

Lancang-Mekong Cooperation Special Fund Projects

Policy Study of Lancang-Mekong Water Environment Management



生态环境部对外合作与交流中心
Foreign Environmental Cooperation Center



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Abstract

Water is an irreplaceable basic natural resource and strategic economic resource in the process of human survival and development. It is also an important environmental element that serves as a carrier of material and energy transmission to support the virtuous cycle of ecosystems. The self-purification ability of water bodies maintains ecosystem balance. In view of prominent contradictions and issues such as global water shortage, severe water pollution and fragile ecological environment, as well as rapid expansion of urban population, the management and protection of water environment has increasingly become an issue of concern to be urgently addressed in various countries.

This study takes water environment management policy as the theme, summarizes relevant laws and regulations of the water environment management in the Lancang-Mekong basin countries, explores the water environment management related cases and practices of the Lancang-Mekong basin countries, and analyzes the water environment of relevant governments and non-governmental organizations in the basin. Environmental management practices and explorations provide references for the Lancang-Mekong countries to formulate relevant policies, regulations and management practices for water environment management, as well as for regional water environment management with similar natural, social and economic conditions.

The Lancang-Mekong River is the most important source of freshwater in the region. The quality of water environment is of vital significance for the livelihood and development for the peoples in the region. Although countries have performed active water environment governance through their own, bilateral and multilateral efforts, the water environment still tends to deteriorate severely under the pressure of economic development. In the future, the water environment governance of Lancang-Mekong Basin can focus on in the following areas:

1. Rural Water Environment Governance

The Lancang-Mekong Basin is an underdeveloped region. Agriculture accounts for a large proportion of the total national economic output in each country. Chemical fertilizers and pesticides applied in farming have become an important incentive for water quality degradation in the river basin. In addition, the low domestic sewage collection and treatment rate in the basin has also affected the rural water environment to a certain extent. The vast rural areas are the main source of drinking water for urban and rural residents. Strengthening agricultural non-point source pollution and domestic sewage treatment is an important measure to ensure water safety in the river basin.

2. Mitigation of Water Quality Impact of Water Conservancy and Hydropower Projects

For the purpose of development and utilization of rich water resources, various types of water conservancy and hydropower engineering facilities have been constructed in the Lancang-Mekong River Basin. They affect water quality and aquatic plant and animal habitats by changing river connectivity, reducing flow rate, changing erosion and deposition, and increasing water depth. To cope with the adverse impact, measures should be developed and implemented, which is important for safeguard the health of freshwater ecosystems and maintain the supply of various ecosystem services in the basin.

3. Water Pollution Control of Industrial Parks

Wastewater treatment in industrial parks is difficult because of diverse types and high concentrations of water pollutants. Water environment management of industrial parks should focus on wastewater treatment process design while improving water efficiency by means of water resource recycling. Based on information collected about pollutant types and concentrations in the effluent from various enterprises, sewage is mixed in a well-designed order to facilitate physical and chemical reaction among water pollutants, so that chemicals can be recycled and reused and pollutant concentrations reduced to achieve more efficient sewage treatment.

Foreword

Water is an irreplaceable basic natural resource and strategic economic resource in the process of human survival and development. It is also an important environmental element that serves as a carrier of material and energy transmission to support the virtuous cycle of ecosystems. The self-purification ability of water bodies maintains ecosystem balance. In view of prominent contradictions and issues such as global water shortage, severe water pollution and fragile ecological environment, as well as rapid expansion of urban population, the management and protection of water environment has increasingly become an issue of concern to be urgently addressed in various countries (Wang Junmin 2016).

Water environment management aims to maintain or improve the quality of water environment by investigating and regulating water quantity and quality to satisfy the main functions of water bodies in different regions, which will promote economic and social development in harmony with environment. To achieve the purpose, government as the core shareholder can use a combination of legal, information, economic, fiscal and other means to solve and prevent water pollution.

Water environment management encompasses planning, monitoring, simulation and assessment of water environment, control of pollution sources (point source, non-point source, line source, etc.), emergency response to pollution incidents, mediation of water pollution disputes, formulation and implementation of water policies and regulations, and water environment research.

While territoriality-based traditional governance is difficult to solve water pollution of the entire basin due to the interregional and external characteristics of water resources, collaborative governance emerges as be an inevitable choice to expand the positive externalities of water environment governance and prevent the interregional spread of negative externalities. (Wang Junmin and Shen Juqin, 2016).

The Lancang-Mekong River is a major Asian river originating from the Qinghai-Tibet Plateau. It flows through China's Qinghai, Tibet and Yunnan Provinces into Myanmar, Laos, Thailand, Cambodia and Vietnam before entering the South China Sea in the Mekong Delta near Ho Chi Minh City, Vietnam. "Shared River, Shared Future" is a concrete and vivid description of the close ties of Lancang-Mekong countries.

This study takes the water environment management policy as the theme, summarizes the relevant laws and regulations of the water environment management in the Lancang-Mekong basin countries, explores the water environment management related cases and practices of the Lancang-Mekong basin countries, and analyzes the water environment of relevant governments and non-governmental organizations in the basin. Environmental management practices and explorations provide references for the Lancang-Mekong countries to formulate relevant policies, regulations and management practices for water environment management, as well as for regional water environment management with similar natural, social and economic conditions.



Chapter 1 Overview of Lancang-Mekong River Basin

1.1 Physical Geography

The Lancang-Mekong River is an international river that flows through Asia. It is the sixth longest in the world, the third longest in Asia, and the longest in Southeast Asia. The river originated from Zaqu, Gangguo Mountain Peak in the Tanggula Mountains of Qinghai Province, China. The section from Changdu to Yunnan in China is known as Lancang, and the section beyond the border through Nanla River Mouth known as Mekong. Dubbed as "Danube of the East", this major river in Asia has a total length of 4,900 km and a drainage area of 810,000 km².

The Lancang-Mekong River Basin consists of seven board physiographic regions featuring diverse topography, drainage patterns, and geomorphology. The Qinghai-Tibet Plateau, Three-River Source Area, and Lancang River Basin form the Upper Basin, and the Northern Highlands, Khorat Plateau, Tonle Sap Basin, and Mekong Delta make up the Lower Basin.

1.2 Climate

June to October is the wet season in the Lancang-Mekong River Basin, and with the exception of two brief transition periods, the rest of the year in the basin is the dry season.

The distribution of mean annual rainfall over the basin follows a distinct east-to-west gradient. The rain-soaked uplands in Laos and Cambodia receive the most precipitation (3,000 mm) and the semi-arid Khorat Plateau in northeast Thailand the least (1,000 to 1,600 mm). The Upper Basin is similar to the lower basin in that rainfall is regulated by the global monsoon system. In the Upper Basin, annual rainfall can be as little as 600 mm in the Tibetan Plateau and as much as 1,700 mm in the mountains of Yunnan Province.

The Lancang-Mekong River Basin is among the most vulnerable areas in the world with respect to climate change. Projections for climate change in the basin for the next two to three decades are as follows¹:

- Basin-wide temperature increase of 0.79°C, with larger rises in colder catchment areas in the north;
- Annual precipitation increase of 200 mm (a 13.5% rise);
- Increase in dry-season precipitation in northern catchments and decrease in southern catchments;
- Total annual runoff increase of 21%;
- Increase in floods in all parts of the basin, with the greatest impact on downstream catchments of the Lancang-Mekong River;
- Climate change expected to affect natural ecosystems and agriculture throughout the Lancang-Mekong River Basin, thereby exacerbating the challenges of meeting the increasing demand for resources from growing populations.



¹ <http://www.mrcmekong.org/mekong-basin/climate/>

1.3 Natural Resources

1.3.1 Water Resources

The Lancang River delivers only 16% of the total annual flow of the Lancang-Mekong River, while tributaries on the left bank in Laos and Se Kong, Se San and Sre Pok (3S) river systems (highlands in central Vietnam; Laos and Cambodia) supplies 55% of the total annual flow. In dry season, however, snow melt from China contributes to 24.1% of the total flow. The flood season in the Lancang-Mekong River Basin lasts from June to November and accounts for 80–90% of the total annual flow.

In terms of per capita water resources available, the Lancang-Mekong River Basin is not short of water compared with other parts of the world. Nevertheless, the region is currently facing a number of key water issues, such as:

- Water shortage due to increased demand for irrigation water in Thailand;
- Increased saltwater intrusion in the Mekong Delta, Vietnam;
- Reduction of fishery resources in many parts of the basin and degradation of natural fish habitats;
- Frequent non-seasonal floods and droughts;
- Water quality deterioration, land formation and morphological changes in floodplains and deltas;
- Intensified sector competition for water within and among Lancang-Mekong countries.

1.3.2 Fishery Resources

The inland fisheries of Lancang-Mekong River Basin are among the largest in the world and are a lifeline for the people in the region. They provide most people with their primary source of protein. As the population of the Lower Basin is predicted to grow to over 100 million by 2025, dependence on the fishery sector will increase. If fishery productivity declines or if fishery products are contaminated with industrial waste, the consequences could be severe.



Chapter 2 Water Environment Management Scheme of Lancang-Mekong Countries

2.1 Water Environment Management Scheme of Cambodia

Cambodia has carried out some reforms of the royal government, including the reorganization of government departments, and formulated national development planning and goals. The multi-level policies and strategies have been adopted and implemented as early as 2003, and have now entered the third phase of implementation. These strategies and plans set forth national commitments and relevant roadmaps and objectives. In order to promote green development, the Cambodian Government has devised the National Strategic Plan on Green Growth (2013–2030) and Green Growth Roadmap.

2.1.1 Laws

At the legislative level, Cambodia has passed laws and regulations to strengthen natural resource management and environmental protection. In addition, a series of related sub-decrees have been enacted, of which the most important is the Sub-decree on Water Pollution Control issued by MOE in 1999.

Table 2–1 Cambodian laws and regulation for environmental protection

	No.	Title	Year of enactment	Competent authority
Laws	1	Law on Environmental Protection and Natural Resources Management	1996	MoE
	2	Law on The Amendment of Investment Law in the Kingdom of Cambodia	2003	CDC
	3	Law on Administration of Factory and Handicraft	2006	Ministry of Industry, Mining and Energy (MoIME)
	4	Law on Water Resources Management in the Kingdom of Cambodia	2007	MoWRAM
	5	Law on the Management of Pesticides and Fertilizers	2012	MoAFF
Sub-decrees	6	Sub-Decree on the Establishment and Management of the Special Economic Zone	2005	CDC
	7	Sub-decree on Standards and Management of Agricultural Materials	1998	MoAFF
	8	Sub-decree on Water Pollution Control	1999	MoE
	9	Sub-decree on Solid Waste Management	1999	MoE
	10	Sub-decree on EIA Process	1999	MoE
	11	Sub-decree on the Industrial Standards of Cambodia	2001	Ministry of Industry, Mining and Energy (MoIME)

2.1.2 Water Quality Monitoring System

MoE takes charge of water quality monitoring system in Cambodia and is responsible for water quality assessment and water pollution control, with particular attention to industrial wastewater, domestic sewage, and effluent discharged from public water areas. For public water areas, water quality monitoring is carried out once a month by collecting 163 samples in 18 monitoring sites. For sources of water pollution, a total of 123 samples are collected in 12 monitoring sites once a month.

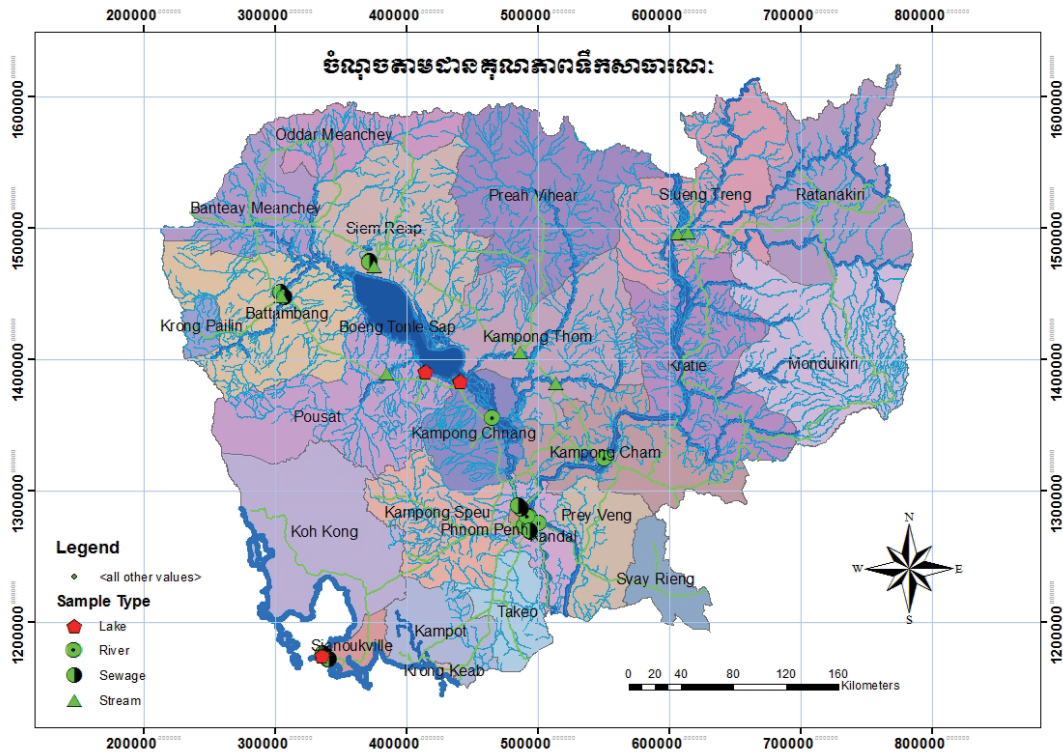


Figure 2–1 Distribution of sampling sites for water quality monitoring of public water areas and sewers in Cambodia

MoE provides wastewater treatment suggestions to wastewater discharge units based on water quality monitoring results, so that the discharge of eutrophication-related pollutants follows national effluent standards. Effluent discharge requires a permit, and effluent must be treated to meet the standards before discharged as permitted.

For pollution monitoring of public water areas, the pollutant concentrations are measured using dedicated equipment, and the monitoring results are recorded. MoE officials check effluent samples on a regular basis. If pollutant concentrations exceed the limits, MoE will play an administrative role to require these pollution sources or polluting enterprises to make rectification within a prescribed period of time. Those that fail to make rectification as required will be penalized by suspension of production and rectification.

2.1.3 Boeung Prek Lapouv Management Plan 2014–2018 of Cambodia

Boeung Prek Lapouv (BPL) is one of the largest remaining remnants of seasonally-inundated wet grassland in the Lower Mekong River. It is important for birds, plants and other wildlife, much of which are still unrecorded. These wet grasslands are under threat wherever they occur, including BPL, because hydrology has been significantly altered as a result of climate change or to facilitate hydropower development and rice growing. The reserve will require long-term management interventions to conserve this valuable habitat. BPL is essential to the lives and livelihoods of many thousands of people because of the wetland resources it provides, such as fish, edible plants, firewood and land for farming. BPL wetlands are being transformed into rice fields on a large scale, which is likely to cause a sharp decline in the value of ecosystem services.

Working to implement the sub-decree awarded to BPL in 2007 and towards the interim 20-year vision for BPL, the Boeung Prek Lapouv Management Plan, which applies to the period January 2014 to December 2018, sets out the following over-arching aims:

(1) To increase the use of BPL by Sarus Cranes through appropriate management of hydrology and habitats;

(2) To manage, maintain and enhance wetland biodiversity in BPL to support human livelihoods.

However, BPL faces major threats, including

(1) Conversion of wetlands to rice fields has caused a decline of 35% in wetlands in the wider BPL area between 2004 and 2011. The subsequent increased irrigation and channel construction causes the wetland to dry up rapidly after the flood season.

(2) Prevailing high use of chemicals and fertilizers in dry season rice farming exert a great impact on fish, other aquatic biodiversity and human health.

(3) Hunting, illegal fishing and other unsustainable activities are still of great concern.

(4) Lack of clear and effective regulation, demarcation and signposting, low awareness and limited enforcement of existing laws allow these unsustainable practices to continue.

To address these key threats and to reverse the trend of wetland degradation, the following projects are implemented to sustain the wetland for its people and wildlife:

(1) Sustainable agriculture project

(2) Community fisheries and natural resource management project

(3) Community-based ecotourism project

(4) Biodiversity and water management project

(5) Demarcation and land tenure project

(6) Laws and regulations projects

(7) Awareness and capacity building project

2.2 Water Environment Management Scheme of China

2.2.1 Laws and Regulations

China attaches great importance to legislation related to water environment management. Since 1984, many laws and regulations related to water environment management have been promulgated and revised. The laws and regulations concerning the prevention and control of water pollution in China are shown in the table below:

Table 2–2 Chinese laws and regulations for water pollution prevention and control

Laws and regulations	Time of enactment and amendment
Water Pollution Prevention and Control Law of the People's Republic of China	Enacted in 1984, amended in 1996 and 2008
Water Law of the People's Republic of China	Enacted in 1988, amended in 2002, 2009 and 2016
Soil and Water Conservation Law of the People's Republic of China	Enacted in 1991, amended in 2010
Environmental Protection Law of the People's Republic of China	Enacted in 1989, amended in 2014
Environmental Impact Assessment Law of the People's Republic of China	Enacted in 2002, amended in 2016 and 2018
Hydrological Regulation of the People's Republic of China	Enacted in 2007, amended in 2013, 2016 and 2017

2.2.2 Innovative Policies

China has refined and innovated relevant management systems for water pollution prevention and control in the national social and economic contexts while drawing on the governance experiences of developed countries. The general principle for water pollution prevention and control is putting prevention first, combining prevention and control, and controlling pollution in a comprehensive way. Priority will be given to the protection of drinking water supplies. Industrial pollution and urban domestic pollution will be strictly controlled, agricultural non-point source pollution prevented and controlled, and ecological treatment projects accelerated, so as to prevent, control and reduce water environment pollution and ecological damages.

- (1) Implementing the accountability system and evaluation system for water environment protection goals
- (2) Further strengthening the cap control system for aggregate discharge of major water pollutants
- (3) Fully implementing the pollutant discharge permit system and regulating the pollutant discharge behavior of enterprises
- (4) Upgrading the monitoring network and establishing a unified information disclosure system for water environment
- (5) Improving the management system of protection zones for drinking water sources
- (6) Tightening urban sewage control
- (7) Paying attention to the prevention and control of agricultural and rural water pollution
- (8) Making good emergency response to water pollution incidents
- (9) Increasing penalties for illicit sewage discharge

2.2.3 Urban Water Environment Management and Water Ecological Landscape Restoration in China

China's Guangxi and Yunnan Provinces are geologically connected with the Mekong countries and most similar to the Mekong countries in climate. Therefore, urban water environment management and lake ecological landscape restoration in the two provinces are analyzed herein to provide reference for water environment governance in countries in the Lancang-Mekong River Basin.

■ Restoration and Comprehensive Governance of Urban Water Environment in Nanning, Guangxi

Nanning, the capital city of Guangxi, is located in the subtropical zone and on the Tropic of Cancer. The climatic conditions and industrial structure are very similar to those of Lancang-Mekong countries. Nanning is a permanent venue for the China-ASEAN Expo and an important gateway for the organic integration of the maritime Silk Road in the Belt and Road Initiative, which secures very obvious geographical advantage. In addition, Nanning is also one of China's first pilot sponge cities. There are 18 rivers with a total length of 550 km in the entire urban area of Nanning, including 150 km in the built-up area. They form a rich water network system, a picture similar in most cities of Mekong countries.

(1) Status of Water Environment in Nanjing

- Backward environmental protection infrastructure construction and planning
- Low sewage collection rate
- Serious non-point source pollution from agriculture and aquaculture
- Concentrated industrial sewage discharge

(2) Measures for Water Environment Governance in Nanjing

Water environment governance should not be limited to the later treatment, but must intervene in the whole process from the source to the end. Comprehensive management of the water environment should be carried out by adjusting the industrial layout and structure, innovating environmental supervision and financing models, comprehensive treatment of pollution sources, and ecological restoration and protection.

■ Protection and Management of Plateau Lakes in Yunnan

(1) Overview of Lakes in Yunnan

There are a total of 30 natural lakes with an area of 1 km² each in Yunnan (including nine plateau lakes), of which nine lakes are larger than 30 km². The total area of lakes is 1,143.5 km², and the total area of basins is 14,865.37 km².

Yunnan is mountainous with a small part of dam area that has the most concentrated economic and social activities of the province. Located in the dam area, the nine large natural lakes account for about 2% of the province's land area, but bring together 10% of the province's population and contributes to 34% of the province's GDP. The relatively concentrated socio-economic development brings great challenges to the protection and management of plateau lakes.

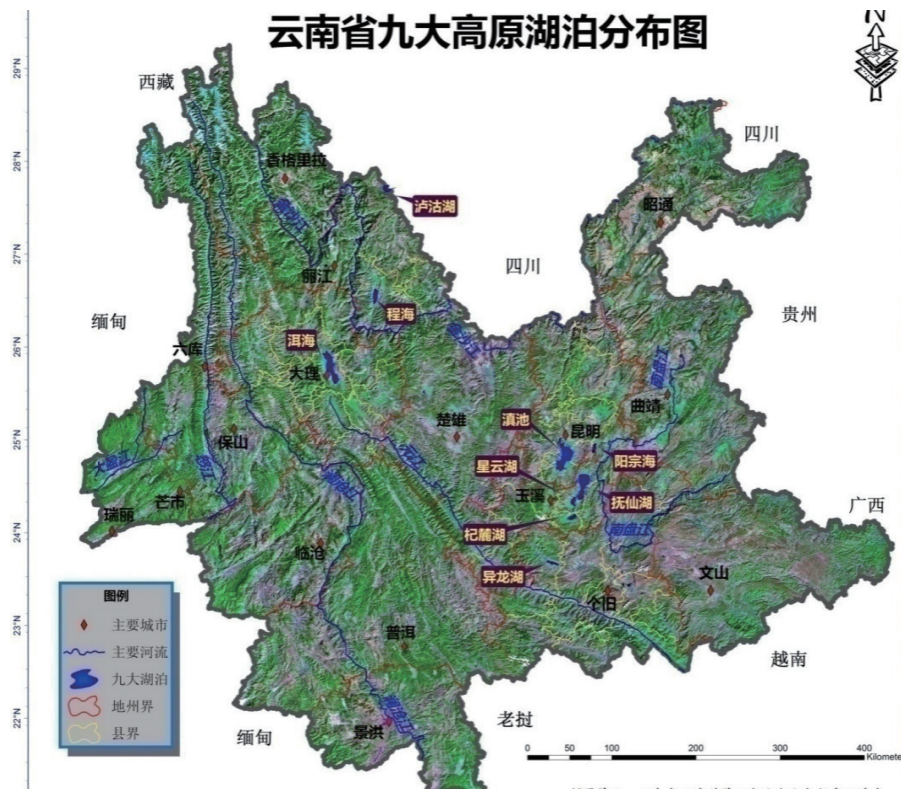


Figure 2- 2 Distribution of Yunnan's nine major lakes

(2) Challenges in Plateau Lake Protection and Management

- Unsuccessful constraint and management of lake space
- Imperfect sewage interception and control system
- Water shortage
- Aquatic ecosystem degradation

(3) Strategies for Plateau Lake Protection and Governance

- Protection of lakes with excellent water quality (precise management and ecological conservation)

Protection is given priority in pursuit of green development. Space management and control is strictly implemented. With ecological protection red lines delineated in the river basin, production, living and ecological space is arranged and regulated in a scientific and rational way to maintain ecosystem stability and health.

- Further improvement of lakes with good water quality (strict control and risk prevention)

Efforts are continued and intensified to prevent risks and control pollution. Pollution control and interception is carried out in all aspects, with strict control on the scale and intensity of waterfront construction. The overall utilization of water resources is strengthened, the regulation of lake ecosystems optimized, and the capacities of cyanobacteria bloom early warning and water environment risk prevention and control improved.

- Comprehensive treatment of polluted lakes (accurate and effective integrated management)

Comprehensive treatment measures are adopted, such as controlling pollution sources and intercepting sewage, improving inlet rivers, controlling agricultural and rural non-point sources ecological restoration, desilting watercourse, and ecological water replenishment.

2.3 Water Environment Management Scheme of Laos**2.3.1 Laws and Regulations**

The legislation concerning water environment in Laos includes the Regulations on Industrial Wastewater Discharge (2005), Environmental Protection Law (2012), Industrial Processing Law (2013), Decree on Environmental Impact Assessment (2010), and Environmental Impact Assessment Guidelines (2014). The Regulations on Industrial Wastewater Discharge, taking effect in 2012, targets industrial waste management. In addition, Laos enacted the National Environmental Standard and Water Resource Law in 2017.

2.3.2 Action Plan for Industrial Wastewater Treatment

Laos has launched the Strategy and Action Plan for Wastewater Treatment 2030. The vision for 2030 is to ensure hygienic lives for the urban population, provide wastewater treatment services for every household, and more effectively safeguard public health and promote economic growth, social security and sustainable environment. The goal is increasing access to sustainable wastewater facilities and services in urban areas for every districts with proprietary technology that is energy-efficient and low-cost (construction, operation and maintenance) and supports local materials and labors.

2.3.3 Urban Water Pollution and Effluent Discharge

Water demand has increased sharply with rapid population growth in Laos. Wastewater from human activities, households, small and medium-sized enterprises, and industrial sectors is directly discharged without treatment to roadside rainwater collection systems (or public areas). In most urban areas of Laos, wastewater is currently treated only through on-site disposal systems (toilets or septic tanks) without any other measures.

Residents in urban areas discharge untreated sewage directly into the public drainage system because the existing legislation does not make specific requirements on treatment of domestic sewage. Large plants must treat wastewater before discharge. The existing drainage system is not enough to handle all heavy rains, which accounts for frequent flooding during the rainy season.

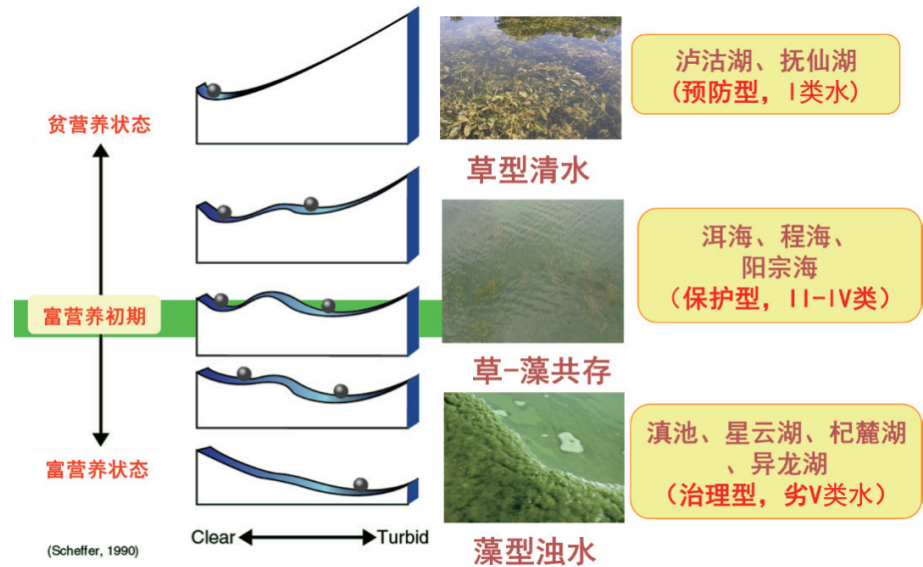


Figure 2- 3 Eutrophication status of Yunnan's nine major lakes

2.3.4 National Water Resources Strategy 2020 of Laos

Laos has developed the National Water Resources Strategy 2020. The vision of the strategy is as follows: "Coordinated, optimized and sustainable development and use of water resources, protection of the environment and improvement of social well-being".

The mission statements of the strategy are listed below:

- (1) Ensure sustainable development and management of water resources and minimize water environment and social impacts;
- (2) Manage and protect water sources and systematic, formulate comprehensive planning for water resources development and use, balance socioeconomic outcomes and water ecosystems;
- (3) Strengthen ownership and participation of stakeholders on management of water resource development and use through capacity building and use of local knowledge;
- (4) Prioritize water allocation for basic human needs, ensure equitable water uses and share the benefits of water availability and development.

The 12 components of the Lao Water Resources Strategic Plan 2020 are as follows:

- (1) Institutional strengthening & coordination
- (2) Legislation, plans and implementation
- (3) River basin and sub-river basin water resource planning
- (4) Groundwater management
- (5) Data & information management
- (6) Water allocation
- (7) Protection of water quality and ecosystems

- (8) Wetland management
- (9) Flood and drought management
- (10) WR risk management & climate change adaptation
- (11) Integrated water resource management (IWRM) financing
- (12) Awareness, participation & capacity building

2.4 Water Environment Management Scheme of Myanmar

2.4.1 Overview of Myanmar's Laws and International Cooperation on Water Environment Management

The Ministry of Natural Resources and Environmental Conservation of Myanmar has formulated multiple laws and regulations concerning water pollution:

- (1) Environmental Conservation Law (2012)
- (2) Environmental Conservation Rules (2014)
- (3) Environmental Impact Assessment Procedure (2015)
- (4) National Environmental Quality (Emission) Guidelines (2015)

Myanmar has actively conducted international cooperation concerning water pollution, and introduced international advanced technology, equipment and experience of wastewater treatment to improve water pollution monitoring and control capabilities.



Table 2–3 Myanmar's international cooperation on water pollution control

No.	Name	Partner	Project status	Cooperation type
1	Project on Capacity Development in Basic Water Environment Management and Environmental Impact Assessment System	Japan International Cooperation Agency (JICA)	2015-2018	Technical cooperation
2	Demonstration and Experimental Project (Facility Installation) on Local Pollution Control of Untreated	HORIBA	2015-2018	Technical cooperation
3	Wastewater from Dyeing in Wun Dwin Town, Mandalay Region	Asian Development Bank (ADB)	Completed	Technical cooperation
4	Formulation of National Environmental Quality Standards Establishment of System and Laboratory for Continuous Environmental Monitoring	HORIBA	Completed	Technical cooperation

2.4.2 Assessment of Ecological Status of Inlay Lake in Myanmar

Inlay Lake is the second largest natural lake in Myanmar. It is of particular importance to the Myanmar people due to its cultural significance and beauty. However, the lake is affected by increasing population and rapid growth in both agriculture and tourism. Considering this situation, Inlay Lake was selected as a case study area in the project Integrated Water Resources Management, Institutional Building and Training, to provide monitoring results for assessing the ecological status of the lake and to contribute to a lake monitoring program.

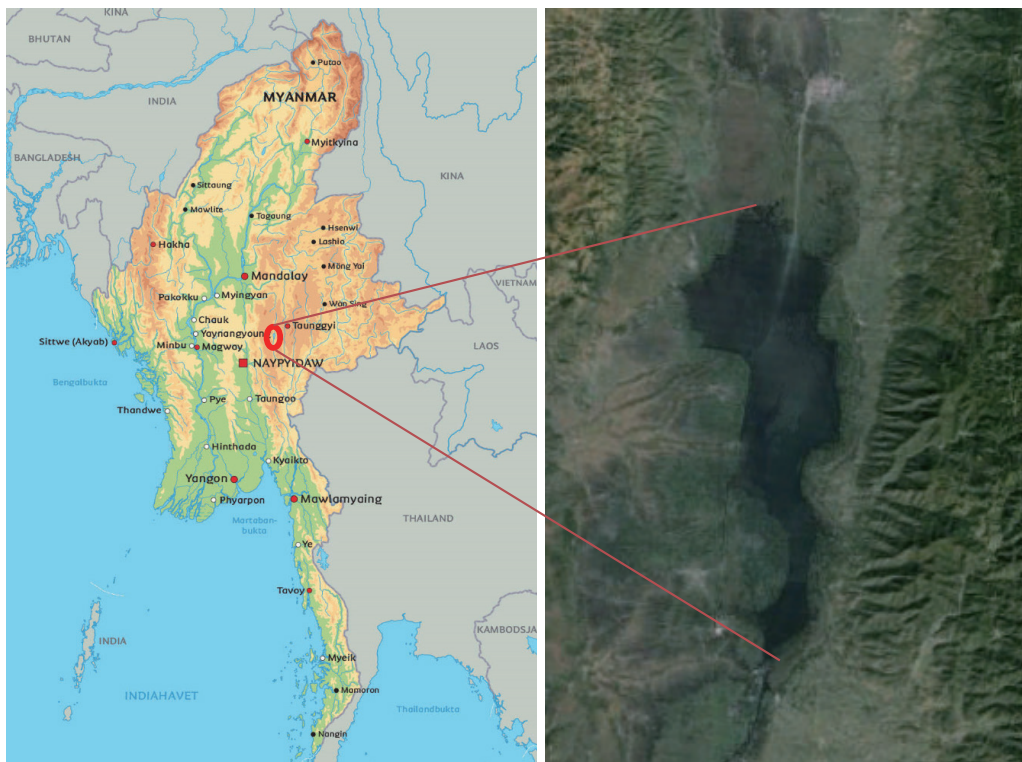


Figure 2- 4 Geographical location of Inlay Lake in Myanmar

2.4.2.1 Main Threatens faced by Inlay Lake

Deforestation in the Inlay Lake watershed is large, but degraded forest covers 30% of the watershed². Deforestation is expected to be the main reason for the increasing silt load in Inlay Lake. Agriculture on floating gardens is the main business in Inlay Lake. In the process of agriculture on floating gardens, lake farmers will apply chemical fertilizers, pesticides and organic fertilizers. Many toilets in the area are ground pit toilets, and the feces are discharged directly into the lake. Some factories and accommodation facilities with septic tank systems do not have complete sewage treatment facilities, and waste water such as untreated domestic sewage flows directly into the lake from around the area (Akaishi, Satake et al. 2006).

2.4.2.2 Evaluation Results

(1) Typology of Inlay Lake

Inlay Lake is a shallow lake with inflow from four large rivers. The water is clear with a turbidity value of 4.5 and 5.7 FNU. However, some of the inlet rivers have high turbidity. Inlay Lake is a calcareous lake, with an average calcium value of 49 mg Ca/L. With average color values of 17 mg Pt/l, it can be characterized as a clear lake. The nutrient concentrations in Inlay Lake show mesotrophic to semi-eutrophic conditions (Salas and Martino 1991). Both phosphorous and nitrogen concentrations are generally higher in the investigated inlet rivers.

Table 2–4 Physico-chemical data of Inlay Lake, 2015

2014-2015	Water temperature °C	pH	Conductivity µS/cm	Turbidity FNU	Silicate µg/L	TOC mg /L
Mini	20.30	7.33	286	0.64	1920	1.20
Max	28.00	9.43	491	-	13400	10.70
Mean	24.67	8.23	369	-	6989	5.08

Table 2–4 continued

2014-2015	Calcium mg Ca/L	Chroma mg Pt/L	Total phosphorus µg P/L	Phosphate µg P/L	Total nitrogen µg /L	NO3-N+ NO2-N µg N/L	Chlorine mg/L	Sulfate mg/L
Mini	46.7	16.7	3	1.0	290.0	3.0	6.4	2.9
Max	50.4	16.7	122	15.0	810.0	286.0	6.4	3.4
Mean	48.6	16.7	17.1	3.6	478.3	33.8	6.4	3.2

The river entering the lake transports the total suspended solids to the lake, and at the same time also brings the attached inorganic and organic matter into the lake. Eutrophication is one of the possible impacts of Lake Inlay, because the lake is very shallow, and the depth and oxygen content have little correlation with eutrophication. The rivers entering the lake are the sources of total nitrogen in Lake Inlay, and the concentration is slightly higher than the concentration measured in Lake Inlay. The sediments at the bottom of the lake and the large aquatic plants covering the bottom of the lake store more total phosphorus, and the rivers entering the lake are transporting more total phosphorus into the lake. The high total phosphorus comes from erosion in the catchment area and the use of fertilizers, as well as the direct discharge of wastewater from residential areas.

² MOECAAF 2014. 5 years Action Plan for the Sustainability of Inle lake and Environmental Conservation in Myanmar. Ministry of Environmental Conservation and Forestry, Forest Department).

(2) Phytoplankton

The phytoplankton composition and biomass are influenced by the availability of nutrients, especially phosphorous and nitrogen compounds. Inlay Lake, however, is a very shallow and clear lake with a water depth less than 4 m. These conditions support the strong growth of aquatic macrophytes. Macrophytes compete with phytoplankton for available nutrients and are so far preventing the massive growth of phytoplankton and especially nuisance cyanobacteria. Removal of large amounts of aquatic macrophytes from Inlay Lake would probably lead to increased growth of phytoplankton and have very negative effects on the water quality of the lake.

(3) Aquatic Macrophytes

The species diversity of aquatic macrophytes seems to be high in Inlay Lake. The large aquatic plants in the lake are dominated by tolerant species, and the ecological status obtained based on this is poor. But this index is uncertain because it is based on preliminary species sensitivity and the Norwegian border. Macrophyte cover, particularly in shallow lakes like Inlay lake, is important for maintaining the clear water state. Since the nutrient input to the lake is high, decreased macrophyte cover will lead to increased phytoplankton biomass and decreased water clarity.

2.5 Water Environment Management Scheme of Thailand

2.5.1 Competent Departments

The Pollution Control Department of the Ministry of Natural Resources and Environment is responsible for water pollution prevention and control in Thailand. Established in 1992, the Pollution Control Department consists of Water Quality Management Bureau, Air Quality and Noise Management, and Waste and Hazardous Substance Management Bureau, as well as Legal Division, Inspection and Enforcement Division and other divisions.

The Water Quality Management Bureau is responsible for enacting water pollution control policies, laws and regulations; developing water pollution control plans and water quality standards; and water quality monitoring in Thailand.

2.5.2 Water-related National Strategies

(1) National Water Vision

Thailand's National Water Vision: By 2025, Thailand will have sufficient water of good quality for all users through an efficient management, organization and legal system that will ensure equitable and sustainable use of water resources, with due consideration to participation of all stakeholders.

(2) National Economic and Social Development Plan

Purpose:

- Promote integrated water resource management to support sustainable food and energy security and mitigate floods and droughts;
- Develop, improve, and restore water resources to increase water supply;
- Promote efficient, low-cost and eco-friendly water use;
- Develop a master plan of water infrastructure to systematically manage water consumption.

Objectives:

- Create a more pleasant environment by reducing the pollution and threats to health from development;
- Regulate water quality in at least 80% of the main water sources and major rivers and restore coastal water quality in the inner Gulf of Thailand;
- Bring air quality in urban and industrial areas up to health standards and maintain this level;
- Dispose 50% of total solid waste in a sanitary fashion and recycle at least 30% of trash.

2.5.3 Status of Water Quality

The main parameters that cause water quality deterioration in Thailand include ammonium nitrogen, dissolved oxygen, total coliform bacteria, fecal coliform bacteria, and biochemical oxygen demand. Their contributions are shown in the following figure.

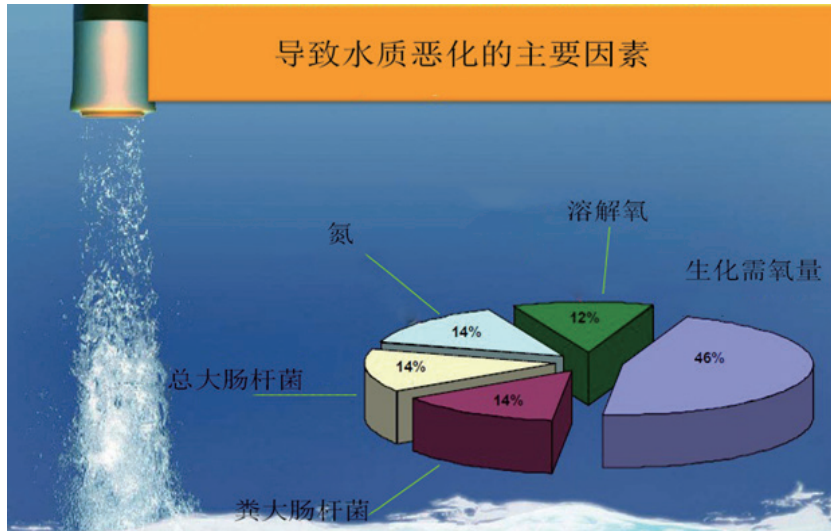


Figure 2-5 Contributions of main parameters to water quality deterioration

Domestic sewage, industrial sewage, and agricultural sewage are the major sources of water pollution in Thailand, accounting for 67%, 32.5% and 0.5% respectively (Figure).

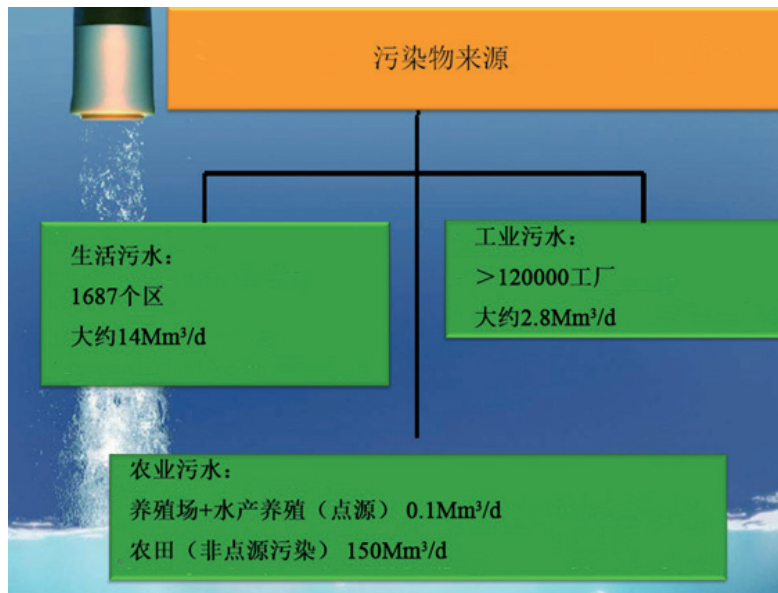


Figure 2-6 Contributions of major sources of sewage in Thailand

2.5.4 Ecological Health Monitoring of Thailand Rivers in 2015

The aquatic resources of the Mekong River and its tributaries are essential to the livelihoods of a large portion of the 60 million or more people who live in the Lower Mekong Basin. Maintaining the ecological health of the Mekong River is the basis of the sustainable management of natural resources. The Environment Program of the Mekong River Commission (MRC) has monitored the ecological health of the Mekong river system by using biological indices since 2003. This case study describes the biomonitoring activities field surveys in 2015. In this year, MRC has monitored the systems in place for hydrology and water quality. Normally, the activities have been based on measurement of physical-chemical parameters, but from year 2003, MRC has planned for the eventual integration of this system into the activities of the National Mekong Committees (NMCs) and their line agencies. The representatives of NMCs and line agencies together with national experts and international consultants developed a program and selected appropriate methods and procedures for ecological health monitoring (EHM).

Objectives of Ecological Health Monitoring

- (1) Collect biomonitoring samples by using the methodologies and protocols which are derived from the Biomonitoring Handbook published in 2010.
- (2) Determine the physical and chemical parameters as the ecological health condition at the selected sampling sites in Thailand.

2.6 Water Environment Management Scheme of Vietnam

2.6.1 Laws and regulations

Laws concerning water environment management in Vietnam include:

- Law on Environmental Protection

The Law on Environmental Protection of Vietnam took effect in 1999 and was amended in 2005 and 2014 respectively. It contains a lot of special legal provisions regarding water pollution control.

- Law on Water Resources
- Other laws and regulations concerning environmental protection, such as the Chemicals Law, Law on Natural Disaster Prevention and Control, and Law on Plant Protection and Quarantine;
- Water technology regulations and standards

2.6.2 Financial Instruments

There are funds at national and provincial levels for water environment governance in Vietnam. Under different competent departments, these funds raise capital through concessional loans and put focus on sewage treatment.



Table 2–5 Environmental governance funds of Vietnam

Fund	Year	Description
National level		
Vietnam Environmental Protection Fund	2002	<ul style="list-style-type: none"> • Under MoNRE • Capital from environmental protection fees, fines, compensation payments, carbon trade funds, and government development assistance • Funding through concessional loans • Targeting pollution control at establishments identified in Decree 64, waste treatment in urban areas, craft villages and hospitals
Vietnam Development Bank	2006	<ul style="list-style-type: none"> • Under the Ministry of Finance • Funding from deposits and bond issues • Funding through concessional loans • Targeting environmental protection projects, including urban wastewater treatment
Provincial level		
Local Infrastructure Development Funds (various provinces)	From 1997	<ul style="list-style-type: none"> • Under provincial PCs, with close involvement of the Ministry of Finance and DPI • Funding consolidated from different sources, including bond issues in some provinces • Funding through concessional loans • Targeting large-scale infrastructure projects —including wastewater treatment
Quang Ninh Provincial Environmental Protection Fund	2010	<ul style="list-style-type: none"> • Under DoNRE , with involvement of the Ministry of Finance and LIDFs depending on the province • Generally capital from provincial finance • Funding through concessional loans, replenished from environmental fees and fines • Targeting wastewater treatment and pollution control projects from municipal and point sources
Hanoi Environmental Protection Fund	2009	
Tay Nguyen Environmental Protection Fund	2010	
Vinh Phuc Environmental Protection Fund	2010	
Ba-Ria Vung -Tau Environmental Protection Fund	2005	
Binh Duong Environmental Protection Fund	2009	
Dong Nai Environmental Protection Fund	2004	
HCMC Revolving Fund for Industrial Pollution Control	2001	<ul style="list-style-type: none"> • Under HIFU • Capital from ADB and HIFU • Funding through concessional loans • Targeting small and medium-sized enterprises (SMEs), handicraft enterprises, and cleaner production projects
HCMC Industrial Pollution Minimization Fund	1999	<ul style="list-style-type: none"> • Under HIFU, with technical support from the Ministry of Natural Resources and Environment • Capital from provincial budget • Funding through concessional loans • Targeting SMEs and handicraft manufacturers
HCMC Waste Recycling Fund	2006	<ul style="list-style-type: none"> • Under DoNRE • Capital from provincial budget and various sources, including carbon trading • Funding through concessional loans • Special focus on sewage treatment plants

2.6.3 Flood and Saltwater Intrusion Management in Vietnam

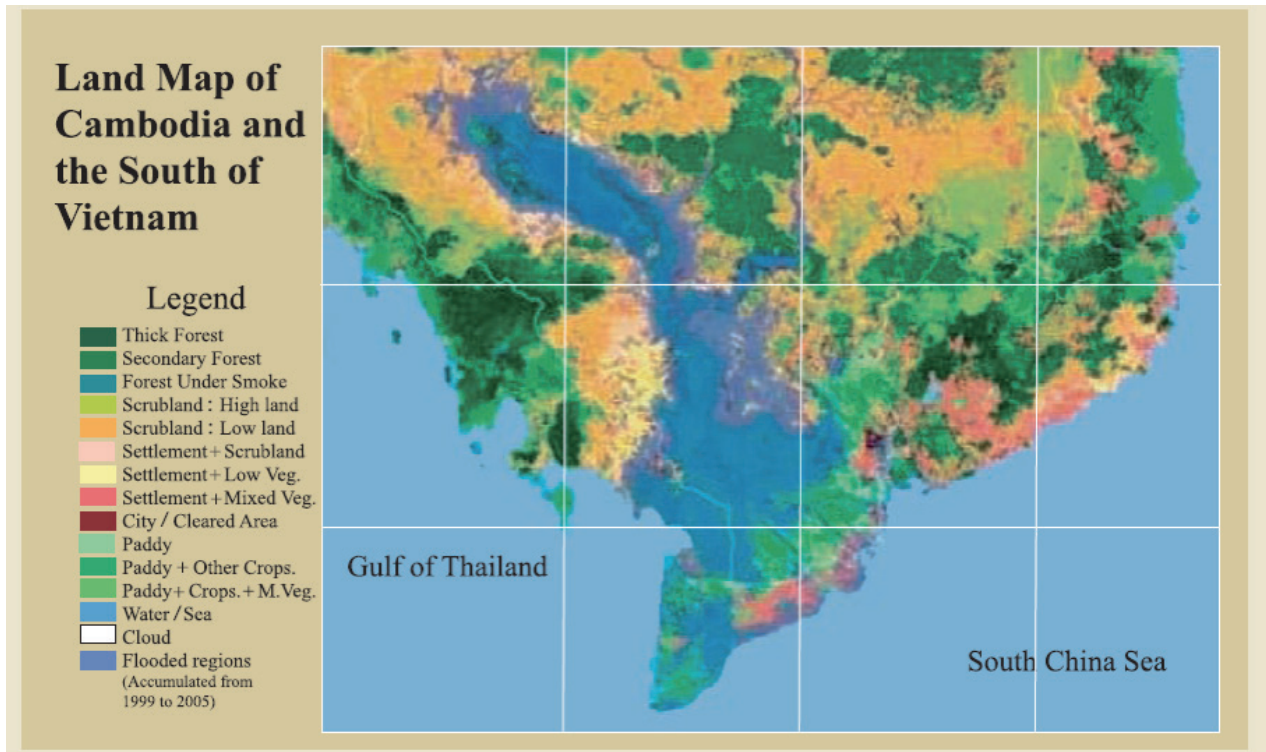


Figure 2- 7 Land cover in the Mekong Delta

Water is life for people and nature, not only in present years but also in the future. In general, to protect the people and their property for stable development conditions and to limit the damage of unusual natural disasters, there should be a flexible response system from the central to local levels. Flood and saline intrusion in the Mekong Delta may be looked at from different views if compared with other places in Vietnam and other countries. Within the delta, water management issues should be approached from various angles. The best people can do is to try to anticipate the flood and be prepared to live with the floods, both when the floods are beneficial and when they are harmful³.



Flood and salinity intrusion are natural phenomena, not disasters. They are typical characteristics of Mekong Delta. Both have given positive and negative impacts on natural habitats, human life, people's aqua-agricultural production, and infrastructure. They only become "disasters" when a great number of a valuable property is damaged and the life of people is endangered. This is due the increased industrial development and expansion of human settlement in the flood prone area as the delta is one of the most resource rich in the country. An early warning system and participatory water management are needed to reduce the disaster risks related to flood.

Conceptually, normal flood and saline intrusion in the Mekong Delta are not considered serious disasters to the people who are living and facing these events from year to year. For this reason, flood and saltwater intrusion management in the Mekong Delta has emerged differently to other regions in the north or center of Vietnam. Thus the strategy appropriate for the delta is a mitigation strategy or "living with flood and flood control" with specific solutions such as planning of residential clusters, construction of irrigation systems for supplying clean water and preventing salt invasion, and construction of low embankment system for preventing salt invasion⁴.



³ Ministry of Agriculture and Rural Development, Government of Vietnam [MARD] (2003) Atlas of Some Selected Hydraulic Works of Vietnam. Hanoi, Vietnam.

⁴ Vietnam, S.R. [SRV] (2005) National Report of Disaster Reduction in Vietnam. The World Conference on Disaster Reduction. Kobe-Hyogo, Japan.

Chapter 3 MRC Policies for Water Environment Management

3.1 Mekong Agreement

On April 5, 1995, the Governments of Cambodia, Laos, Thailand and Vietnam, being equally desirous of continuing to cooperate in a constructive and mutually beneficial manner for sustainable development, utilization, conservation and management of the Mekong River Basin water and related resources, concluded in Chiang Rai, Thailand, the agreement setting forth the framework for cooperation acceptable to all parties hereto. The contents concerning water environment are as follows:

(1) Areas of cooperation

To cooperate in all fields of sustainable development, utilization, management and conservation of the water and related resources of the Mekong River Basin including, but not limited to irrigation, hydro-power, navigation, flood control, fisheries, timber floating, recreation and tourism, in a manner to optimize the multiple-use and mutual benefits of all riparians and to minimize the harmful effects that might result from natural occurrences and man-made activities.

(2) Projects, programs and planning

To promote, support, cooperate and coordinate in the development of the full potential of sustainable benefits to all riparian States and the prevention of wasteful use of Mekong River Basin waters, with emphasis and preference on joint and/or basin-wide development projects and basin programs through the formulation of a basin development plan, that would be used to identify, categorize and prioritize the projects and programs to seek assistance for and to implement at the basin level.

(3) Protection of the environment and ecological balance

To protect the environment, natural resources, aquatic life and conditions, and ecological balance of the Mekong River Basin from pollution or other harmful effects resulting from any development plans and uses of water and related resources in the Basin.

(4) Maintenance of flows on the mainstream

To cooperate in the maintenance of flows on the mainstream from diversions, storage releases, or other actions of a permanent nature; except in the cases of historically severe droughts and/or floods: a) Of not less than the acceptable minimum monthly natural flow during each month of the dry season; b) To enable the acceptable natural reverse flow of the Tonle Sap to take place during the wet season; and c) To prevent average daily peak flows greater than what naturally occur on the average during the flood season. The Joint Committee shall adopt guidelines for the locations and levels of the flows, and monitor and take action necessary for their maintenance.

(5) Prevention and cessation of harmful effects

To make every effort to avoid, minimize and mitigate harmful effects that might occur to the environment, especially the water quantity and quality, the aquatic (eco-system) conditions, and ecological balance of the river system, from the development and use of the Mekong River Basin water resources or discharge of wastes and return flows. Where one or more States is notified with proper and valid evidence that it is causing substantial damage to one or more riparian States from the use of and/or discharge to water of the Mekong River, that State or States shall cease immediately the alleged cause of harm until such cause of harm is determined.

(6) Emergency situations

Whenever a Party becomes aware of any special water quantity or quality problems constituting an emergency that requires an immediate response, it shall notify and consult directly with the party(ies) concerned and the Joint Committee without delay in order to take appropriate remedial action.

3.2 Procedures for Implementing the Mekong Agreement

MRC has developed a series of specific procedures for the specific implementation of the Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin.

- (1) Procedures for Data and Information Exchange and Sharing
- (2) Procedures for Water Use Monitoring
- (3) Procedures for Notification, Prior Consultation and Agreement
- (4) Procedures for the Maintenance of Flows on the Mainstream
- (5) Procedures for Water Quality

Chapter 4 Exploration of International Organizations in Regional Cooperation on Water Environment

There are a large number of NGOs dynamic in the Lancang-Mekong region, in particular resource and environmental organizations such as the World Wide Fund for Nature (WWF) and Conservation International (CI). At present, the environmental governance of Lancang-Mekong region with abundant natural resources has begun to attract widespread attention from the international community. As the first to get involved, NGOs have set up many outlets in Lancang-Mekong countries and areas, built exchange platforms, and infiltrated widely into all corners of society in the region. They apply a different perspective from governments and intergovernmental organizations and form an important social force in regional environmental issues. This has not only put great pressure on the local governments, but also exerted profound influence on the internal affairs and diplomacy of local countries (Yang Chaohui, 2010).

4.1 CI Mekong Projects of Ecosystem Health Assessment

4.1.1 Freshwater Ecosystem Health Assessment of Lancang-Mekong River in Xishuangbanna

Freshwater ecosystems of the Lancang mainstream in Xishuangbanna are healthy due to many factors such as geographical environment, economic structure, effective local governance, and active stakeholder engagement. However, with the further increase of people's demand for a better life along with social and economic development, health indicators such as water quality and quantity will face pressure from balancing ecological environment and economic development. In addition, further improvements are needed in land cover naturalness, recreation, and governance and stakeholder engagement, as indicated in the current assessment results.

It is advisable to maintain the existing environmental advantages of Lancang-Mekong section in Xishuangbanna, such as water quantity, water quality, biodiversity, and biomass for consumption. Under this premise, work will be continued to prevent agricultural non-point source pollution; and water-related recreation projects will be strengthened that organically integrate natural capital into economic development. Since rubber and banana plantations, which have a huge impact on farmers' income, have weak water and soil retention and large water consumption, the introduction of eco-friendly cash crops should be considered to promote the green transition of rural economy. Efforts will be intensified in freshwater ecosystem management, water resource use and protection planning, and stakeholder engagement to push forward local freshwater ecosystem management overall.

4.1.2 Freshwater Ecosystem Health Assessment of Highland Erhai Lake

The results show that the Erhai Lake ecosystem is stable in structure and sound in function. As the surrounding tourism and human activities are strictly controlled, the lake ecosystem gains a momentum of sustainable development. Although ecosystem vitality is

seriously impaired by the early development and ecosystem services are also limited, the health status of freshwater ecosystem in Erhai Lake is continuously improving to a high level, owing to China's increasing efforts to protect Erhai Lake from 2015 onwards.

Nevertheless, pressure is still large facing Erhai Lake and protection should not be relaxed. Based on the assessment results, efforts are recommended in the following priority areas:

- (1) Optimize spatial layout and rationalize land use
- (2) Adjust industrial structure and develop green economy
- (3) Intercept and reduce pollutants entering the lake
- (4) Restore ecosystems

4.1.3 Freshwater Ecosystem Health Assessment of the Lower Mekong River

The Sekong-Sesan-Sre Pok (3S) river, crossing the border between Laos and Vietnam, supports 3.4 million people, of which 24% are poor. There are 329 native fish species in the basin, of which 17 are endemic and 14 critically endangered or endangered. As an important tributary, the 3S river contributes to about 25% of the flow and 15% of the sediment in the Mekong River, which, in turn, provides nutrients to Tonle Sap Lake, the world's largest inland fishery as well as the Mekong Delta, an economic pillar of Vietnam.

The results of freshwater ecosystem health assessment show that, thanks to good natural conditions, the 3S river basin scores highest for ecosystem vitality, basin condition and water quality. It faces great threat in biodiversity as a large number of aquatic species are endangered. Performance is also poor in comprehensive management capacity, regulating system, and resilience to undergoing rapid changes in the basin.

Overall, the results of the 3S river basin assessment match with expectations and show signs of ecological stress. It highlights the necessity to substantially improve the governance system to ensure that further economic development does not undermine basin sustainability.

4.2 WWF Water Stewardship

In order to stimulate the lead of enterprises in water resource management, WWF has pioneered the water stewardship program that encourages and guides enterprises to strengthen cooperation with upstream and downstream stakeholders through systematic processes. By fostering a model for engaging businesses, the government and the public in basin management, the program aims to achieve the effective management of water resources in key river basins while reducing the water risks faced by enterprises and all relevant parties.

As a link between businesses, governments, and communities, WWF promotes basin-scale corporate water management from five aspects:

- Basic research
- Project demonstration
- Tool development and standard setting
- Capacity building
- Publicity and education

WWF is promoting water stewardship projects around the world, primarily to continuously improve water conditions and reduce water impacts within the enterprise and in the value/supply chain. The Guidance guides park management departments, key enterprises in parks, financial institutions, NGOs and research institutions to jointly participate in the industrial park water stewardship project, through innovation mechanisms and information exchange platforms. It also helps improve the water management capacities and performances of industrial parks and enterprises by encouraging enterprises in the parks to learn from successful cases and explore the public-private partnership (PPP) model. On this basis, the Guidance aims to raise the awareness of water risks within the park basin to form the shared value of sustainable utilization of water resources among relevant stakeholders.

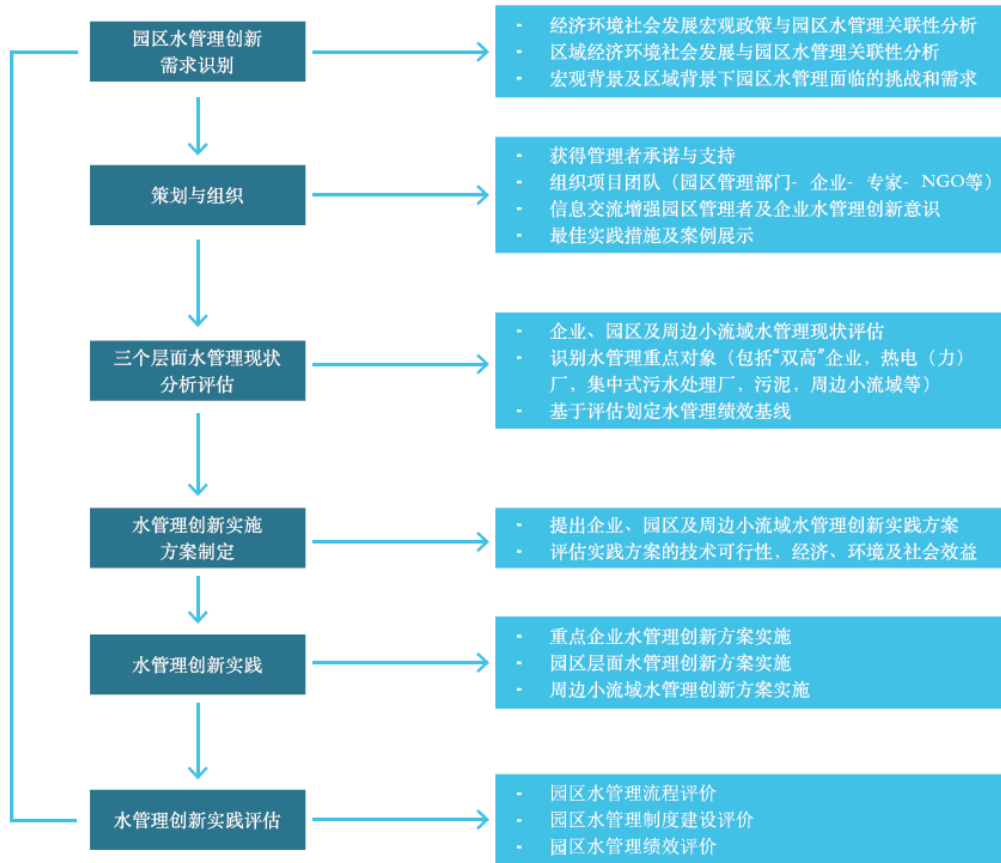


Figure 4- 1 Basic procedure of industrial park water stewardship implementation



Chapter 5 Lancang-Mekong Water Environment Governance and Sustainable Investment and Financing

China has imposed hard restrictions on energy conservation and emissions reduction and pushed for the construction of resource-saving and environment-friendly society. Under this new situation, green finance has emerged and is rising as an innovative environmental and economic policy (An Wei, 2008).

5.1 Sustainable Investment and Financing for Xiaomengyang–Mohan Expressway Construction

The construction of Xiaomengyang–Mohan Expressway is inseparable from the protection of Lancang-Mekong River. The highway runs through 13 tributaries of the Lancang River in total. In order to protect local freshwater resources, a targeted survey was conducted and a special plan prepared before the project construction. According to the findings, three of these rivers are relatively representative, including the Luosuo River, which have abundant fish resources. Also important are the catchment of Nanyuan River in Mengla County with a vegetation coverage of 88% and the catchment of Nanmuwo River with relatively intensive human activities and a large number of farmland and agricultural irrigation facilities. Based on green design, pollution prevention and control were practiced at the operation stage.

5.2 Sustainable Investment and Financing for Sihanoukville Special Economic Zone (SEZ) in Cambodia

In active response to China's "go global" policy, Hongdou Group financed Cambodia industrial park construction in 2017. This builds a platform for international production capacity cooperation. Sihanoukville SEZ is among the earliest economic and trade cooperation zones approved by the Ministry of Commerce and Ministry of Finance. It is also the largest SEZ approved by the Cambodian Government, and the best-developed and most-employed SEZ in Sihanoukville Province. It has been recognized as an iconic project in the Belt and Road Initiative and highly affirmed by the leaders of China and Cambodia.

The success of Sihanoukville SEZ is inseparable from its focus on and practice of sustainable development, which is mainly reflected in the following aspects:

- (1) Attention to communication with stakeholders
- (2) Persistent pursuit of green development
- (3) Full respect for local culture
- (4) Active fulfillment of social responsibility





Chapter 6 Outlook

The Lancang-Mekong River is the most important source of freshwater in the region. The quality of water environment is of vital significance for the livelihood and development for the peoples in the region. Although countries have performed active water environment governance through their own, bilateral and multilateral efforts, the water environment still tends to deteriorate severely under the pressure of economic development. In the future, the water environment governance of Lancang-Mekong River Basin can focus on in the following areas:

1. Rural Water Environment Governance

The Lancang-Mekong River Basin is an underdeveloped region. Agriculture accounts for a large proportion of the total national economic output in each country. Chemical fertilizers and pesticides applied in farming have become an important incentive for water quality degradation in the river basin. In addition, the low domestic sewage collection and treatment rate in the basin has also affected the rural water environment to a certain extent. The vast rural areas are the main source of drinking water for urban and rural residents. Strengthening agricultural non-point source pollution and domestic sewage treatment is an important measure to ensure water safety in the river basin.

2. Mitigation of Water Quality Impact of Water Conservancy and Hydropower Projects

For the purpose of development and utilization of rich water resources, various types of water conservancy and hydropower engineering facilities have been constructed in the Lancang-Mekong River Basin. They affect water quality and aquatic plant and animal habitats by changing river connectivity, reducing flow rate, changing erosion and deposition, and increasing water depth. To cope with the adverse impact, measures should be developed and implemented, which is important for safeguard the health of freshwater ecosystems and maintain the supply of various ecosystem services in the basin.

3. Water Pollution Control of Industrial Parks

Wastewater treatment in industrial parks is difficult because of diverse types and high concentrations of water pollutants. Water environment management of industrial parks should focus on wastewater treatment process design while improving water efficiency by means of water resource recycling. Based on information collected about pollutant types and concentrations in the effluent from various enterprises, sewage is mixed in a well-designed order to facilitate physical and chemical reaction among water pollutants, so that chemicals can be recycled and reused and pollutant concentrations reduced to achieve more efficient sewage treatment.



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About LMEC: Lancang-Mekong Environmental Cooperation(LMEC), established in 2017 in Beijing, China, aims to boost the capacity of environmental governance of each country and achieve regional sustainable development through the promotion of environmental cooperation among the Lancang-Mekong Countries.