated water resources management, which can be used in policy development and decision making, and can be embedded into the day-to-day working practices of Sanjiang Plain wetlands and watershed resources managers.

Topic/Issue of Concern	Capacity Building Needed	Best Practice Needed	Comment
Integrated Water Resource Management			
The Asian Development Bank's 25 elements of integrated water resources management in river basins (i.e., watersheds)	✓ Set up working groups to develop policy for implementing the remaining elements	✓ Meeting the Asian Development Bank's best practice	Complete the remaining 40% of elements not fully embedded into agency work practices on the Sanjiang Plain.
Upstream thinking and action	✓ Create awareness of upstream thinking and the fact that wetlands cannot be managed in isolation from the rest of the watersheds	✓ Use upstream thinking to develop and implement better land-use management practices to reduce nonpoint pollution	The wetlands of Sanjiang Plain are at risk from the effects of land-use practices, high up in the watersheds. The idea is to raise awareness among land users (normally farmers or land managers) of their land-use practices that are causing nonpoint pollution and then to advocate the use of better land-use practices that will have both on-site and off-site benefits. This is a very cost-effective way of changing poor land-use behavior and thereby mitigating nonpoint pollution.
Contiguous biodiversity corridors	✓ Create awareness of the value and use of biodiversity corridors	✓ Plan and build contiguous biodiversity corridors from the main headwaters through the plain to the wetlands	With joined-up thinking and action, it is suggested that riparian planting is used to create a series of contiguous biodiversity corridors from the forest reserves through the middle reaches to the lower-reach wetlands. This will mitigate nonpoint pollution and make the ecosystem from the forest reserves to the lower-reach wetlands more robust and reduce the vulnerability of biodiversity becoming isolated in fragmented reserves.

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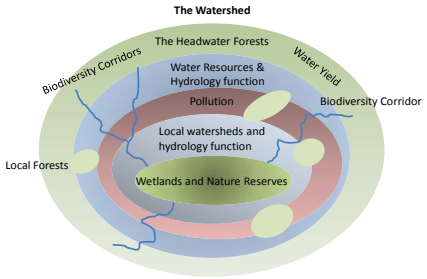
Appendix 4 Table *continued*

Topic/Issue of Concern	Capacity Building Needed	Best Practice Needed	Comment
Visual aids			*This riparian and biodiversity corridor is a lifeline for water, plants, and wildlife, from the forests through the Sanjiang Plain to the nature reserves and wetlands. Please protect it.* 
Hydrology			
Loss of hydrology function	✓ Principles of applied hydrology	✓ Managing the hydrological status both inside and outside the reserve at the same time	Needs more attention in considering changes to water use and allocation. Conservation effectiveness of wetland reserves is determined by both the management intensity inside the reserves and the hydrological status outside the reserves. Therefore, differences of ecological functions inside and outside the reserves are an integrated indicator for assessing conservation effectiveness and were the subject of a study of wetland nature reserves in Sanjiang Plain.
Water quality standards and monitoring	✓ Create awareness of the standards Create awareness and introduce "trend line" water quality monitoring	✓ Enforcement of existing standards Embed "trend line" monitoring into day-to-day work practices	The de facto Class IV water standard for phosphorus and nitrogen is unsatisfactory as there is no buffer against further lowering of water quality, and it represents a high level of risk to the wetlands. Hence, progress toward reducing water pollution in wetlands and setting a target for the improvement to Class III standard would provide a buffer against future deterioration in water quality and protect the fishery values of the wetlands. Current water-quality monitoring is inadequate for effective management purposes. General monitoring results showing a static Class IV standard water quality are meaningless as they give no indication of trends in wetland water quality which are suspected of deteriorating from significant fish kill events in the wetlands. Trend line monitoring needs to be embedded as the best practice into water quality work programs.

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Appendix 4 Table *continued*

Topic/Issue of Concern	Capacity Building Needed	Best Practice Needed	Comment
Water-saving practices	✓ Use and application of water-saving measures	✓ Develop best practice for Sanjiang Plain	Agricultural water use presents the highest potential management opportunities for implementing water-saving practices in, for example, water use for irrigation. Agricultural use accounts for more than 80% of total water use in Sanjiang Plain and is expected to continue to increase in the future because the irrigated paddy acreage is still expected to increase. Hence, the need for advocating better land-use practices in the sense of reversing the current land-use practices of using and polluting too much water. A major worry is that not all land users have utilized the opportunity of taking water from the new facility. Hence, the full impact on the wetlands of the full utilization of water withdrawals from this newly built infrastructure is yet to be seen. Public investment in irrigation infrastructure needs to be coupled with public/farmer education to raise awareness of the ecological consequences of water overuse and the ways to prevent it.
Wetland fragmentation	✓ Create awareness of risks of further fragmentation	✓ Avoid further fragmentation	A major ongoing risk to wetlands is their fragmentation. The gap of a contiguous network of wetlands exposes each of them to a separate and higher risk of not receiving a fair allocation of the hydrological resource of the watersheds of Sanjiang Plain.
Water Resources			
Stakeholder consultation	✓ Introduce "bottom-up" stakeholder consultation into work practices	✓ Use both "top-down" and "bottom-up" stakeholder consultation at the same time	A major weakness of the current water resources practices is the emphasis on "top-down" stakeholder consultation. Best practice integrated water resources management envisages both "top-down" and "bottom-up" stakeholder consultation to ensure downstream communities and other interest groups have input into the stakeholder consultation process.
Water quality improvement and management	✓ Progressively introduce water quality improvement plans Progressively introduce water quality management plans	✓ Produce water allocation plans and water quality improvement plans at the same time Produce water quantity management plans and water quality management plans at the same time	A second major weakness of the current water resources practices is the absence of water quality improvement plans or water quality management plans to accompany the water allocation plans for water quantity. Normal best practice would see these plans as "twins" to be prepared and implemented together. Knowledge of the pollutants reaching the wetlands would provide the basis for the development of improved watershed management plans through the development of associated water quality management plans. Such plans should incorporate measures to address point pollution by better urban and rural wastewater and storm water systems, and nonpoint pollution by better land-use management practices.

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Appendix 4 Table *continued*

Topic/Issue of Concern	Capacity Building Needed	Best Practice Needed	Comment
Pollution from Upstream Sources			
Water pollution monitoring	✓ Develop site-specific metrics for establishing the quantity and quality of pollutants reaching the wetlands	✓ Ongoing use of site-specific metrics for key wetlands	Metrics on the quantity and quality of water pollution reaching wetlands is scarce; there are water bodies at two nature reserve sites, the small Xingkai Lake (at Xingkaihu NR) and the Crescent Lake (at Zhenbaodao NR), where the local physical features provide opportunities to measure the impacts of pollution through ongoing water quantity and quality monitoring
Forest Management Improvement			
Planting the "right" tree in the "right place" in the watershed	✓ Raise awareness and embed into day-to-day work practices	✓ Consolidating existing proven practice	Planting the right tree in the right place is vital to avoid poor planting results, more potential land disturbance during a second replanting, higher establishment costs, less than optimal forestry yields at harvest, and poor economic returns. Examples of the right tree in the right place in Heilongjiang are spruce, dahurian larch, poplar, and birch. Conversely, eucalyptus is an example of the wrong tree in the wrong place in Heilongjiang province. It is likely to be easier to target parts of the landscape for reforestation under a "farm forestry" or agroforestry approach, rather than broad area or whole-farm planting. New landscape-scale plantations on flat or shallow slope grasslands, croplands, or farmlands are not recommended because of the huge impact on water yields.

APPENDIX 5
Applying an Ecosystem-Based Management Approach in the Sanjiang Plain Wetlands—A User's Manual

Introduction

A carefully tailored, integrated set of approaches is required to respond to the complex set of challenges, constraints, and opportunities that characterize the environment and development situation in the Sanjiang Plain wetlands.

Identifying the optimal means to achieve integrated, sustainable environment management and economic development requires attention to the biological, hydrological, socioeconomic, policy, and regulatory conditions that in combination, define the situation.

To optimize potential for success, integrated conservation and development approaches minimize incompatibilities among the various sector objectives, seeking to harmonize and create synergies among them.

Ecosystem-based approaches take account of all sector-specific characteristics in relation to the various ecological domains that constitute the Sanjiang Plain ecosystems.

Sustainable ecosystem management depends on how an area is used to produce essential economic outputs while nurturing and preserving natural ecosystem services.

Ecosystem-based management (EBM) plans represent a coordinated strategy which aims to ensure sustainable resource utilization while minimizing negative impacts on critical ecozones and species. Satisfactory and reliable livelihoods are linked with ecological protection.

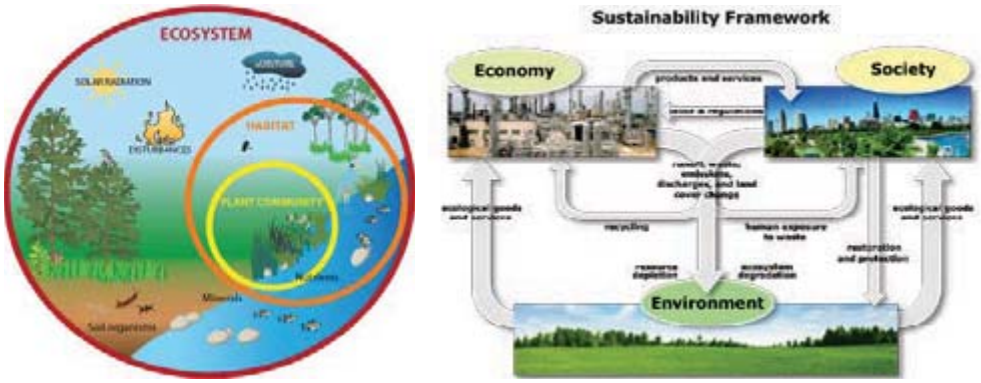
Harmonizing sustainable use and conservation is the basis for integrated, sustainable economic development and environment management.

Ecosystem-Based Management

While delivering a range of socioeconomic benefits within the limits of ecosystem sustainability, EBM plans maximize capacity to provide vital ecosystem services in ways that resemble the functioning of the original undisturbed ecosystems.[1]

[1] These functions include, for example, habitat and biodiversity maintenance; soil production, anchoring, and soil erosion control; hydrological regulation, and flood and drought mitigation; climate regulation; preservation of pest–predator balance; and natural maintenance of ecosystem productivity.

Figure A1: Interactions within and among Natural, Social, and Economic Systems Are Complex



Ecosystem-based approaches decipher this complexity to enable design of sustainable management regimes suited to local conditions.

Source: https://gfsgeog.wordpress.com/ and EPA's Report on the Environment: External Review (draft), cfpub.epa.gov.

To achieve these objectives, a coordinated and harmonized set of multiple-use scenarios is required.[2]

EBM can be described as "an integrated area management approach that considers the entire ecosystem, including humans."

EBM is not a static approach. It requires continual fine-tuning and adaptation to remain relevant in the context of changing socioeconomic demands and values, policy constraints, and opportunities, at the same time responding to dynamic changes in hydrology and water quality, habitats, and species.

To achieve this responsiveness, ecosystem management is linked practically to an *adaptive management framework*.

Through a cyclical process of planning, implementation, and periodic reassessment of conditions and results, adaptive management enables response to socioeconomic and demographic shifts, climate change, and the impacts of ongoing activities and interventions.[3] Iterative planning and adaptive management respond to these ongoing changes and uncertainties.

[2] Ecosystem-based management differs from a single-species or single-sector approach to management by considering complex interactions between humans and the living and the nonliving environment over multiple scales in space and time. The goal of ecosystem-based management is to sustainably manage target and nontarget species, by preserving or restoring habitat quality to desired future conditions. These conditions integrate ecological, socioeconomic, and institutional perspectives and are applied within a geographic framework defined primarily by natural ecological boundaries. It is based on a collaboratively developed vision of future desired conditions that maintain ecosystem services for long-term sustainability.

[3] The ecosystem approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning. The ecosystem approach does not preclude other management and conservation approaches, such as biosphere reserves,

The EBM toolkit includes methods for examining options and scenarios with the aim of anticipating the consequences that different management decisions will have on natural resources, people, and the economy.

The substantive involvement of interested and affected stakeholders in EBM planning is also an integral facet of EBM.

EBM emphasizes connectivity within and between systems, such as uplands and lowlands, watersheds and wetlands, hydrology and habitats, focusing on the consequences of human activities and their environmental impacts on adjacent or linked ecosystems.[4]

Compared with conventional environment management and conservation approaches in which the environment is of paramount concern, EBM involves a shift to a more comprehensive set of considerations, including the economy and society.

The ecosystem-based approach for integrated natural resource management takes into account the entire system, including its natural, physical, and ecological attributes; interrelationships among components of the ecosystem; and the interaction between natural, socioeconomic, and institutional systems.

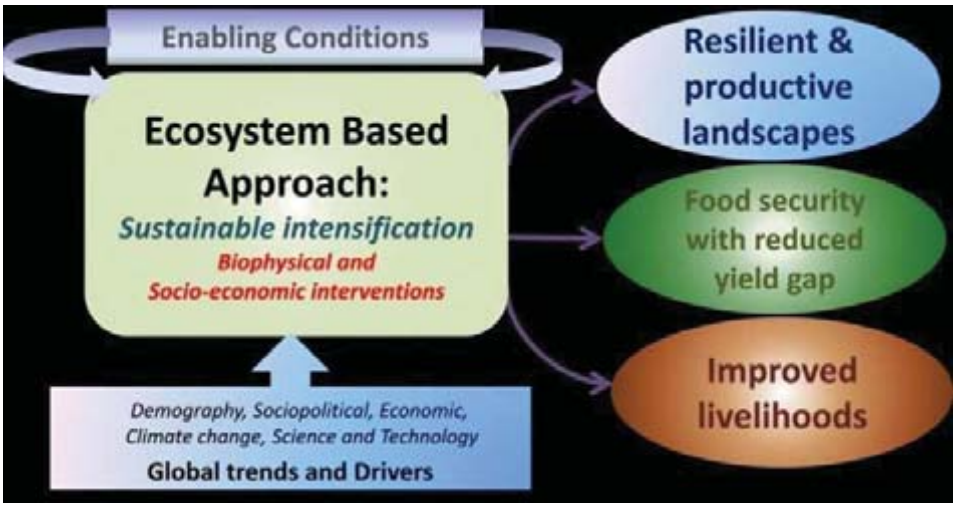
Figure A2: Ecosystem-Based Management Involves a More Comprehensive Set of Considerations Compared with Conventional Conservation Science

Source: United Nations Environment Program. http://www.unepscs.org/Wetlands_Training/Wetland%20Management/14-Ecosystem-Approach-Wetlands-Management-Presentation.pdf

protected areas, and single-species conservation programs, as well as other approaches carried out under existing national policy and legislative frameworks but could, rather, integrate all these approaches and other methodologies to deal with complex situations. http://www.unepscs.org/Wetlands_Training/Wetland%20Management/14-Ecosystem-Approach-Wetlands-Management-Presentation.pdf

4 P. Clarke and S. Jupiter. 2010. *A Guide for Conservation Practitioners in the Tropical Western Pacific*. Suva, Fiji; Bronx, NY: World Conservation Society.

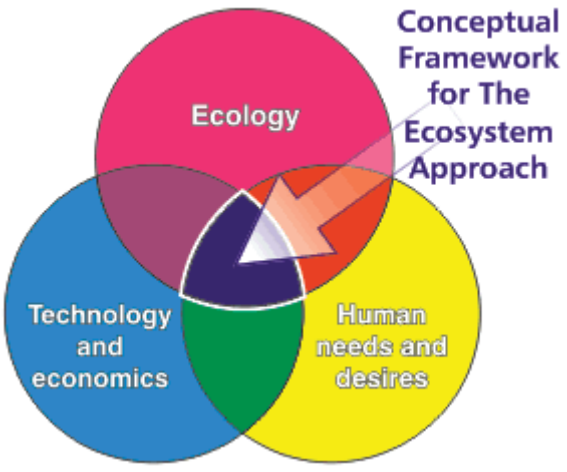
Figure A3: In the Ecosystem-Based Management Approach, Environmental Concerns Are Contextualized within a Wide Range of Objectives and Variables



This holistic, extended systems approach is more realistic and comprehensive, and therefore more effective.

Source: http://ciat.cgiar.org/soils-2-2/ecosystems-based-approaches-needed-to-build-resilient-landscapes-and-prevent-future-famines

Figure A4: Basic Conceptual Framework for the Ecosystem-Based Management Approach



Source: G. K. Meffe et al. 1997. *Principles of Conservation Biology, in Kulvadee Kansuntisukmongkol, Ecosystem Approach to Wetlands Management*. http://www.unepscs.org/Wetlands_Training/Wetland%20Management/14-Ecosystem-Approach-Wetlands-Management-Presentation.pdf

Ecosystem-Based Management Approaches for Effective Wetlands Planning and Management

Conservation science has tended to focus project planning and management efforts on individual discrete ecosystems, such as wetlands, forests, or coastal and marine areas. Increasing recognition of the need for a more holistic way to consider and address the complex interactions between neighboring natural systems, and between natural and social systems, has led to the development and adoption of the EBM approach.[5]

Figure A5: Upland and Lowland Ecosystems Are Closely Interlinked

Proper management of hill forests and watershed vegetation is essential to maintain sufficient flows of clean water to service wetlands habitats as well as for agricultural and economic production activities and human settlements.

Source: http://iwlearn.net/iw-projects/2706/photos/mauritius-integrated-aquifer-management/image_large

From an ecosystems-based perspective, upland–lowland/forest–basin relationships are encompassed in a broad purview of the system in its entirety. Interactions among key natural, social, economic, and governance system components form an integrated whole. The impacts of natural processes and human activities on the various components of the system must be considered, and accorded due attention to sustainably manage the ecosystem in its totality.

[5] A similar shift toward a more holistic approach has occurred in hydrological science with the adoption of integrated water resource management or IWRM. See, for example: Global Water Partnership (www.gwp.org). *A Handbook for Management and Restoration of Aquatic Ecosystems in River and Lake Basins* (No.3, 2015). http://www.gwp.org/Global/ToolBox/References/aquatic%20ecosystems.pdf

This is because of the interlinkages within and among natural systems and the relationships between natural and social systems.

Examination of upland–lowland relationships and interactions provides a simple illustration. Maintaining upland watersheds is essential for their hydrological integrity, which, in turn, is vital for the steady and reliable flow of water to low-lying wetland ecosystems, human settlements, and for economic production activities. The health of lower elevation ecological and social systems depends on proper management of higher elevation forest and hill ecosystems.

Economic production activities located above low-lying wetlands basins may contribute toxic effluent flows to the wetlands below. Insufficient regulation of upland activities then results in damage to wetlands habitats and species, and also leads to the disruption of vital ecological services that the wetlands provide for sustaining society's economic and material needs .

Multiple-Use Zoning for Environmental Conservation and Sustainable Economic Utilization

Given the interrelationships and interactions among components of a given ecosystem and among related ecosystems, multipurpose, multiple-use zoning is employed to designate what is permitted and what is not in various portions or zones within the overall ecosystem. Each zone is associated with regulations that govern the utilization or setting aside of areas for a range of conservation purposes.

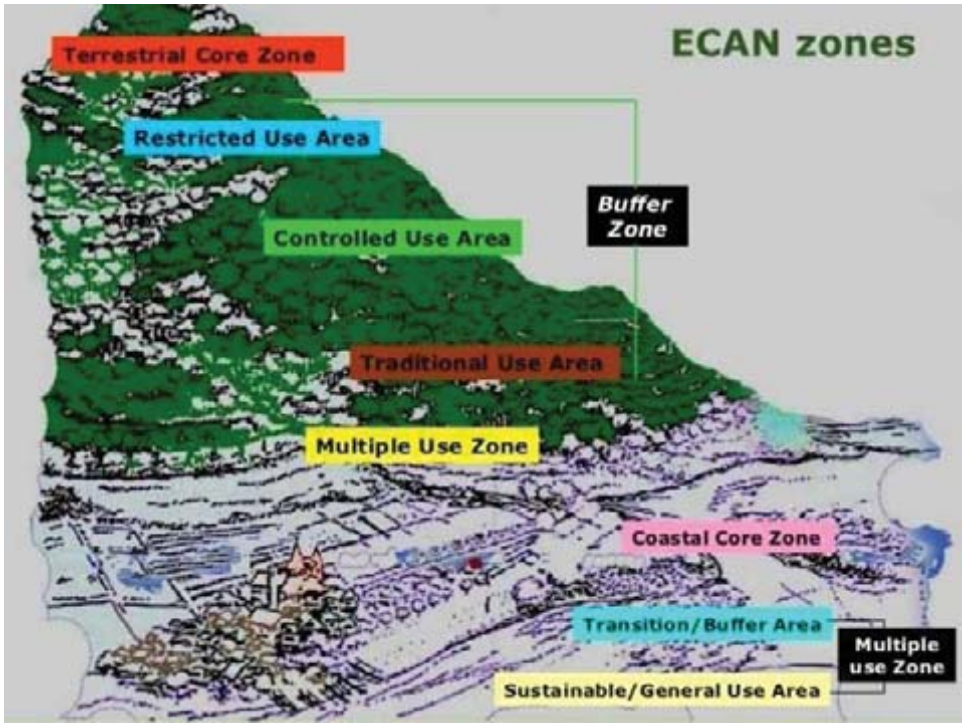
Even within the "economic" zones, sustainable environmental management is required to ensure that activities in these zones do not adversely impact either the local ecology or conservation areas to which they are linked.

Multiple-use zoning aims to harmonize environmental conservation objectives with economic production. Agricultural production zones, for example, often stipulate maximum application rates for agricultural chemicals to protect conservation core zones from toxic runoff. Buffer zones separating the agricultural production zones from downstream conservation core zones are designed to mitigate negative impacts, for example, by filtering chemical residues from overland water flows.

EBM anticipates potential negative environmental impacts, mitigating them to the maximum possible extent as part of the overall sustainable ecosystem management plan.

The result is systematic integrated development and conservation.

Figure A6: Map Showing Multiple-Use Zoning for Integrated Conservation and Development



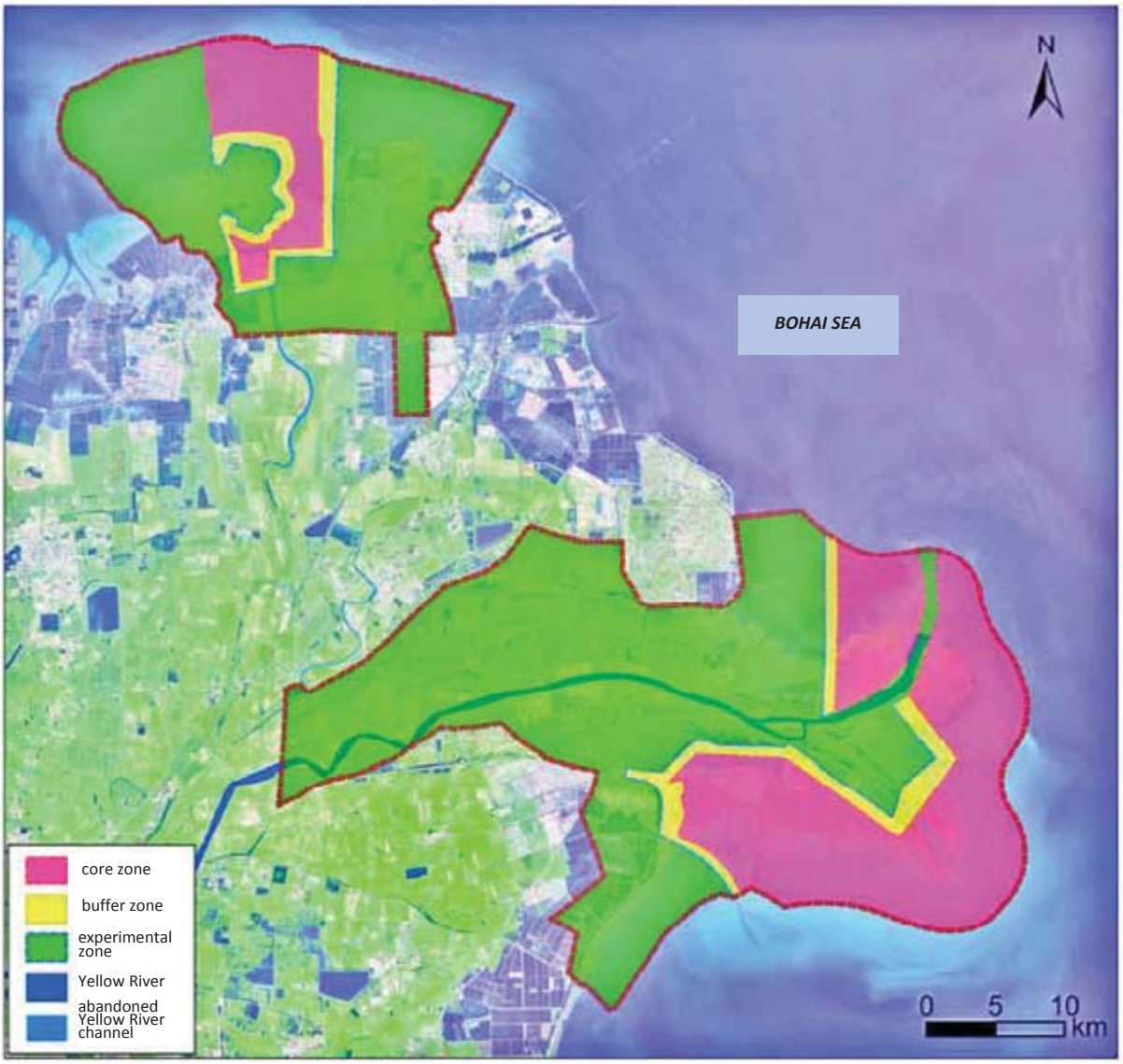
Source: J. Pontillas. 2011. *Role of UNESCO's Man and Biosphere Reserves in Climate Change Adaptation*. UNESCO Man and the Biosphere Program. http://www.slideshare.net/no2mininginpalawan/pontillas-j-role-of-unescos-man-and-biosphere-reserves-in-climate-change-adaptation

Ecosystem-based management emphasizes the protection and restoration of ecosystem structure, function, and key processes, and integrates biological, socioeconomic and governance perspectives. Use of land and resources may result in significant alteration of ecosystems, disrupting connectivity within and between habitats. Ecosystem modifications may reduce their health, productivity and resilience, and must be managed to ensure ongoing preservation of ecosystem services.[6,7]

[6] A. A. Rosenberg and K. McLeod. 2005. Implementing Ecosystem-Based Approaches to Management for the Conservation of Ecosystem Services. *Marine Ecology Progress Series*. 300. pp. 241–296.

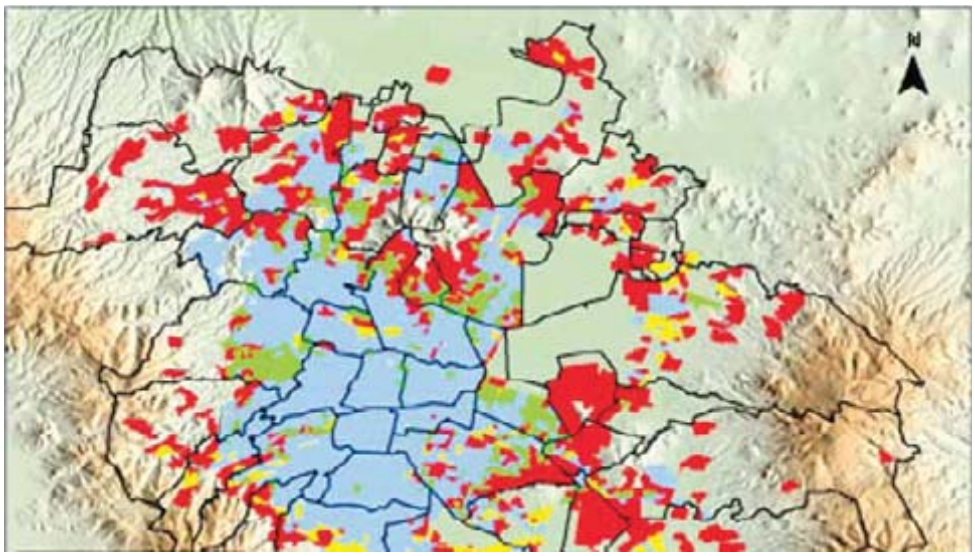
[7] K. L. McLeod and H. M. Leslie. eds. 2009. Why Ecosystem-Based Management? In *Ecosystem-Based Management for the Oceans*. Washington, DC: Island Press. pp. 3–12.

Figure A7: Zonation Plan, Shandong Yellow River Delta National Nature Reserve (PRC) Showing Core, Buffer, and Experimental Zones



Source: Courtesy of Mingxiang Zhang, Beijing Forestry University, Beijing. 2015 (unpublished).

Figure A8: Color Coding of Management Zones within a Multiple-Use System: Each Zone is Associated with Specific Regulations Designed to Ensure Sustainable Management, Minimizing Negative Impacts on Protected Areas and Resources



Source: U.N. World Tourism Organization Network. Sustainable Development of Tourism. http://sdt.unwto.org/en/content/tourism-and-wetlands

Multiple-use zoning is a strategic tool for ecosystem-based planning and management. The zoning system is developed based on scientific knowledge of the ecosystem, its characteristics, and component interactions. This knowledge is complemented by collaborative stakeholder problem assessment and planning, which taps local knowledge and enables stakeholders' preferences and objectives to be factored into area management plans.

Zoning accords special attention to the preservation or restoration of ecological integrity in areas critical for preserving natural ecological processes, services, species, and habitats (conservation core zones). "Buffer" or "economic zones" within or adjacent to the core zones protect the core zones from negative impacts. The location and nature of economic activities is managed such that adverse impacts on protected area resources and ecology are minimized. What is and is not permitted is specified in the overall management plan with regard to each management zone.

Figure A9: Permitting Low-Intensity Multiple Uses in a Wetlands Conservation Area

Enabling local people to benefit from conservation and multiple use helps to ensure their support for successful implementation.

Source: TripAdvisor website. (n.d.). Govuro wetlands, Mozambique. https://www.tripadvisor.co.uk/LocationPhotoDirectLink-g479219-d7290558-i143262751-South_East_Africa_Safaris_Vilanculos_Canoe_Trails-Vilanculos_Inhambane_P.html

Although hunting and egg collection may be strictly prohibited in designated portions of protected wetlands, low-intensity fishing or aquatic vegetable and herb collection for household subsistence may be permitted in other areas based on scientific considerations. Strict protection and prohibition of human entry is required in critical portions of the ecosystem where, for example, bird mating, nesting, brooding, and rearing are concentrated. This "dual approach" contributes to achieving conservation objectives, while reducing difficulties associated with patrolling, interdiction, and prosecution.

Stakeholder Consultation and Collaboration on Planning and Adaptive Management Are Integral to Effective Ecosystem-Based Management

Throughout all stages of development, EBM ensures that multiple-use goals and targets incorporate the social dimensions of resource use and ecosystem values. These goals and targets should reflect a common vision among stakeholders and be iteratively informed and adapted based on learning and experience.

The involvement of interested and affected stakeholders is an integral part of EBM. Stakeholders are consulted during the planning process and their expressed needs and objectives are reflected in management plans. Since EBM planning is an iterative process, stakeholders have a role to play throughout.

Substantive stakeholder involvement enables projects to draw on a wide range of knowledge and experience including that derived from local residents.

A perception is built among stakeholders that they are "part of the program," as reflected by the inclusion of their expressed objectives and project design preferences in the management plan.

The ongoing role of stakeholders in planning and management helps to mobilize a broad-based constituency sharing a common stake in ensuring that plans and projects succeed.

Adaptive management essentially means learning-by-doing, that is, applying lessons from experience to fine-tune and improve implementation plans, while responding to ecosystem, socioeconomic, and policy changes.

The adaptive management process involves assessing stakeholders periodically, identifying newly emerging opportunities, countering constraints that arise, and assimilating changes occurring as a result of program implementation.

The results of these periodic assessments provide the basis for modifying implementation plans so that they remain optimally adapted and tailored to achieve expected results.

Figure A10: Simplified Diagram Illustrating the Adaptive Management Project Cycle

Source: British Columbia, Canada: Ministry of Forests. https://www.for.gov.bc.ca/hfp/amhome/Admin/index.htm

Figure A11: A More Detailed Illustration of the Adaptive Management Process

Source: Parks and Wildlife Service, Tasmania (Australia): http://www.parks.tas.gov.au/indeX.aspX?base=575

Adaptive management (sometimes referred to as "agile management" because of rapid processing and response to new information and change) enables projects to learn from experience and to adapt by incorporating what is being learned into a new cycle of planning. Based on regular review of experience and generation of lessons learned, projects implement timely adaptations. In this way, implementation remains consistent with real-time conditions, opportunities, and constraints. As a result of this agility, outcomes are significantly improved.

Strategic Environmental Assessment, Integrated and Harmonized Multisector Planning

Strategic environmental assessment (SEA) is another key tool used to support environmentally sustainable conservation and development decision making. SEA takes as its starting point an understanding of the current environmental, socioeconomic, and policy framework in a designated (project) area, and its relationship to resource utilization and management.

Setting targets aimed at improving both environmental and human well-being, SEA poses potential scenarios hypothesized as being potentially effective for bringing about the range of changes and improvements identified by program targets.

The alternative scenarios are then analyzed (sometimes using mathematical modeling) to determine the extent to which each proposed set of interventions is likely to achieve the desired results.

SEA can be used to evaluate the environmental effects of a proposed policy, plan, or program and its alternatives, and to inform strategic decision making through a careful analysis of environmental risks and opportunities.[8]

> **Strategic environmental assessment** is a systematic decision-support process which aims to ensure that environmental and other sustainability aspects are considered effectively in policy, planning, and program development. It facilitates environmental integration and the assessment of the opportunities and risks of a proposed set of strategic actions in a sustainable development framework. The planning of strategic actions is often strongly linked to the formulation of policies and is developed in a context of planning and programming procedures. Strategic environmental assessment is a scientifically rigorous, participative, open, and transparent process based on environmental impact assessment.[9]

SEA facilitates the integration of environmental considerations early in the project planning and policy formulation processes to identify measures that will enhance positive environment and development impacts and mitigate the negative ones.

Importantly, SEA enables consideration of the cumulative environment and development effects of a host of interventions being planned that will have cascading effects on a number of interrelated socioeconomic and environmental systems.

Effective SEA works within a structured and tiered decision framework aimed at supporting more effective and efficient decision making for sustainable development and improved governance by providing for a substantive focus on questions, issues, and alternatives to be considered in policy, planning, and program design (footnote 9).

The scope of SEA includes physical, ecological, social, cultural, and economic aspects to the extent that they are relevant in determining the quality of the context in which we live and the risks and opportunities for sustainable development.

The objectives of SEA are to

(i) ensure the integration of environmental, social, and economic aspects in planning, programming, and policy-making processes;
(ii) identify opportunities and risks, assess and compare alternative development options; and

[8] Environment Canada. https://www.ec.gc.ca/ee-ea/default.asp?lang=En&n=A01CABBD-1
[9] Maria do Rosário Partidário. 2007. Strategic Environmental Assessment Good Practices Guide-methodological guidance. Portuguese Environment Agency, Amadora. http://www.apambiente.pt/_zdata/Divulgacao/Publicacoes/Guias%20e%20Manuais/SEA_guide.pdf

Figure A12: Based on Designated Environment and Development Targets, Strategic Environmental Assessment Assesses the Potential for Various Sets of Ecosystem Management Options to Deliver Expected Results

Oregon State University website. http://oregonstate.edu/dept/range/sites/default/files/EcologicalProvincesOfOregon/coast.htm

Changes in land and resource use in one portion of an ecosystem often impact upon contiguous ecosystems. These impacts may be amplified as they move "downstream" along a cascading continuum. Deforestation, for example, increases soil erosion, causing river sedimentation, which, in turn, increases the risk, frequency, and severity of flooding. Depending on flood frequency, extent, and severity, damage to downstream productive resources and assets is amplified. Strategic environmental assessment considers the potential for these cumulative impacts. Ecosystem-based management plans are designed so that in total, component sets of activities preempt potential for cascading negative impacts and contribute instead to sustainable development and conservation.

(iii) contribute to establishing a development context appropriate for guiding future development proposals.

Through these objectives, SEA contributes to identifying, selecting, and justifying win–win options relative to environmental and development objectives, and to discussion of major environmental, social, and economic options (footnote 9).

Summary

The diverse components of natural and human-modified ecosystems comprise a complex web of interrelationships. The goals and objectives of environmental conservation and economic development often compete or conflict with one another. To achieve sustainable economic development and environmental conservation, these conflicts must be resolved and objectives and methods for environment development must be harmonized.

The complexity of achieving integrated multiuse environmental management in the context of sustainable economic development is insufficiently addressed by conventional conservation science. EBM provides a holistic and inclusive approach for managing this complexity.

EBM aims to maintain or restore the composition, structure, and functions of natural and modified ecosystems with the goal of ensuring long-term ecosystem sustainability in concert with prosperity for the human populations dependent on them.

EBM draws upon knowledge and experience of interested and affected stakeholders by engaging them in a collaborative effort to formulate a shared vision of desired future ecological and socioeconomic conditions. Stakeholders then design EBM plans that aim to optimize sustainable natural resource use while conserving and restoring species, habitats, and ecological services in ways that fulfill human socioeconomic requirements.

SEA is a tool for assessing a range of environmental, management, and development options. In the context of EBM, SEA helps stakeholders to understand the benefits and impacts of various alternative management scenarios.

On the basis of this understanding, actions considered best-suited to achieve the collaboratively agreed objectives (the EBM Plan) are selected for implementation.

Since socioeconomic and ecological changes are inevitable, EBM applies a process of adaptive management. Adaptive management involves periodic progress monitoring to draw lessons from project implementation, assess progress, and analyze constraints and opportunities against a backdrop of dynamic ecological and socioeconomic conditions.

Insights gained as a result of this ongoing learning process are used to inform modifications of EBM plans. This enables the suitability of the plans to be continually optimized for achieving the agreed objectives.

APPENDIX 6
List of Persons Consulted

No.	Name	Title	Office/Agency
1	An Rui	Section Chief	Wetland Conservation Center, Forestry Department
2	Chen Wenfeng	Deputy Chair	Northeast Branch, Chinese Traditional Culture Research Association (Qixinghe)
3	Cheng Shaoxia	Project Director	Heilongjiang Provincial Forestry Department/PMO
4	Cui Shoubin	Chief of Monitoring and Research Division	Qixinghe Nature Reserve
5	Ding Cheng	Section Chief	Naolihe Nature Reserve
6	Dong Yinglai	Director	Qixinghe Nature Reserve
7	Feng Minxiu	Deputy Director	PMO, Forestry Department
8	Feng Shangzhu	Director	Xingkaihu Nature Reserve
9	Fu Hongchen	Staff Member	Sanhuanpao Wetland Nature Reserve
10	Gao Ruirui	Project Director	Green Longjiang (NGO)
11	Gu Qinghua	Director General	Dajiahe Nature Reserve
12	Han Dongming	Section Chief	PMO, Forestry Department
13	He Jingshi	Director General	Anbanghe Nature Reserve
14	Hu Guishan	Enforcement and Inspection	Qixinghe Nature Reserve
15	Huang Junyang	Deputy Director	Flora and Fauna Management Division, Heilongjiang Forestry Department
16	Huang Limin	Science Staff	Qixinghe Nature Reserve
17	Huang Shuxia	Deputy Director General	Anbanghe Nature Reserve
18	Jiang Weihua	Director General	Suibin Liangjiang Nature Reserve
19	Jin Leshan	Professor	China Agricultural University
20	Kang Tiedong	Deputy Director	Heilongjiang Wetland Conservation Center
21	Garrett Kilroy	Evaluation Specialist, Independent Evaluation Department	Asian Development Bank
22	Yoshiaki Kobayashi	Senior Water Resources Specialist, Environment, Agriculture, and Natural Resources Division	East Asia Department, Asian Development Bank
23	Li Chuanguang	Deputy Director General	Sanjiang Nature Reserve
24	Li Hongpeng	Deputy Director General	Suibin Liangjiang Nature Reserve

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Appendix 6 Table *continued*

No.	Name	Title	Office/Agency
25	Li Jia	Section Member	PMO, Forestry Department
26	Li Jibo	Chief of Monitoring and Research Division	Anbanghe Nature Reserve
27	Li Jinling	Head of Communication Division	Xingkaihu Nature Reserve
28	Li Weina	Section Member	PMO, Forestry Department
29	Li Xiaomin	Professor	Northeast Forestry University
30	Li Yingjiu	Head of Nature Reserve Patrolling	Xingkaihu Nature Reserve
31	Jeffrey Liang	Principal Economist, Office of the Director General, East Asia Department	Asian Development Bank
32	Liu Huajin	Head of Scientific Research Institute	Xingkaihu Nature Reserve
33	Liu Tao	Ecological Project Officer	Green Longjiang (NGO)
34	Liu Yuxiang	Deputy Director	Heilongjiang Finance Department
35	Lu Yunfeng	Principal Staff Member	Environmental Protection Department
36	Ma Yun	Director	Xiaobeihu Nature Reserve
37	Ma Zhong	Dean	Renmin University of China
38	Peng Hui	Deputy Director	Water Resources Department
39	Quan Wuxian	Professional Engineer	Heilongjiang Provincial forestry Department/PMO
40	Shang Di	Deputy Head of Nature Reserve Patrolling	Xingkaihu Nature Reserve
41	Su Liying	Director	International Crane Foundation
42	Su Zhaozhe	Deputy Director	Anbanghe Nature Reserve
43	Sun Minghu	Deputy Director	Dajiahe Nature Reserve
44	Sun Shufen	Section Chief	PMO, Forestry Department
45	Sun Weibin	Director	Flora and Fauna Management Division, Forestry Department
46	Sun Wen	Science Staff	Qixinghe Nature Reserve
47	Sun Yonggang	Director	Office of Heilongjiang Forestry Department
48	Sun Yubo	Deputy Director	Qixinghe Nature Reserve
49	Teng Huajun	Chief of Research, Communication and Education Division	Dajiahe Nature Reserve
50	Teng Xing	Deputy Director	Institute of Agriculture Reclamation Survey and Design
51	Tian Yafang	Principal Staff Member	PMO, Forestry Department
52	Wan Jie	Director	State Forestry Administration
53	Wang Chao	Secretary	Qixinghe Nature Reserve

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Appendix 6 Table *continued*

No.	Name	Title	Office/Agency
54	Wang Hongbin	Section Chief	PMO, Forestry Department
55	Wang Jianfeng	Section Chief	Fisheries Bureau, Agriculture Committee
56	Wang Jinwu	Deputy Director General	Naolihe Nature Reserve
57	Wang Renchun	Director	Heilongjiang Wetland Conservation Center
58	Wang Shengli	Chief of Finance Division	Qixinghe Nature Reserve
59	Wang Xiaoming	Director	Development Planning Division, Forestry Department
60	Wang Xijun	Deputy Director	Provincial Development and Reform Commission
61	Wen Jijuan	Senior Engineer	Institute of Water Resources Design
62	Wu Zhibo	Chief of Production Division	Qixinghe Nature Reserve
63	Xie Bin	Section Chief	PMO, Forestry Department
64	Xue Yongjun	Engineer	Institute of Agriculture Reclamation Survey and Design
65	Ye Shengxin	Director	Institute of Forestry Survey and Design
66	Yu Wentao	Head of Environment Protection	Xingkaihu Nature Reserve
67	Yu Zhihao	Director	Development Planning Office, Forestry Department
68	Yu Zhimiao	Section Chief	Environmental Protection Department
69	Zhang Fengshan	Deputy Director	Dajiahe Nature Reserve
70	Zhang Hongjun	Deputy Researcher	Agriculture Committee
71	Zhang Jie	Researcher	Tourist Administration
72	Zhang Qingfeng	Director, Environment, Agriculture, and Natural Resources Division	East Asia Department, Asian Development Bank
73	Zhang Xiguo	Deputy Director General	Zhenbaodao Nature Reserve
74	Zhang Xuewu	Deputy Director General	Heilongjiang Provincial Forestry Department
75	Zhao Xudong	Deputy Director	Anbanghe Nature Reserve
76	Zhao Yongsheng	Administrator	Qixinghe Nature Reserve
77	Zhao Yue	Deputy Director	Wokenhe Nature Reserve
78	Zheng Zhigang	Director General	Sanjiang Nature Reserve
79	Zhu Ronghua	Chief of Education and Communication	Anbanghe Nature Reserve

NGO = nongovernment organization, PMO = project management office.

APPENDIX 7
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Reviving Lakes and Wetlands in the People's Republic of China, Volume 3
Best Practices and Prospects for the Sanjiang Plain Wetlands

The Sanjiang Plain wetlands are among the most important wetlands in the People's Republic of China with unique habitats, species, and ecology. There is a considerable body of literature devoted to various aspects of the Sanjiang Plain wetlands including their ecological values. Building on lessons from the Sanjiang Plain Wetlands Protection Project supported by the Asian Development Bank and the Global Environment Facility—and based on a comprehensive literature review and discussions with experts who have been directly involved in wetland conservation efforts—this publication synthesizes current knowledge on the Sanjiang Plain wetlands, best practices, and options for achieving sustainable wetland management.

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