

its transboundary nature, with no preference implicit in the order of the names. Its basin is a part of the Wusuli/Ussuri drainage basin, which is part of the larger Heilong/Amur basin (also given in Chinese/Russian order), ultimately draining into the Sea of Okhotsk. The lake actually consists of two lakes: the small, northern Chinese Xiaoxingkai (small Xingkai) and the main Lake Xingkai/Khanka.

Although the lake is located in a relatively remote area, its basin is a significant source of agricultural products for both countries, providing livelihoods and water resources for the local inhabitants. There is evidence that the basin has been settled since Neolithic times. Much of the land use in the basin is either forest or agriculture. The lake is also important for its biodiversity and role as a habitat for animal and plant species, including the red-crowned crane (*Grus japonensis*), white-naped crane (*Grus vipio*), and oriental white stork (*Ciconia boyciana*).

The most important features affecting the ecological uniqueness of the Lake Xingkai/Khanka drainage basin include the territory's relief characteristics and geological structure; the distinctive monsoon climate with its constant possibility for catastrophic sequences of different natural phenomena (floods, typhoons, soil erosion); the uneven nature of its economic development; and the concentration of anthropogenic pressures in the region conducive to zones of ecological distress. Because of the environmental and economic importance of the Lake Xingkai/Khanka Basin to both China and Russia, crucial issues for the population of the region include: wetland conservation and management; water quality control (particularly nutrients and pesticides from agricultural runoff); groundwater protection; and water use for irrigation, drinking water and fishing.

According to current information, the main environmental problems facing Lake Xingkai/Khanka include the following:

- Its wetlands and moorlands are vanishing quickly due to over-reclamation, causing destruction of the eco-environment and aggravating soil erosion;
- Precious animal and plant resources are being destroyed in the catchment, with the numbers of rare wild animals and plants falling rapidly; for example, the oriental white stork (*Ciconia boyciana*), red-crowned crane (*Grus japonensis*) and Xingkai pine on the verge of extinction; and,
- Parts of the lake have been seriously polluted because of increasing human activities and the resulting high pollution loads from around the lake.

The management response to these issues is still in an early phase, with most work being done on an individual country basis. The reader will note that many of the statistics given in this report are given separately for the Chinese and Russian sides of the lake, primarily because no comprehensive program has

been established to gather information in a consistent manner. Thus, equivalent data are not available for all topics discussed in this report. Further, both China and Russia have established separate special nature protected areas in the drainage basin (i.e., Khankaisky State Nature Reserve in Russia; Xingkai Lake Nature Reserve in China). Important new cooperative efforts include the UNEP Diagnostic Analysis (2001), conducted by a joint team of Chinese and Russian scientists (and from which this report draws heavily), as well as a proposed Global Environment Facility project called "Integrated Management of the Amur/Heilong River Basin", which will have a significant component addressing Lake Xingkai/Khanka issues.

2. Background

The landscape of Lake Xingkai/Khanka and its basin differs from other regions of Northeast Asia. The basin contains widespread meadow vegetative communities and grassy bogs. The wetlands at the eastern coast of Lake Xingkai/Khanka have unique vegetation and fauna, with no analogs in the region. As a whole, the Lake Xingkai/Khanka drainage basin is characterized by substantial biodiversity. The availability of a large freshwater source (the lake) has resulted in a huge abundance of waterfowl and near-water birds. There also are many freshwater species of fish and other aquatic species in Lake Xingkai/Khanka, and a significant number of rare and endangered species of plants grow in its waters and adjacent territory.

2.1 Biophysical Features

2.1.1 The Lake and its Drainage Basin

Lake Xingkai/Khanka was formed by the breaking and sinking of the Earth's crust. The lake later shrank in the late Pleistocene era, with plate-like and belt-like sand mounds appearing and separating the lake into two parts, as well as separating the Muling River basin from the Lake Xingkai/Khanka basin. The lake area varies between 3,940–4,510 km², reflecting rainfall variations between seasons and years. The average lake depth and volume are 4.5 m and 18.3 km³, respectively, with its maximum depth and volume being 10.6 m and 22.6 km³, respectively. Table 1 presents a summary of some key morphological characteristics of the lake and its basin.

Lake Xingkai/Khanka is shallow, with the greater depth in the northern part, and shallower depth in the southern part. Although some areas along the western shore of the lake have steep, rocky cliffs (a few tens of meters high), most of the lakeshore is low and swampy, reflecting the fluctuating nature of the lake's surface area. The topography of the lake's drainage basin is characterized by a transition from mountainous ridges of middle mountainous and low mountainous relief, to a zone of tumulus and hummocky relief and, subsequently, to high and low accumulative plains. Overall, the basin is quite flat, especially in the northern and eastern parts, contributing to the complex hydrology of the area.

Table 1. Main Morphological Characteristics of Lake Xingkai/Khanka Basin.

Water area (lowest; average; highest)	3,940; 4,070; 4,510 km ²
Average depth (lowest; average; highest)	3.22; 4.50; 4.51 m
Volume of water (lowest; average; highest)	12.7; 18.3; 22.6 km ³
Altitude above sea level (at average level)	68.9 m
Length of shoreline (average long-term water level)	308 km
Basin area (not including Muling River basin)	21,766 km ²
Ratio of lake volume (average long-term water level) to annual inflow of water	9.4

Source: Based on Table 2.3, p. 25 in UNEP (2001), with corrections and additions.

It is challenging to accurately specify the Lake Xingkai/Khanka drainage basin, due to both natural conditions and the effects of human interventions. In the absence of any diversion projects, the natural drainage basin of the lake is illustrated as the darker-colored area in Figure 1; namely, the area containing rivers that naturally drain into the lake. This “main basin,” with an area of 21,766 km², contains approximately 23 rivers flowing into the lake; 8 drain from China and 15 drain from Russia. The Song’acha River is the only river that flows out of the lake, subsequently flowing to the Wusuli/Ussuri River and on to the Heilong/Amur River system, finally emptying into the Pacific Ocean at the Tatar Strait.

The construction of flood diversion canals and sluice gates on the Muling River (indicated in lighter color in Figure 1) dramatically altered the hydrology of the Xingkai/Khanka Basin by allowing part of the flood waters of the Muling River basin to enter the Xingkai/Khanka basin. The Muling River originates from the Woji Mountains and flows through several major cities and towns, including Muling, Jixi, Jidong, Mishan, and Huling, and converges into the Wusuli/Ussuri River. The Muling River, with a basin area of 15,184 km², has an annual runoff of 2.2 km³. Unfortunately, there is very little wastewater treatment in this basin.

Flood control dams were constructed along the banks of the Muling River, in order to prevent the flooding of farmland during the wet period. Furthermore, and most important for Lake Xingkai/Khanka, a flood-diversion sluice gate was constructed nearby Hubei Village (20 km East of Yanggang) to protect cultivated land in the downstream Muling basin (the areas north and northeast of Lake Xingkai/Khanka in Figure 1). This diversion is called the Muxing flood-diversion course or the Hubei sluice gate. The flood-diversion sluice gate is opened when the Muling River water level exceeds the warning stage. The flood waters are diverted into either of two distinct paths: (a) through the Muxing flood diversion course, Dongdihe Canal, wetlands, Lake Xiaoxingkai, Lake Xingkai/Khanka, Song’acha River or (b) through the Muxing flood diversion course, Dongdihe Canal, wetlands, Galatong River and Song’acha River. What path is used depends on the seasonal conditions: the Dongdihe Canal flows into the small lake through wetlands and moorlands during the wet season, but flows into the Galatong River through wetlands and bogs in the normal and dry seasons. It should be noted that only the former path leads to the direct discharge of waters into

Lake Xingaki/Khanka, whereas the latter path takes a more northeasterly path, avoiding the lake itself.

Approximately 0.65 km³ of water flows into the Dongdihe canal from the Muling River each year. Since the Muling River water flow is controlled by precipitation, the water flow of Hubei gate varies distinctively, both seasonally and annually. In dry years, there is no flow through the Hubei sluice gate. Considering all of the relevant factors, including the large evaporation from wetland and bog surfaces, it is estimated that 0.4 km³ of flood water enters the small lake (Xiaoxingkai) from the Dongdihe Canal annually.

In regard to the connection between the smaller and larger lakes (i.e. between Xiaoxingkai and Xingkai/Khanka), there is a natural sand mound lying between Xiaoxingkai and Xingkai/Khanka. The mound is approximately 35 km long, 75 m above sea level (5-6 m above the average lake level), 10 m wide at the top and 60-70 m wide at the base, with primitive forests growing on it. However, a large-scale hydraulic engineering-flood-diversion sluice was constructed between the large and small lake in September 1976, making it possible for the Muling River to flow into Xingkai/Khanka Lake. The water enters Lake Xiaoxingkai through three main paths, including (a) discharge from rivers in the “main” basin (0.12 km³); (b) diversion from Dongdihe Canal (0.4 km³); and (c) direct precipitation (0.08 km³). Water leaves Lake Xiaoxingkai via four main paths, including (a) flow through a flood-diversion sluice gate to Lake Xingkai/Khanka (0.31 km³); (b) irrigation (0.25 km³); (c) flow to the Xingkailiu River (0.02 km³); and (d) evaporation (0.17 km³).

The total inflow and outflow of Lake Xiaoxingkai does not add up precisely, indicating the need for further study. Nevertheless, it seems reasonable to conclude that over 75% of the diverted Muling River flood flows end up in Lake Xingkai/Khanka. The total annual inflows to Lake Xingkai/Khanka were estimated by UNEP (2001, p. 28) to be 0.696 km³ from the Chinese side, and 3.4 km³ from the Russian side. Although these numbers also must be treated with caution, they nevertheless indicate that much of the inflow to Lake Xingkai/Khanka comes from the Russian side of its drainage basin. Thus, one significant factor regarding the Muling River flood inflows is not so much their quantity, but rather the fact that they come from an urbanized area with virtually no sewage treatment.

2.1.2 Climate

The Lake Xingkai/Khanka basin is located in the continental monsoon climatic zone, with the climatic characteristics of the region being affected by the monsoon character of the air mass circulation. The lake basin territory is predominantly influenced by very cold, dry air masses forming in the area of strong Asian anticyclones. During this period, the weather is primarily clear and frosty. The cold period is approximately 200 days in length, with the coldest month being January (an average monthly air temperature lower than -18°C). The duration of the frost-free period in the lake drainage basin is 153-161 days over the annual cycle. The annual precipitation in the Lake Xingkai/Khanka drainage basin averages between 530-630 mm, decreasing progressively from south to the northwest. Strong winds are common, and cause significant mixing of this shallow lake, thereby leading in part to high turbidity and low transparency.

2.1.3 Biota

There are unique natural complexes of international significance in the lake's drainage basin, comprising wetlands, stepped oak forests and light forests (including *Pinus densiflora*). Residual Ussuriiskii deciduous-cedar forests still exist in the southeastern part of the basin. The Khankaiskii State Natural Reserve is a special protected natural area.

Suitable climatic conditions and fertile lands have favored the agricultural development of the Xingkai/Khanka drainage basin. The agricultural area in the six Russian lake districts is 4,642 km², with soybeans, rice, vegetables and potatoes being important crops, in addition to fodder areas. The total farmland area is approximately 1,669 km² in the Chinese portion of the drainage basin, abounding in soybean, rice, corn and wheat, as well as industrial beet crops. Mechanized agriculture is used in about 85% of the farmland area in the Chinese portion of the drainage basin.

The highly-productive ecosystems in the lake drainage basin are the source of many species and population-genetic diversity. They consist of many valuable species of plants and animals with outstanding landscape-forming, climate, economic, recreational and aesthetic significance. Lake Xingkai/Khanka is the major fishery resource for the region, and contains 65 species of fish. The major species include cyprinidae (*Cyprians carpio*, *Carassius auratus*, *Erythroculter erythropterus*, *Erythroculter mongolicus*, etc.). Forests cover approximately one-third of the area of the Lake Xingkai/Khanka "main" drainage basin.

2.1.4 Other Resources

Although the Lake Xingkai/Khanka drainage basin does not contain a wide range of natural resources, there are significant deposits of coal, cement raw materials, and fluorspar raw materials. There is comparatively little industry on the drainage-basin scale, with most of the existing industry concentrated on the Russian side of the basin.

2.2 Political and Socio-economic Features

2.2.1 The Jurisdictional Features

As noted above, the Lake Xingkai/Khanka basin is shared by Russia and China, with both countries being riparian to the lake. At the provincial level, the lake is within the Heilongjiang Province in China and Primorsky Krai in Russia. Within China, the lake belongs to the People's Government of Mishan City (which includes 2 towns and 6 villages), the Xingkaihu State Farm, the Xingkaihu Agriculture Factory of Heilongjiang Province and the Army. On the Russian side, Primorsky Krai consists of 6 administrative districts (Khankaisky, Spassky, Pogranichny, Khorolsky, Mikhailovsky and Chernigovsky) with one major city, Spassk-Dalny, situated in the lake basin.

2.2.2 The Political Significance

The Lake Xingkai/Khanka drainage basin is relatively remote from the main center of each country, with a population of approximately 345,500 people (1998); about 68.7% of the population lives in rural areas. There are only two main cities in the drainage basin; namely Spassk-Dalny in Russia and Mishan in China. However, the area is a major agricultural zone for both countries, with farming dominating the economy. Fisheries also represent an important economic activity in the lake's drainage basin. The Russian lake shoreline contains two fish-breeding enterprises and one fish-processing factory. Fishing activities in China are conducted in the lake, as well as the river, channels and reservoirs. Some mining, industry, forestry and tourism also take place in the basin.

2.2.3 The Past Social and Economic Development History

Although the Lake Xingkai/Khanka drainage basin is sparsely populated, its suitable climatic conditions and fertile land favor agricultural development.

Chinese Side of Basin. The population in the Chinese portion of the Lake Xingkai/Khanka drainage basin is smaller than that in the Russian portion, with about 73,500 people living near the lake (not including the population in the Muling River basin). Most people in the region are engaged in agricultural activities, while the urban population is primarily engaged in business, manufacturing and agricultural management activities.

Although a State Farm was established for large-scale land reclamation in 1945, the area was not developed on a large scale until after 1949. A first-grade port (Mishan port) was built in the town of Dangbidian in 1988. The irrigated area around the lake is approximately 233 km². A breeding farm was set up in the northern bank of the small lake (Xiaoxingkai) in 1955, with a maximum fish catch of 1,046 tons/year. Animals such as mink are also raised in the lake basin. The Xingkaihu State Farm is located in the northeast part of Lake Xingkai/Khanka, and contained a paper mill which has recently been shut down.

Russian Side of Basin. The Tury Rog military post was created on the boundary of Khanka Lake and Manchuria in 1859, and the first Russian ploughmen arrived in 1862. The development

of both the Khanka Lake basin and practically all Primorsky Krai began from that point, with the basin being mainly an agricultural area from the beginning of its settlement.

The population in the Russian portion of the Lake Xingkai/Khanka drainage basin is relatively small (approximately 272,000 residents), with 61% living in rural areas. The Russian portion of the drainage basin is the most developed territory (primarily agriculture) in Primorsky Krai. Of particular interest is the reduction in the Russian population density since the 1980s, which is attributed both to a decrease in the birth rate and the migration of people to other areas.

2.3 Institutional and Managerial Features

There currently is no unified plan or authoritative organization to manage the lake. Instead, programs and responsibilities are divided between the two countries, and also divided within the countries themselves. On the other hand, both China and Russia have established special nature protected areas in the drainage basin (Russian Federation Khankaisky State Nature Reserve; Xingkai Lake Nature Reserve of the People's Republic of China). Nevertheless, substantial irrigation and industrial activity takes place in these protected areas, being one of the main reasons for the environment problems in the lake and its basin.

3. Biophysical Environment

The Lake Xingkai/Khanka drainage basin is recognized by the international scientific community as one of the world's most important regions in regard to its biodiversity characteristics. It was included in the list of the Ramsar Convention for Russia as one of the largest wetlands in Northeast Asia, and as a nesting center for rare and endangered bird species.

The drainage basin has a striking diversity of plant and animal species. The Chinese portion of the drainage basin, for example, contains 1,460 species of plants and 282 species of wild animals. Based on preliminary data, the Russian portion of the drainage basin contains at least 620 species of vascular plants, 61 species of mammals and 342 species of birds. Fifty-eight of the bird species have the status of being rare species in the territory. Forty-four species are included in the Red Book of Russia, and 12 species are included in the International Red Book.

3.1 Past and Current Conditions

The biodiversity in the Lake Xingkai/Khanka drainage basin is connected historically with intensive geological processes, resulting in a unique mixture of flora and fauna. The area contains grassy swamps (red-sedge swamps, sedge bogs, and large-grass swamps) and meadow vegetative communities, being of fundamental importance to the bird communities. No comparable-sized areas in Russia contain as large a number of bird communities. Of the 48 endangered bird species of the Russian Far Eastern territory, 10 species are unique to

the Prikhankaiskaya Lowland. Further, 225 species of the 287 species protected under Soviet-Japanese (1973) and Russian-Korean (1998) conventions dwell in the Lake Xingkai/Khanka drainage basin.

3.1.1 Forests

The forests in the drainage basin belong to the temperate-cold forest sub-zone. Broadleaf forests of *Quercus mongolica*, *Tilia amurensis*, *Fraxinus mandshurica*, *Phellodendron amurensis*, *Populus davidiana*, *Betula platphylla*, *Ulmus propinqua*, Mongolian Scotch pine, Manchurian walnut, maple and *Indigobush amorphia* occupy the largest area. The bush and liana include filbert, shrub lespedeza, prickly rose, Mongolian willow, Amur grape, *Marlyprickle acanthopanlax*, *Fimbriate orostachys*, Mongolian ephedra, Chinese magnoliavine, fourleaf ginseng and lily of the valley, as well as more than 20 healing plants.

According to Chinese experts, the flora in the Chinese portion of the lake's drainage basin comprises plants of 53 orders, 104 families, 477 genera and more than 1,060 species. Industrial forests in the Chinese portion of the drainage basin, as well as water protection zones or forest belts, comprise Korean cedar, Chinese juniper, various species of spruce, larch, fir, tree-like willow, poplar, pine (*Pinus silvestris*), and Manchurian nut chozenia (*Chosenia macrolepis*).

3.1.2 Fauna Biodiversity

The Lake Xingkai/Khanka drainage basin is estimated to contain one-third to one-half of the species known in Russia. Focusing on the Russian Far East, the drainage basin contains 61.5% of the mammal species, 65% of the bird species, 80% of the amphibian species, and 45.4% of the reptile species. These totals include 498 species of Vertebrata of Chordata, comprising 6 classes, 37 orders, 104 families, and 291 genera. Considering only mammals, there are 61 registered species of 44 genera of 18 families of 6 orders. The Chinese portion of the Lake Xingkai/Khanka drainage basin has relatively fewer groups of animals, primarily because of the degraded remaining natural biotopes, as well as an apparently high degree of anthropogenic transformation and fragmentation of sites.

The current ornitho-fauna in the Lake Xingkai/Khanka drainage basin is comprised of 342 bird species. Of this number, 185 have been determined as authentically nesting in the basin, with an additional 7 species thought to nest there. During the winter period, 93 species were observed, with 28 other species being occasional visitors, and the remaining species appearing only during seasonal migrations. In regard to the nesting habits of bird species in the Russian portion of the drainage basin, 333 species of birds have been recorded at the Khanka Nature Reserve up to the present time. Forty-four of these species are included in the Red Book of Russia and 12 in the Red Book of the International Union for Nature Conservation, which is a record for Russia.

The Lake Xingkai/Khanka drainage basin has 8 permanent species of amphibians, representing two orders: Caudata (*Salamandrella keyserlingi*) and Anura (representatives of 4 families). Ten species of reptiles from two orders, 2 species of lizards, and 7 species of snakes also have been recorded.

Lake Xingkai/Khanka also contains a diversified ichthyofauna, primarily because of the lake's shallow depth and hydrological regime. The ichthyofauna includes 1 species of Petromyzonidae, and 73 species of fishes incorporated in 58 genera, 18 families and 8 orders. The Lake Xingkai/Khanka drainage basin contains about one-quarter of all representatives of freshwater fish fauna in Russia. The diversity of the freshwater fish fauna in the lake's basin has no analog either in Russia or in the entire Palearctic region. Some of the fish species comprise important fisheries, including *Erythroculter erythropterus*, *Erythroculter mongolicus*, *Erythroculter oxycephalus*, *Hypophthalmichthys molitrix* and Chinese perch, accounting for about 70% of the total fish catch. The autochthonous species of Lake Xingkai/Khanka can be grouped as follows:

- Eurasian species, for which the Amur/Heilong River Basin represents their marginal, extreme southeastern extent (20%);
- Endemic species of the Amur/Heilong River Basin (Amur Province, without Sakhalin) (17%);
- Species spread only in the Amur (Manchurian) transition region, or that visit Northern China through the Yellow (Huanghe) River (21%); and,
- Sino-Indian species, for which the Amur/Heilong River Basin is the border of their northern extent (42%).

The mollusks in Lake Xingkai/Khanka include 84 species of 28 genera and 15 families. Gastropoda comprise 55 species of 28 genera and 15 families, while large bivalves comprise 21 species of 7 genera and 2 families, and small bivalves comprise 8 species of 4 genera and 3 families.

3.1.3 Phytoplankton

The phytoplankton in Lake Xingkai/Khanka is characterized by the relatively constant presence of diatoms, being most abundant in autumn. The most abundant phytoplankton in summer include *Cyanophyta* of the genera *Microcystis*, *Gloeocapsa*, *Aphanathece* and especially *Anabaena*, whose growth usually continues until late autumn. Algal blooms attributed to the mass development of *Cyanophyta* and colonial filamentous algae, coupled with diatoms, also have been observed.

Based on 1995 data, the Lake Xingkai/Khanka basin contained 180 species and intra-species of algae, including *Cyanophyta* (26 species), *Euglenophyta* (9 species), *Dinophyta* (1 specie), *Cryptophyta* (4 species), *Chrysophyta* (12 species), *Bacillariophyta* (64 species), *Xanlhophyta* (1 species) and *Chlorophyta* (62 species).

In winter and spring, diatoms comprise the main phytoplankton biomass and species vary in the lake. In summer and autumn, the number of *Chlorophyta* species increases, with their biomass becoming comparable to that of diatoms. In July and October, the phytoplankton biomass consists of approximately equal biomasses of the following species: *Snowella rosea*, species of diatom genera *Stephanodisvus*, *Cyclotella*, *Nitzschia*, *Navicula*, *Aulacoseira*, *Schroederia setigera*, *Ulothrix tenerriam*, species of *Chlorophyta* and *Chrysophyta* from *Ankistrodesmus*, *Monoraphidium*, *Scenedesmus dinobryon* and *Mallomonas tonsurata*.

3.1.4 Water Quantity and Quality

The drainage basin's water resources are used for a variety of human activities. The annual runoff to the lake totals about 4.1 km³. The majority of the water input from the Chinese portion of the basin is from the Muling River's floodwater. The water use in the basin in 1995–1996 indicates that, of the total water use of 0.739 km³/year, about 0.693 km³/year is used for irrigation purposes.

Lake Xingkai/Khanka is characterized by high concentrations of suspended solids and low water transparency. Typical transparencies are less than a meter, and sometimes decrease to less than 10 centimeters, primarily because of the winds, which easily mix this shallow lake, causing the suspension of materials in the water column. Although human-induced land use changes, as well as direct pollution, undoubtedly affect the lake's water quality, it is difficult to discern the magnitude of this problem, given the paucity of long-term data. UNEP (2001) identifies soil erosion caused by "irrational exploitation" of land in both the main and Muling River basins as a very serious problem. The annual average suspended solid concentrations are illustrated in Figure 2. It is noted that values for the Russian side of the basin are much lower, which may reflect different methods for measuring suspended solids, as much as it represents actual differences in the lake's quality. Nevertheless, although relatively high for a lake, the values are characteristic of Lake Xingkai/Khanka.

Because of the lack of wastewater treatment in either the main basin, or the Muling River basin, one may expect high organic loadings to the lake. The Biochemical Oxygen Demand (BOD₅) and Chemical Oxygen Demand (COD) values for Lake Xingkai/Khanka are illustrated in Figures 3 and 4. Although the COD is quite high, the BOD₅ is fairly low. It should be noted that the methods for measuring COD are different in China and Russia, so the data are not directly comparable. Despite this apparently high organic loading, however, the dissolved oxygen level of the lake is relatively high, as shown in Figure 5.

Because of the lack of wastewater treatment in the drainage basin, pathogenic contamination also is a likely problem in the lake. Unfortunately, however, there is little hard data to support or refute this claim. The Muling River water quality parameters indicate the river is suffering from serious organic pollution originating from Mishan City (see UNEP 2001, p. 38–39 for further discussion on Muling River water quality).

The nutrient concentrations (phosphorus, nitrogen) for Lake Xingkai/Khanka are presented in Figures 6 and 7, respectively, being indicative of a eutrophic status. There does not appear to be a discernable trend in total phosphorus concentrations. There has been a substantial decrease, however, in the ammonia (NH₄-N) concentration on the Russian side (the only side for which nitrogen data is available), reflecting a sharp decrease in fertilizer use on the Russian side since the early 1990s.

Toxic contamination is more of an issue on the Russian side than on the Chinese side, given its relatively higher industrial and mining activities. UNEP (2001) reports a wide range of contaminants, including heavy metals, pesticides (DDT, HCH), phenol, and oil. It is noted that the level of copper found in certain areas (Kamen-Rybolov) is about 100 times the maximum allowable concentration of 1 mg/L. Unfortunately, neither the sources nor time trends of these pollutants are known.

3.2 History of Lake Degradation

The Lake Xingkai/Khanka drainage basin has undergone significant economic development, including agricultural activities, over the past 140 years. This development has resulted in negative ecological impacts, including contamination of surface waters and (partly) groundwater; soil cover erosion; and reduced communities of rushes in wetlands and related biodiversity degradation. The occurrence of natural calamities in the region further exacerbates such negative impacts.

UNEP (2001) identifies the main reasons for biodiversity degradation in the Lake Xingkai/Khanka drainage basin as: draining of swamps; lowering of the lake's water level; agricultural development (particularly affecting bird nesting areas); stress due to the noise and other impacts of technical facilities; large-scale environmental contamination; cutting forests; and reduction and/or elimination of ecological corridors.

Although deciduous forests of poplar, birch, oak, linden, elm, and walnut on typical brown soils once existed in the foothills of the Eastern-Manchurian Mountains, many have subsequently been clear-cut and transformed into agricultural fields.

Economic development of the coastal zone, and water pollution related primarily to agrochemicals, has resulted in major biotic changes. Seven species of birds that previously bred in the Russian portion of the drainage basin, for example, have subsequently disappeared, including three listed in the Russian Red Book. Four other species also are on the verge of extinction.

Because birds have high ecological integrity, unlimited mobility, and respond to changes in habitat environment, the dynamics of the former and existing bird populations in the drainage basin provide a model for estimating biodiversity loss. Based

on available data, several species of birds, including *Nipponia nippon*, *Cygnus olor*, *Lyrurus tetri*, and *Otis tarda*, have either disappeared, or have been greatly reduced in number in the basin, due to hunting and human-induced habitat changes.

There also has been a decrease in fish catches. By 1987, fisheries production had dropped by about 10 times the level of 50 years before then (UNEP 2001, p. 16). Overall, the fisheries are reported to be in relatively poor condition, due to anthropogenic pollution and overfishing (especially economically-important fish).

3.3 Lake and Drainage Basin Resource Conflicts

Open conflict over resource use has not yet become a feature of the Lake Xingkai/Khanka drainage basin. That is not to say, however, that various users of the lake and its resources do not negatively affect other users. Industrial pollution, for example, affects the quality of fish. Overfishing compromises the ability of future users to earn a livelihood. Pathogenic contamination from upstream users may be impairing the health of downstream users, and so on. Nevertheless, and perhaps reflecting the remoteness of the lake basin, the two riparian countries have not experienced serious conflicts over the lake basin resources. Nevertheless, a further, sudden reduction in the lake's quality or biodiversity could put much more pressure on users and ultimately lead to possible conflicts.

4. Management Environment

4.1 Lake Management Programs and Processes

The management of Lake Xingkai/Khanka and its drainage basin is characterized by fragmentation at all governmental levels. Although no unified plan exists for the basin, this situation may change in the future, with the further development of a proposed GEF project, which could ultimately lead to the development of a drainage-basin scale Strategic Action Program.

The Lake Xingkai/Khanka Natural Reserve has already been brought into an integral strategic system for ecological protection of China, Russia and the whole world. The countries first signed the world's wetland protection convention, and subsequently the Agreement on Lake Xingkai/Khanka on 22 April 1996 in Beijing. On 7 March 1997, approval to enter the northeastern crane network was obtained. In 1998, the lake was listed as one of the demonstration engineering regions for biodiversity protection and sustainable utilization of a Chinese wetland by the GEF project.

4.1.1 Chinese Side of Basin

According to Environmental Protection Laws, Mishan City applied for approval to establish the Lake Xingkai Natural Reserve, receiving approval on 27 April 1986 from the Heilongjiang Province to set up a provincial natural protection zone, and being ratified as a national natural reserve in 5 April 1996. Mishan City drafted Environmental Management

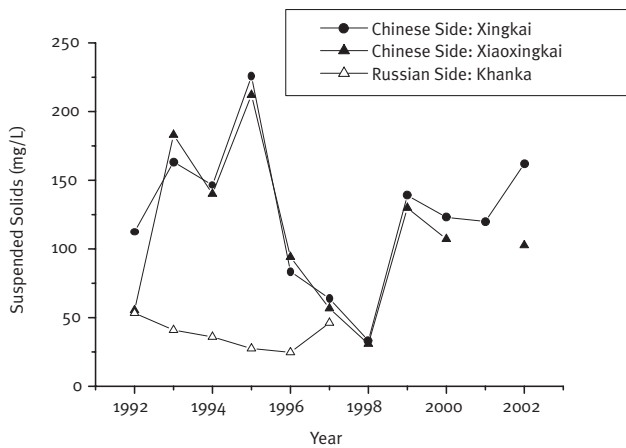


Figure 2. Annual Average Suspended Solids Concentration (mg/L) (Source: Derived from UNEP 2001, p. 30.).

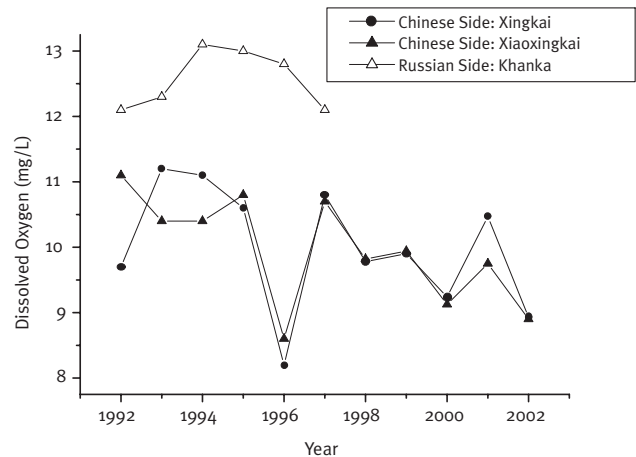


Figure 5. Annual Average Dissolved Oxygen (DO) Concentration (mg/L) (Source: Derived from UNEP 2001, p. 30 with additional data provided by author).

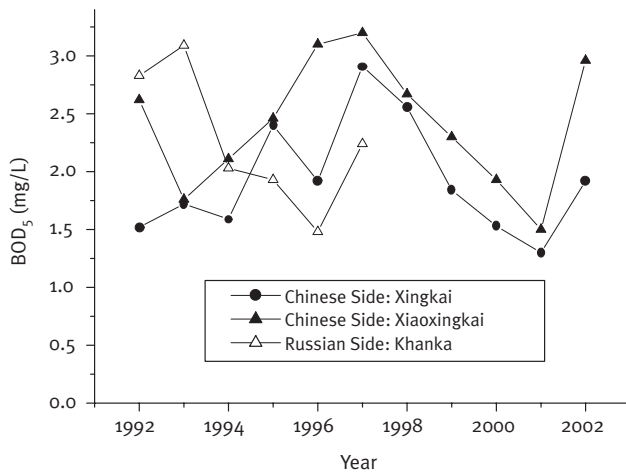


Figure 3. Annual Average Biochemical Oxygen Demand (BOD₅) Concentration (mg/L) (Source: Derived from UNEP 2001, p. 30, with additional data provided by author).

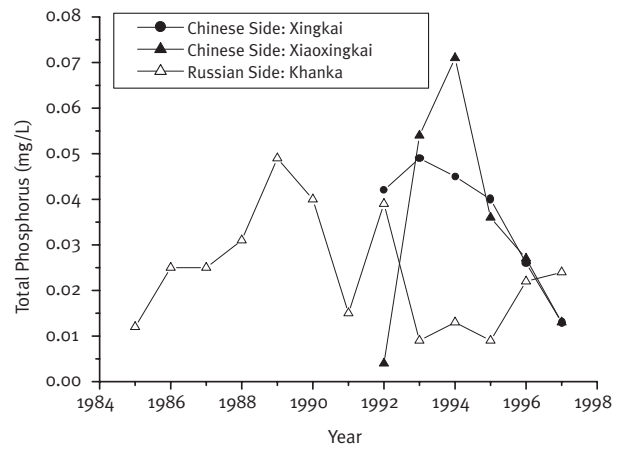


Figure 6. Annual Average Total Phosphorus Concentration (mg/L) (Source: Derived from UNEP 2001, p. 30.).



Figure 4. Annual Average Chemical Oxygen Demand (COD) Concentration (mg/L) (Source: Derived from UNEP 2001, p. 30 with additional data provided by author).

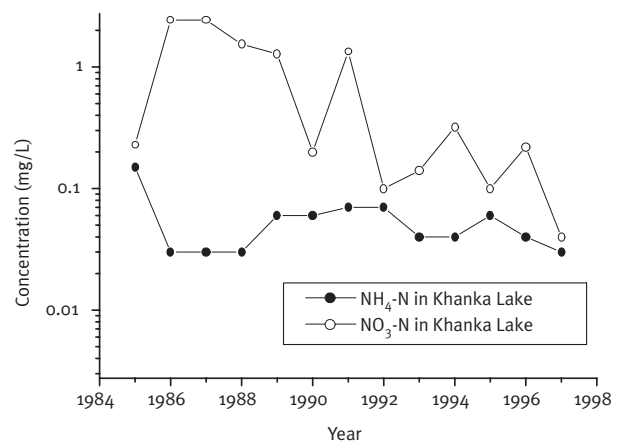


Figure 7. Annual Average Ammonia (NH₄-N) and Nitrate (NO₃-N) Concentrations (mg/L) (Source: Derived from UNEP 2001, p. 45.).

measures for the Lake Xingkai Natural Reserve in 1994, based on national laws and regulations.

Based on the present condition of the lake and its wild animals and plants, the protection zone is divided into 3 functional zones: kernel zone, buffer zone and experimental zone. The kernel zone is further sub-divided into two sub-zones: Psammophyte kernel zone and swamp-wetland-waterbird kernel zone. The main protection species in the Psammophyte kernel Zone include Xingkai pine and other famous and precious plants. The main protection species in the swamp-wetland-waterbird kernel zone include Oriental white stork, red-crown crane, gold eagle and white-tailed sea eagle. The experimental zone is a base for wild animals. The function of the buffer zone is to prevent outside influences and damage to the kernel zone, as well as for experimental production research.

4.1.2 Russian Side of Basin

The specific protected natural territories in the Lake Khanka drainage basin are presently represented by three categories: the Khankaisky State Nature Reserve, nature monuments and wetlands of international meaning.

Lake Khanka “wetland of international meaning”. The administration of Primorsky Krai enacted the decree “About wetlands of Lake Khanka of international meaning,” and the appropriate regulations about these wetlands of international meaning, in 1995. Unfortunately, the borders of the given wetlands are still not legalized. The wetland borders probably will not spread outside of the limits of the buffer protected zones of the Khankaisky Reserve.

The Khankaisky State Nature Reserve. The reserve was established by the Russian party for the purpose of fulfilling obligations under the Ramsar Convention “On wetlands of international meaning mainly as habitats of waterfowl.” During the signing of the Ramsar Convention, the amelioration of wetlands in Lake Khanka drainage basin had not yet been conducted, so the former Soviet Union had declared an area of 310,000 hectares in the Khanka Lake basin as falling under the convention. By the time the reserve was created (1989–1990), the main part of the wetlands was ameliorated.

Thus, a nature protection complex consisting of protected nature sites of four gradations was created, including sites of the Khankaisky State Nature Reserve; specific protected zones; protected zone of special assignment; and protected zone of common assignment. Each protected zone has its own objects and appropriate protection regime. However, because of the fragmentation of protected zones, as well as a lack of enforcement, the prohibited activities in these areas have not yet been significantly curtailed.

4.2 Reduction of Lake Stresses

The most important reduction in stresses on the lake came unexpectedly in the early 1990s, a result of the downturn

of the Russian economy, which led to lower industrial and agricultural production on the Russian side, as well as a degree of de-population. Nutrient, pesticide and toxic contamination on the Russian side of the drainage basin is reported to have decreased as a result of this downturn. Water consumption for irrigation was reportedly 80% lower than previous levels in the Khankaisky district.

There have been moves on the Chinese side to relocate the Xingkaihu Farm, which is located in the center of the protection area, and to restore the reclaimed area. The Lake Xingkai Paper Mill, which was located in a key wetland area, has been closed.

Nevertheless, because much of the basin still lacks wastewater treatment facilities, as well as other pollution control measures, the total stresses on the lake cannot be considered as being controlled in a sustainable fashion.

Some current activities that may help reduce stresses to the lake include the following.

4.2.1 Chinese Side of Basin

Construction of Qinglongshan Reservoir in Jixi. The main function of this project is to prevent flooding, facilitate irrigation and reduce pollution.

Wastewater treatment projects. A reed culturing and irrigation project (23.3 km²) is being carried out on the basis of the present oxidizing pond (0.2 km²). After this project is implemented, the wastewater can be treated to reach discharge standards, and the superficial wastewater discharged into the escape canal and subsequently flowing into Galatong River and eventually into Song’acha River. As a result, the wastewater impacts on Xingkai Lake will be reduced.

Coordination activity. The Lake Xingkai Natural Reserve is managed by 4 separate units. It is suggested that, under the direction of the local government, a unified protection committee must be organized. In this manner, the administration of the Lake Xingkai Natural Reserve can be carried out smoothly and effectively.

Strictly enforcing the law. According to the administration methods of Lake Xingkai Natural Reserve, it is necessary to carry out investigations of environmental protection activities. As an example, all activities regarding tree felling and agriculture are forbidden.

Participating in international coordination. Because the lake is a boundary water of Russia and China, it is necessary to conduct coordinated research, with both countries doing their best to protect the common environment.

Constructing scientific research and studying the biodiversity base of the reserve. Relevant activities include studying the migrating regularity of wild animals and birds, developing protective countermeasures, while at the same time carrying

out basic investigations and research work, scientific appraisals and effective habitat protection.

4.2.2 Russian Side of Basin

To reduce the risk of disastrous floods within the framework of federal target programs for protecting the population, a number of measures are planned for the Khanka Lake drainage basin. Realization of the elaborated program will significantly reduce the potential losses from disastrous floods. A major problem in implementing the considered program, however, is a funding deficiency.

4.3. Environmental Status

The environmental status of Lake Xingkai/Khanka and its drainage basin was previously discussed in Section 3.1.

4.4 Enabling Environment

4.4.1 The Critical Policy and Institutional Framework for Management

Russian Side of Basin. The main document defining correct uses of water resources is the Water Code of the Russian Federation, adopted by the State Duma of the Russian Federation in 3 October 1995. The adoption of the Water Code, however, only began the process of shaping a new state system of water legislation. Its goal is the regulation of relations (and contradictions) between the Federation and its subjects, and between the subjects located in one river basin.

The main law that defines forest use is the Forest Code of the Russian Federation, adopted by the State Duma of the Russian Federation in 22 January 1997. The regulation of forest use, and the protection and reproduction of forests, are assigned to the united republican specialized Federal Forest Service, financed mainly from the federal budget.

The exploitation of fish resources is determined by the federal target program, "Development of Fishery of the Russian Federation", and legal acts of the Committee of the Russian Federation on fishery, as well as "Rules for fishery in Far Eastern reservoirs."

The exploitation of animal resources is determined by the federal law "On fauna", which determines the state ownership of objects of fauna, restrictions and interdictions for use of objects of fauna, conditions for habitat preservation, protection of fauna, regulation of census of fauna objects, and conditions for economic activity.

Chinese Side of Basin. Since the 1970s, China has paid more attention to environmental protection of the Lake Xingkai basin, as displayed in the implementation of a series of integral systems for laws, and regulations and management systems of organization. At present, environmental protection is identified in the master plans and annual plans for national economic development. Categories of natural protection zones are established, and a great deal of scientific research has been

conducted in the theory, practice, engineering and technology of environmental protection. The environmental protection industry also is developing rather quickly.

Relevant environmentally-related laws, acts and criteria are as follows:

- Environmental Protection Law of People's Republic of China (PRC);
- Anti-Water Pollution Laws of PRC;
- Forest Laws of PRC;
- Quality Criterion of Surface Water Environment (GB 3838-2003);
- Comprehensive Criteria for Effluent-Discharging; and,
- Administration Regulation for Natural Reserves of Xingkai Lake.

4.4.2 Quality of Lake Management Programs

Considering the Russian side, the rather small area of the reserved territory was inadequate to ensure the proper conditions for preserving the biodiversity. On the other hand, it was all territory that had no economic value at the time the reserve was organized. Two-thirds of the main protected species of the reserve, for example, are located outside the reserve, including *Grus japonensis*, *Grus vipio*, *Ciconia boyciana*, etc. Accordingly, protected zones with various regimes of nature use were created in the reserve. They represent the buffers between territories intensively used for economic purposes, and territories with reserved regimes and a complete absence of economic activity.

There are numerous settlements in the Khanka Lake basin, including cities and urban settlements, whose inhabitants became accustomed from generation to generation to using the available natural resources for their own needs. As a result, there were intense social-political circumstances around the reserve, being further aggravated by the fact that these territories have no practical natural-orienting marks of relief.

Another complicating factor is the regular fluctuations of the lake level. In this regard, there is no constant shoreline for the lake. Rather, the descriptions of the reserve are characterized by such notions as "water's edge", "coastline", etc. Further, the borders of the reserve and protected zones are not clear for a large mass of the local population. There also is a difficulty with the understanding of the regime of nature use in each specific site.

The current intense social-economic situation in the country is reflected in the aggravation of the atmosphere around the reserve. The local inhabitants are now largely compelled to ensure their vital needs, using the local natural resources.

The above-noted problems confronting the reserve have resulted in necessary revision of the boundaries of the protected zones and their regime. The negative influence of existing conditions was reinforced by the fact that, in the Federal Law “On specially protected natural territories”, only one protected zone around the reserve is mentioned (i.e., creation of a complex of protected zones is not stipulated). At present, some coordination between the administrations of all districts on the protected zones has been carried out. A draft of a decree about the zones was prepared by the Primorsky Krai Governor, including agreement on expansion of the reserve territory in the Khorolsky district.

Overall, the system of specially-protected natural territories in the Russian part of the Khanka Lake basin requires further development. It requires an expansion of the reserve, and then solutions to conflict problems in its protected zones, as well as maintenance of a special protection regime, and creation of new protection of the existing monuments of nature. Additional financial resources will be required for all these activities.

4.4.3 Stakeholder Involvement

There are some NGO activities, notably the Khanka Lake Organization on the Russian side of the lake basin. Stakeholder participation in the overall management of the lake basin, however, is not high. On the other hand, at the international level, Chinese and Russian scientists were brought together within the context of the UNEP Diagnostic Analysis. It is hoped this sort of activity will continue to be further used to promote international cooperation and wider participation.

The governments of the two riparian countries worked with key stakeholders in both countries. Stakeholder consultation was organized 3 times during the project to discuss an action program and cooperation between the two riparian countries. Through the project, the two riparian countries identified issues for environmental management and the sustainable development of the lake basin through regional cooperation. Two institutes were designated by their respective national governments as focal institutes, including the Chinese Research Academy of Environmental Sciences (CRAES), and the Pacific Geographical Institute (PGI) Far-Eastern Branch, Russia Academy of Sciences in the Russian Federation.

4.4.4 Linkages

A number of regional cooperation activities have been carried out near the lake, including the USAID-US National Committee on US-China Relation project on land-use in the Wusuli/Ussuri River watershed, and WWF activities for biodiversity conservation in the Russian Federation. Specific agreement among the Provincial and Krai administration in the Wusuli/Ussuri River watershed includes articles on regional cooperation for Lake Xingkai/Khanka. The two riparian countries agreed to select joint actions through various international forums and agreements, such as the Memorandum of Understanding (25 May 1998) on the Wusuli/Ussuri River Basin among the Primorsky and Khabarovsk Krai (both in the Russian Federation) and Heilongjiang Province (in China),

with a focus on “joint planning of the coordinated system of protection facilities.” This Memorandum of Understanding also set a goal of initiating applied scientific exchange in the areas of hydrology, watershed management, and related fields to devise plans for enhancing and maintaining water quality and fishery resources in Wusuli/Ussuri River and adjacent waterways. It also was proposed to the respective national governments through the Memorandum that the International Ussuri Commission (IUC) be established. Further, both the Lake Xingkai National Nature Reserve (China) and Khankaisky National Nature Reserve (Russian Federation) agreed to take steps to establish a joint international reserve for Lake Xingkai/Khanka, and to exchange scientific information and experiences.

4.4.5 Successes and Failures

Unfortunately, regional cooperation for environmental protection and management has a short history in northeast Asia. Regional cooperation for Lake Xingkai/Khanka to improve relevant environmental, strategic policy and institutional coordination arrangements has not been achieved. The UNEP-sponsored Diagnostic Analysis produced an analysis of the current state of the environment, and identified current and emerging environmental issues in the basin. Based on the information in the Diagnostic Analysis, a Regional Workshop was organized in Mishan, People’s Republic of China, resulting in the development of recommendations for possible follow-up action.

The cooperative and collaborative spirit already demonstrated by the two riparian countries in these initial activities highlights their willingness to consider these and other possibilities. As previously noted, the continued cooperation of UNEP and its sister agencies within the United Nations system also would facilitate the blueprint of such activities, building on the excellent cooperative work already completed between China, Russia and UNEP.

The two riparian countries also developed their own monitoring and information management system. A lack of adequate technical and institutional capacity to collect, collate, analyze and store relevant data and information on the basin, however, hinders this effort. Further, a lack of dialogue on the monitoring and information exchange and joint planning for the basin has prevented harmonized and cost-effective management actions regarding transboundary environmental issues.

4.4.6 Public Awareness Programs and Access to Information

The UNEP (2001) report noted that in the basin, as elsewhere, people and organizations alike often engage in environmentally-unsustainable socio-economic development activities simply because of an inadequate awareness of the potential environmental damage of such activities. Thus, the two riparian countries must undertake public education and awareness activities directed to both identifying how people and organizations can cause environmental problems,

and identifying their potential role in helping solve these problems.

The UNEP-sponsored Diagnostic Analysis project afforded some avenues for public awareness and education activities, including the written and electronic media, extension programs, school instruction, and work-related training.

4.4.7 Past and Ongoing Financial Investment

Although the two riparian countries want to support more protection for the lake and its drainage basin, they lack the financial resources to effectively do so. In fact, international support has been critical thus far. In 1998, in addition to supporting the Diagnostic Analysis of the Lake Xingkai/Khanka Basin, UNEP also proposed a new full-sized project for funding by the Global Environment Facility (GEF), addressing land-based threats to the Lake Xingkai/Khanka Basin Ecosystem within the Regional Framework for the Amur/Heilongjiang River Basin and Associated Continental and Sakhalin Island Coastal Area (Global Environment Facility 2003).

5. Lessons Learned

5.1 Fragmentation of Responsibility Complicates Lake Basin Management

The border of China and Russia runs straight through Lake Xingkai/Khanka and both countries have approached the assessment and management of the lake and its resources primarily within the context of their national boundaries. One example of this is that many of the statistics in this report are given separately for the Chinese and Russian sides of the basin, making their interpretation and understanding within the context of the entire lake system difficult to comprehend. Not only do the citizens on each side of the border speak a different language, but even the scientists use different methods, as illustrated in the different types of COD tests reported (COD_{Cr} versus COD_{Mn}). Furthermore, this report compiled the individual maps of the partial lake basins from the two countries to provide the map of the lake and its entire drainage basin, as illustrated in Figure 1. Previous reports such as the UNEP (2002) Diagnostic Analysis have shown the lake basin divided into two parts, with the lake cut in the middle.

However, even without international borders, fragmentation exists at the national levels. As noted above, within China, the lake belongs to the People's Government of Mishan City (including 2 towns and 6 villages), Xingkaihu State Farm, Xingkaihu Agriculture Factory of Heilongjiang Province and the Army. On the Russian side, Primorsky Krai consists of six administrative districts (Khankaisky, Spassky, Pogranichny, Khorolsky, Mikhailovsky and Chernigovsky) with one major city, Spassk-Dalny, situated in the lake basin. Even the relatively small Lake Xingkai Nature Reserve on the Chinese side is managed by four different administrative units. This sort of fragmentation of authority and responsibility greatly hinders effective management of Lake Xingkai/Khanka and its resources.

In short, the most significant problem affecting the sustainable use of Lake Xingkai/Khanka is the lack of a central, unified authority to manage the lake and its resources throughout its drainage basin, resulting in a fragmented management approach.

5.2 Humans Can Profoundly Change the Scope of a Drainage Basin

The term drainage basin itself is not straightforward in the Lake Xingkai/Khanka case. Construction of the flood diversion canals and sluice gates on the Muling River have dramatically altered the natural hydrology and extent of the Lake Xingkai/Khanka basin by allowing part of the flood waters from the Muling River basin to enter the lake. In particular, flood waters entering through the Muxing flood diversion course can eventually enter Lake Xingkai/Khanka. Although this engineering effort was initiated to provide flood protection to the citizens and crops in the downstream river basin, the river flows through a number of major cities and towns in its journey to the lake, receiving wastewaters from these cities along its journey. Unfortunately, there is very little wastewater treatment in the basin, resulting in the potential of causing both health and environmental impacts on the lake with the influx of floodwaters. The absence of adequate wastewater treatment in the relatively highly populated cities and towns along the Muling River means that such inputs can dramatically change the lake's water quality and hydrology.

5.3 For Protected Areas, Designation Must Be Followed by Enforcement

One of the unfortunate themes running through the brief for both sides of the basin is the lack of enforcement of rules designed to conserve protected areas. Cynically, it seems easier to designate an area "protected" than to take painful socio-economic measures to actually protect it. Both sides have designated Ramsar sites and nature reserves. However, as noted above, prohibited activities in these areas have not yet been significantly curtailed. For example, substantial irrigation and industrial activity takes place in some of these protected areas.

The protected areas themselves suffer from poor designation, which is in part due to the natural situation at the lake, which experiences seasonal fluctuations in water area and lacks practical natural-orienting marks of relief. The brief noted that difficulty defining a "water's edge" or "coastline" contributes to the confusion of the local population. All of this is taking place against the backdrop of poor economic conditions facing people who traditionally used the areas. It is not surprising that illegal activities continue to occur.

5.4 The State of Future Stresses is Hard to Predict

The decline in economic activity on the Russian side of the basin following the dissolution of the Soviet Union has led to

a decrease in industrial and agricultural pollution loads from the Russian side. While this might be good from a water quality perspective, the social and economic pain has been great. Birth rates have dropped and people have migrated from the area. This sort of major change in the stresses facing a lake was certainly difficult to foresee and somewhat humbling for any manager trying to plan for the future. It is certainly possible that some new and unexpected development completely out of the control of the local lake basin could happen again with either positive or negative effects on the lake.

5.5 International Agencies Can Play a Key Catalytic Role

Although the two riparian countries wish to support more protection for the lake and its drainage basin, they lack the financial resources to effectively do so, particularly over the long term. To this end, international support has been critical thus far in studying the lake, identifying its problems and proposing solutions to them, especially with regard to maintaining the rich biodiversity. The previously-noted UNEP Diagnostic Analysis of Lake Xingkai/Khanka and its drainage basin represents a significant example of such needed support in analyzing the environmental problems of the lake and its drainage basin. Furthermore, in addition to supporting the Diagnostic Analysis, UNEP has proposed a new, full-sized project for funding by the Global Environment Facility (GEF), addressing land-based threats to the Lake Xingkai/Khanka Basin Ecosystem within the Regional Framework for the Amur/Heilongjiang River Basin and Associated Continental and Sakhalin Island Coastal Area.

In view of the limited financial resources of the two riparian countries directed to this lake and its resources, further efforts along this line are essential to the sustainable use of this valuable aquatic resource. It is hoped that relevant international donor agencies and similar financial sources will be forthcoming to further such essential monitoring, assessment and management efforts.

6. References

This report draws heavily from the four sources listed below:

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