Final Report

Strategic Environmental Assessment of the Chi River Basin

Executive Summary Report
Strategic and Integrated Development Program Report

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January 2020

Report Components

Strategic Environmental Assessment for the Chi River Basin

Final Report

Final Report

- **Strategic Environmental Assessment Report**
  - Executive Summary Report of the Strategic Environmental Assessment (Thai version)
  - Executive Summary Report of the Strategic Environmental Assessment (English version)
  - Strategic Environmental Assessment Report
  - Impact Mitigation and Monitoring Measures Report
  - Appendices to the Strategic Environmental Assessment
    - Appendix (1/3)
    - Appendix (2/3)
    - Appendix (3/3)

- **Strategic and Integrated Development Program Report**
  - Executive Summary Report, Strategic and Integrated Development Program Report (Thai version)

- **Executive Summary Report, Strategic and Integrated Development Program Report (English version)**

  - Strategic and Integrated Development Program Report
  - Appendices to the Strategic and Integrated Development Program Report

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Symbols and Abbreviations

B.E.	=	Buddhist Era
e.g.	=	exempli gratia
etc	=	et cetera
GDP	=	Gross Domestic Product
IUCN	=	International Union for Conservation of Nature
km	=	kilometer
km^2	=	square kilometer
m	=	meter
MCA	=	Multi Criteria Analysis
MCM	=	million cubic meter
mm	=	millimeter
MSL	=	Mean Sea Level
NGOs	=	Non-governmental organizations
ONWR	=	Office of the National Water Resources
PWA	=	Provincial Waterworks Authority
RID	=	The Royal Irrigation Department
SEA	=	Strategic Environmental Assessment
SIDP	=	Strategic and Integrated Development Program
SOAR Analysis	=	Strengths, Opportunities, Aspirations and Results Analysis
SWOT Analysis	=	Strengths, Weaknesses, Opportunities and Threats Analysis

Chi River Basin Strategic and Integrated Development Program

1 Area classification in accordance with area use

1. **The Chi and Phong Rivers watershed areas** covering 13.11 million rai
2. **Southwestern highland agricultural area** covering 3.03 million rai
3. **Midstream economic area** covering 6.22 million rai
4. **The Lam Pao River watershed area** covering 4.29 million rai
5. **Downstream area** covering 4.06 million rai

2 Chi River Basin Strategic and Integrated Development Program

Coordination with agencies concerned, improvement and increase in plans/projects that solve problems in the five Chi River Basin areas in line with public needs and serious and continuous acceleration of plans/projects implementation

Integrated water resource development plans for river basin areas consist of 8,008 projects with a total budget of 178,675.16 million baht excluding Mekong Diversion Project (Huai Luang Regulator) costing 44,687.00 million baht and watershed forest conservation (forestation and watershed weirs) comprising:

1. Basic problem-solving program
2. Drought, flood and wastewater mitigation program
3. Water source development for economic development program in the Chi River Basin areas

There are six aspects.

Aspect 1 Consumption-based water management
Aspect 2 Water security creation in the manufacturing sector
Aspect 3 Flood management
Aspect 4 Water quality management and water resource conservation
Aspect 5 Degraded watershed forest conservation and soil erosion prevention
Aspect 6 Management

3 Basic problem-solving program

	No. of projects	Budget (million baht)
Short-term plans		
Aspect 1 Consumption-based water management		
1.1 Consumption-based water provision	615	-
1.2 Local administrative organizations' water supply system improvement projects	876	3,255.94
1.3 Local administrative organizations' water source development projects	3,396	28,271.36
Aspect 2 Water security creation in the manufacturing sector		
2.1 Rainfed agricultural area management		
(1) Cropping to suit areas	-	-
(2) Economic forestation	66,062 rai	-
2.2 Water source management in rainfed agricultural areas	1,149	5,933.85
Aspect 4 Water quality management and water resource conservation		
4.1 Recycled water utilization		
Aspect 5 Degraded watershed forest conservation and soil erosion prevention		
5.1 Forestation	831,406 rai	5,587.00
5.2 Watershed weir construction (permanent weirs)	148	7.40
Aspect 6 Management		
6.1 Provincial/local waterworks management	6.2 Agency delay management	
6.3 Information development for decision-making	6.4 Wastewater management	
6.5 Environmental management		

4 Drought, flood and wastewater mitigation program

	No. of projects	Budget (million baht)
Short-term plans		
Aspect 2 Water security creation in the manufacturing sector		
2.1 Water efficiency enhancement in irrigation areas to increase farming areas	66,460 rai	
2.2 Project improvement, maintanance and efficiency enhancement	444	24,890.71
2.3 Small-scale water source development and pumping projects	546	21,129.33
Aspect 3 Flood management		
3.1 Flood prevention, e.g. river, drainage system and water obstruction improvement	350	3,251.65
3.2 Bank erosion prevention in line with local needs	76	-
3.3 Monkey cheek development in lowland floodplain forests	264	7,199.32
Medium-term plans		
3.4 Floodways (preliminary study)	-	-
3.5 Flood prevention in community areas	32	10,036.50
3.6 Water diversion to solve floods	4	3,630.00
Aspect 4 Water quality management and water resource conservation		
4.1 Wastewater solution	36	-
Aspect 6 Management		
6.1 Soil management due to dredging		
6.2 Non-structural measures to solve floods		

5 Project and water resource development program for economic development in the Chi River Basin areas

	No. of projects	Budget (million baht)
Medium-term plans		
Aspect 2 Water security creation in the manufacturing sector		
2.1 Water source project development in the Chi River Basin at full potential		
1) Medium- and large-scale development in the Chi River Basin	158	60,417.31
2) Water distribution development	46	8,990.38
3) Domestic water network development	16	1,668.81
Long-term plans		
2.2 Water availability increase in the Chi River Basin by Mekong diversion (Huai Luang Regulator)	1	44,687.00*
Aspect 6 Management		
6.1 Large-scale reservoir management		
6.2 Participation		
6.3 Agency delay mangement		

*Project value is 43,597 million baht. Including construction supervision 2.50 percent the project cost is 44,687 million baht.

6 Recommendations

To drive the plans in line with the integrated strategic development approach in the Chi River Basin, the following operations should be conducted :

1) Cooperation and understanding with agencies concerned
2) Cooperation with agencies responsible for improving/adding plans/projects to solve problems in the five areas of the Chi River Basin to suit people's needs
3) Understanding with the River Basin Committee and local people
4) An approval of plans/projects to implement them into practice
5) Coordination with responsible agencies to accelerate the operation of plans/projects and to solve basic problems
6) Feasibility study and environmental impact assessment of water resource development, flood diversion and drought and flood mitigation projects
7) Comparative study of options and selection of the optimum diversion alternative for further feasibility study and environmental impact assessment for the selected Mekong diversion alternative
8) Continuous impact mitigation and monitoring
9) Project outputs are monitored and evaluated by the ONWR.

Executive Summary Report
Strategic and Integrated Development Program Report

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Chapter 1

Introduction

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Introduction

1.1 Background

The Chi River Basin spans approximately 49,132 km^2, which is approximately 30,706,152 rai (30.71 million rai). It covers 13 provinces, namely Kalasin, Khon Kaen, Chaiyaphum, Nakhon Ratchasima, Phetchabun, Maha Sarakham, Yasothon, Roi Et, Si Sa Ket, Nong Bua Lam Phu, Udon Thani, and Ubon Ratchathani. Almost all the river basin area is in Chaiyaphum, Khon Kaen, Kalasin and Roi Et provinces, respectively, with a population of approximately 5,953,334 (5.95 million). It has an average annual rainfall of 1,188 mm and an average annual runoff of 11,994 MCM. The water demand by all sectors amounts to 5,792 MCM; however, the water storage capacity of local large-and medium-scale projects is only 5,687 MCM. Thus, the Chi River Basin always experiences water issues. Top-priority water-related problems include the shortage of water for agriculture, shortage of water for domestic use, flooding in urban and agricultural areas, and water quality issues as a result of municipal and industrial wastewater discharges, washout of agricultural chemicals to water bodies, and saline soils. The Chi River Basin comprises a total forest area of approximately 5,091,486 (5.09 million) rai, which represents 16.58 percent of the river basin area, and comprises a total agricultural area of approximately 20,436,852 (20.44 million) rai, representing 66.56 percent. The total area composed of soils which is suitable for crop cultivation spans 19,564,531(19.65 million) rai, representing 63.72 percent of the entire river basin area.

Given the current conditions of the Chi River Basin, the Office of the National Water Resources has realized the need for the study of the Chi River Basin Strategic Environmental Assessment. This aimed to assess environmental potential and constrains for the management of water resources in the Chi River Basin area which can result in balance and sustainable development in economic, social and environmental dimensions. This also aimed to compare alternatives for the management of water resources in the Chi River Basin area to ensure prudent decision-making and maximum benefits for the country and the general public. This is in line with the strategic issue for the development the river basin system-based water management to increase the country's water security under Strategy 5: Creation of growth on environmentally-friendly quality of life, under Thailand's 20-year National Strategy (2018-2037).

The study of the Chi River Basin Strategic Environmental Assessment involved the selection of the environmentally, socially and economically optimal alternative and hearings. The alternative served as the framework and guidelines for the development of the Chi River Basin area. Based on this alternative, the Strategic Plan for Integrated Chi River Basin Development was developed, which is divided into six areas: 1) Consumption-based water management, 2) Water security creation in the manufacturing sector, 3) Flood management, 4) Water quality management and water conservation, 5) Degraded watershed forest conservation and rehabilitation and soil erosion protection, and 6) Management. This required the development of programs/projects on the development of different areas in the river basin to solve social and environmental problems, increase incomes, and create the opportunities for economic development in the Chi River Basin to achieve stability, prosperity, and sustainability in line with the 20-year Master Plan on Water Resources Management, promulgated in the Government Gazette and has been effective since 18 September 2019.

This is the Executive Summary Report for the Strategic and Integrated Development Program of River Basin (SIDP), which is part of the Strategic Environmental Assessment of the Chi River Basin.

1.2 Location and Characteristics of Study Areas

The Chi River Basin is situated in the northeast region of Thailand, lying between 15° 30′ north latitude and 17° 30′ north latitude and between 101° 30′ east longitude and 104° 30′ east longitude. It comprises 20 sub-basins, with the Chi River as the main river, and different tributaries, e.g. Nam Phrom, Nam Choen, Nam Phong, Nam Pao, and Nam Yang. It mostly covers middle northeastern provinces and partly covers upper northeastern provinces, with these boundaries:

North: Connected to the Mekong River Basin.

South: Connected to the Mun River Basin.

East: Connected to the Mekong River Basin and the Mun River Basin.

West: Connected to the Pa Sak River Basin.

The topography of the Chi River Basin comprises high mountain ranges to the east and north, which are the Phu Phan mountain ranges; and to the west are the Phetchabun mountain ranges and the Dong Phaya Yen Forest, where the Chi River and various tributaries originate. Its middle area consists of plains and undulating areas with slight slopes to the south of the river basin, with the Chi River as the main river. The Chi River originates in the Phu Khiao mountain ranges in the Phu Khiao Wildlife Sanctuary at Ban Lon, Nang Daet sub-District, Nong Bua Daeng District, and then flows to the southeast through Chaturat and Mueang Chaiyaphum Districts, Chaiyaphum Province. Next, it goes back to the northeast through Khon Sawan District, Chaiyaphum Province, and Mancha Khiri District, Mueang Khon Kaen District, Khon Kaen Province. It goes back to the southwest through Kosum Phisai and Mueang Maha Sarakham Districts, Maha Sarakham Province; Selaphum and Phanom Phrai Districts, Roi Et Province; Mueang Yasothon and Maha Chana Chai Districts, Yasothon Province; and Khueang Nai District, Ubon Ratchathani Province. After that, it flows and meets with the Mun River in Mueang Ubon Ratchathani District, Ubon Ratchathani Province. Its total length is approximately 830 km. The Chi River Basin's general topography is illustrated in **Figure 1.2-1,** and the boundaries of the Chi River Basin's sub-basins are shown in **Figure 1.2-2.**

1.3 Objectives of the Study

The objectives of the Project are as follows**:**

1) To study and prepare the report on the strategic environmental assessment (SEA) on the management of water resources in the Chi River Basin.

2) To study and prepare the report under the Strategic and Integrated Development Program (SIDP) of the Chi River Basin

3) To study and develop the database on the Chi River Basin for the Office of the National Water Resources and the River Basin Committee for water management, river basin plan formulation, decision-making, and provision of information for water users and the general public.

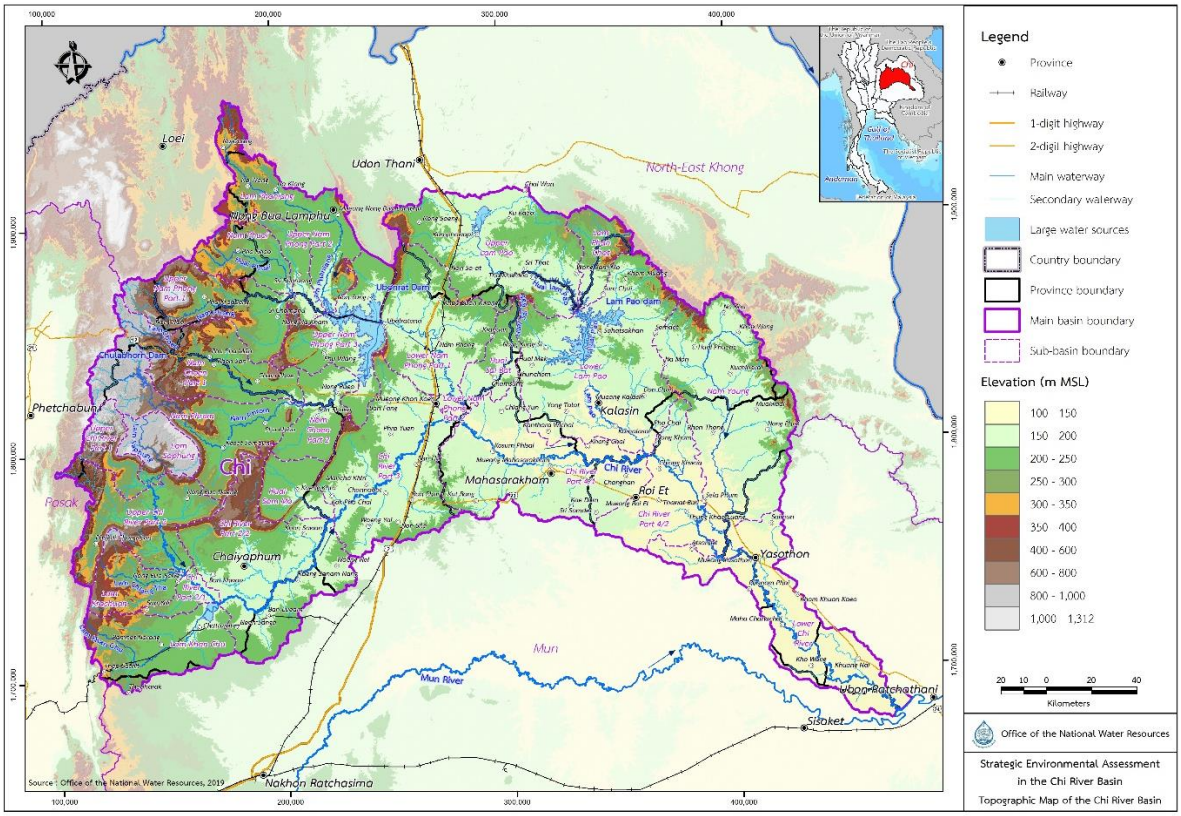


Figure 1.2-1 Area Conditions and Sub-basins of the Chi River

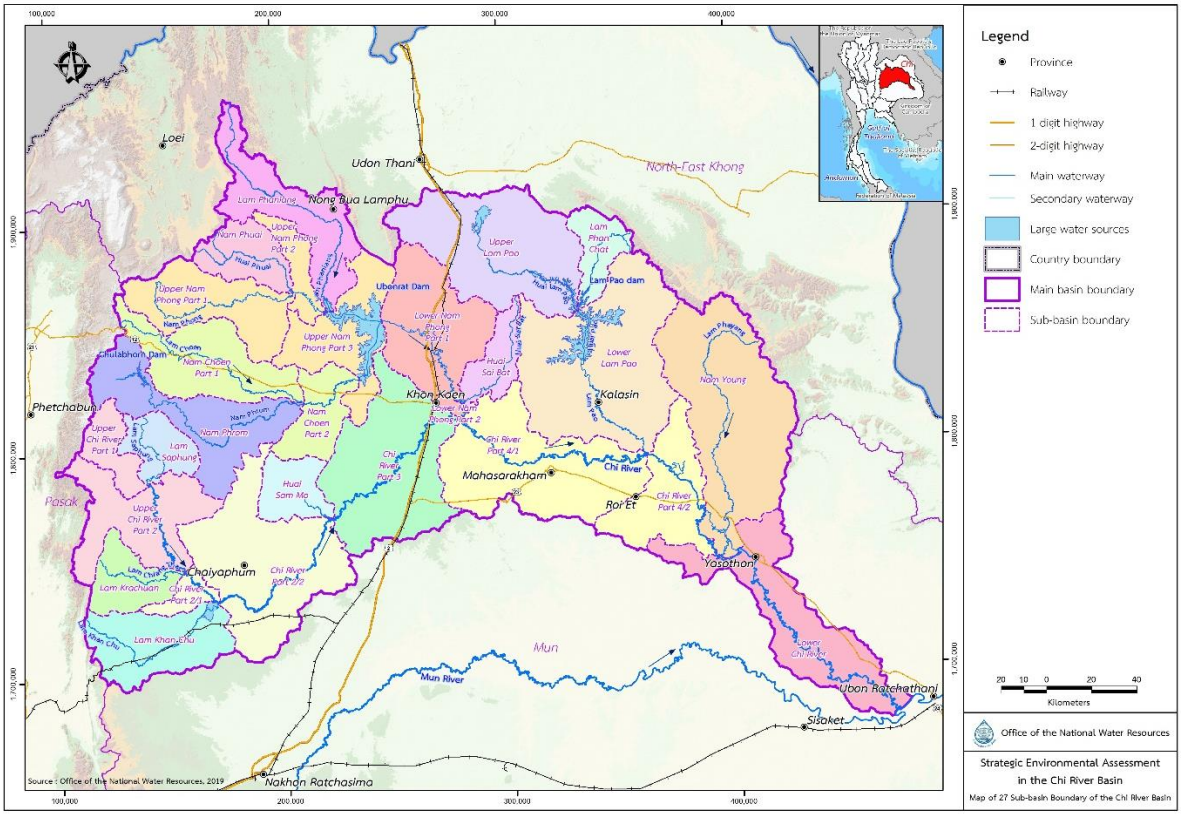


Figure 1.2-2 Sub-basins Boundary of the Chi River Basin

Chapter 2

Summary of Chi River Basin Strategic Environmental Assessment (SEA)

Chapter 2
Summary of Chi River Basin Strategic Environmental Assessment (SEA)

The frequent occurrences of the issues of drought, flooding and water quality in the Chi River Basin area due to physical resource constraints have resulted in the insufficiency of water for a large number of people and agricultural areas and in the Chi River Basin. This has social impacts and results in labor migration and migration of rural people to urban areas because of low agricultural productivity and low incomes among farmers.

2.1 Division of Areas by Area Use Characteristics

The Chi River Basin area is composed of 30,706,152 rai (30.71 million rai) – 20,436,852 rai (20.44 million rai) is agricultural land, 10,199,949 rai (10.20 million rai) is drought-prone areas, and 3,294,267 rai (3.29 million rai) is flood-prone areas. The areas suffering from the wastewater issue consist of the Phong River, Lam Pao River, and the Middle and Lower Chi River. Topographically, the Chi River Basin area can be divided into:

The watershed areas of the Chi River Basin originate in the Phetchabun mountain ranges and the Dong Phaya Yen Forest, which are the watersheds of the Chi River Basin and the Pa Sak River Basin. Being at the upper part of the Chi River Basin, they are characterized as forests, mountains, or highland, which yield water and store water. They are composed of the Chi River watershed, located in Chaiyaphum and Nakhon Ratchasima, the Phong River watershed, in Chaiyaphum and Khon Kaen, the Phuai River watershed, in Loei, the Lam Phaniang Watershed, in Nong Bua Lamphu, as well as the Lam Pao Watershed and watersheds originating in the Pha Phan mountain ranges, which are the watersheds of the Chi River Basin and the Songkhram River Basin in Udon Thani and Kalasin.

The midstream areas of the Chi River Basin are characterized as flat areas, community areas, and agricultural areas, which comprise the Phong River midstream area, the Lam Pao River midstream area, and the Yang River midstream area.

The downstream areas of the Chi River Basin are characterized as flood plain areas. They are agricultural areas which are frequently flooded. The Chi River flows and meets the Yang River before meeting the Mun River.

Due to topographical differences, in the study, the Chi River Basin area was divided into five areas. The study and collection of physical data on natural resources, water resources, land use, water-related disaster (flooding and drought), and socio-economic conditions, as illustrated in **Figure 2.1-1.**

Area 1: The Chi and Phong River watershed areas – Spanning 13,108,043 rai (13.10 million rai), they are composed of 3,856,223 rai (3.86 million rai) forest areas and 7,140,090 rai (7.14 million rai) agricultural areas. Serving as natural resources conservation and rehabilitation areas, they are in five provinces, consisting of Chaiyaphum, Phetchabun, Loei, Nong Bua Lam Phu, and Khon Kaen (34 districts and 242 sub-districts).

Area 2: The southwestern highland agricultural area – This is a drought-prone area. It spans 3,034,608 rai (3.03 million rai) – approximately 1,379,150 rai (1.38 million rai) has a medium to high risk of drought (4-10 times/10 years) and 2,578,925 rai (2.58 million rai) is agricultural land. It is located in four provinces: Chaiyaphum, Nakhon Ratchasima, Khon Kaen, and Maha Sarakham (23 districts and 116 sub-districts).

Area 3: Midstream economic area – It spans 6,215,012 rai (6.22 million rai), which is an important economic hub for the Chi River Basin. It is in four provinces, which consist of Khon Kaen, Maha Sarakham, Kalasin, and Roi Et (28 districts 220 sub-districts).

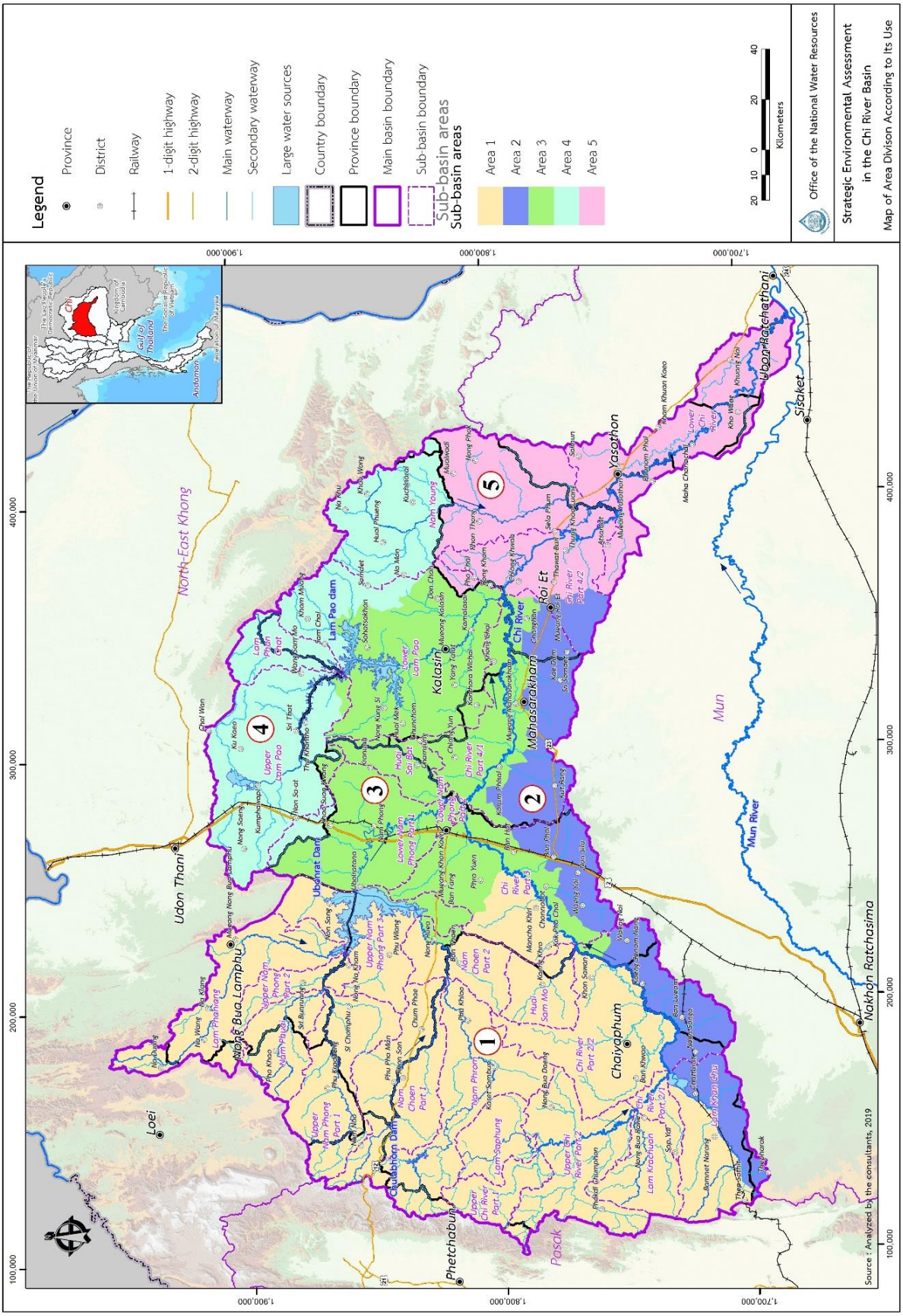


Figure 2.1-1 Area Divison According to Its Use

Area 4: The Lam Pao River watershed area – It spans 4,289,953 rai (4.29 million rai), with 3,116,237 rai (3.12 million rai) as agricultural land. It is located in two provinces – Udon Thani and Kalasin (19 districts and 104 sub-districts).

Area 5 : Downstream area – It is a flood- prone area. It spans 4,058,538 rai (4.06 million rai), with 3,056,528 rai (3.10 million rai) as agricultural land and 915,607 rai (0.91 million rai) as a flood-prone area. It is in four provinces: Roi Et, Yasothon, Si Sa Ket, and Ubon Ratchathani (20 districts and 155 sub-districts).

2.2 Summary of Appropriate Chi River Basin Development Alternatives

Problems, potentials and threats of the Chi River Basin were analyzed in five areas. The steps and methodology are summarized as follows:

1) SWOT analysis of the Chi River Basin is based on internal factors in environmental, social and economic dimensions to analyze strengths and weaknesses as well as external factors to analyze opportunities and threats.

2) SOAR analysis is based on the physical characteristics, land use conditions, socio- economic conditions in the five areas included in the Chi River Basin, as well as opinions from the 1st Focus Group in each of the areas:

2.1) The Chi River and Phong River watershed areas
2.2) Southwestern highland agricultural area
2.3) Midstream economic area
2.4) The Lam Pao River watershed area
2.5) Downstream area

The opinions of people from different areas who participated in the Focus Group were used to analyze strengths in different dimensions, including environmental and socio-economic dimensions, opportunities, aspirations, and results.

The results of the SWOT analysis for the overall Chi River Basin and the SOAR analysis on respective areas are outlined below:

2.1) The watershed forests account for only 16.58 percent of the river basin area. Conservation and rehabilitation should be carried out for the watershed forests and agricultural land reform areas to grow economic forests to increase the size of forest areas.

2.2) The Chi River Basin has large agricultural areas but has the drought problem and an inadequate amount of water for agriculture. Thus, there should be development of small- and medium-scale reservoirs, rehabilitation of natural water bodies, and diversion of water from the Mekong River to increase water and create water stability and security for the Chi River Basin area.

2.3) The downstream area of the Chi River Basin is used for cultivating high-quality jasmine rice, for which sufficient water should be supplied.

2.4) The midstream economic area is ready for economic development which can link with other countries in the Greater Mekong Subregion, and it is a major area for economic crop cultivation in the river basin.

2.5) People and farmers from different areas in the Chi River Basin should gather for economic value-added community products and agricultural production.

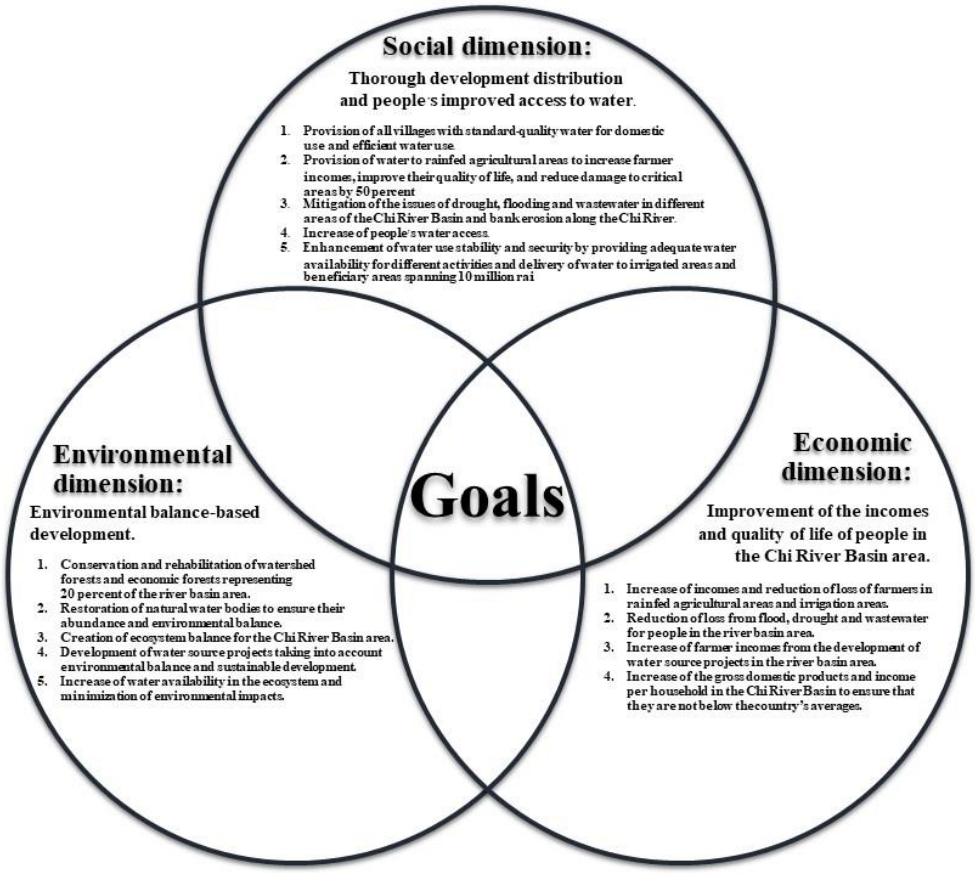
2.6) The agricultural area to the west of the Chi River Basin is highland which experiences aridity and water shortage, to which water should be supplied by rehabilitating small- scale water bodies, distributing water body development, and developing groundwater sources for cultivation to increase incomes and upgrade the quality of life of farmers.

2.7) The issue of bank erosion, which causes flooding and bank erosion and has an impact on assets and living conditions of local people, should be addressed.

2.8) The issue of wastewater from factories, community areas, and agricultural areas should be addressed.

2.9) There is an income disparity between people in urban areas and those in rainfed agricultural areas, to which water should be supplied for crop cultivation to increase farmer income.

3) Goals and alternatives for the River Basin area development: The Strategic Environmental Assessment (SEA) for the river basin area involved brainstorming among people from different provinces situated in the river basin area and analysis of problems and their solutions. In addition, goals and alternatives for the development of the Chi River Basin area were set to allow the Chi River Basin area to enjoy security, prosperity, and sustainability and balance in three dimensions: the economic, social and environmental dimensions. The goals and alternatives for the development of the river basin area are determined as shown in **Figure 2.2-1**.



Source: Analyzed by the consultants, 2019

Figure 2.2-1 Goals of the Development of the Chi River Basin Area

3.1) Economic dimension – Improvement of the incomes and quality of life of people in the Chi River Basin area.

(1) Enhancement of water use stability and security by providing adequate water availability for different activities and delivery of water to irrigated areas and beneficiary areas spanning 10 million rai.

(2) Increase of the gross domestic products and income per household in the Chi River Basin to ensure that they are not below the country's averages.

3.2) Social dimension: Thorough development distribution and people' s improved access to water.

(1) Provision of all villages with standard-quality water for domestic use and efficient water use.

(2) Provision of water to rainfed agricultural areas to increase farmer incomes, improve their quality of life, and reduce damage to critical areas by 50 percent.

(3) Mitigation of the issues of drought, flooding and wastewater in different areas of the Chi River Basin and bank erosion along the Chi River.

3.3) Environmental dimension – Environmental balance-based development.

(1) Conservation and rehabilitation of watershed forests and economic forests representing 20 percent of the river basin area and restoration of natural water bodies to ensure their abundance, ecosystem balance for the Chi River Basin area, and maximum benefits from utilizing water from water bodies.

(2) Development of water source projects taking into account environmental balance and sustainable development.

4) Alternatives for the development of the Chi River Basin area: Addressing the drought, flooding and water quality issues in the Chi River Basin area requires systematic planning on the development and integration among responsible agencies. The five alternatives for the Chi River Basin development to address the issues and develop the local economy were proposed, as follows:

Alternative 1: Business as usual – It is an alternative with no implementation but according to policies, plans or programs or no actions which are deviant from existing directions or guidelines.

Alternative 2: The development for basic necessities and development of sustainable agricultural areas – Supplying high-standard quality water for domestic use for living of local people; providing sufficient water bodies in rainfed agricultural areas to ensure self-dependence, conserving soils and rehabilitating watershed forests, reducing poverty in rural areas, and develop the Sufficiency Agriculture Model or the Khok Nong Na Model.

Alternative 3: The management of water resource-related risks at the area level and the development of related agricultural industries – Processing and adding the value to agricultural products, organic farming, and provision of water to support existing industries. This alternative aims to address the issues of drought, flood and wastewater, especially protection of floods in main cities to reduce the income gap between rural and urban people.

Alternative 4: The development of agroindustry in the northeast region – This focuses on water resource development at its full potential and provision of water to support new industries and tourism (ecotourism and prehistoric tourism). This alternative aims to increase the incomes of people in the river basin, reducing social inequality, and increase the GRP of the northeast region.

Alternative 5: **The development of business agriculture as the center of the Mekong Subregion –** This alternative involves the diversion of water from the Mekong River to increase irrigated agricultural areas to respond to the expansion of all types of industries, create the stability and security of water for agriculture, especially in the dry season, and add the value of water in production (business agriculture and exportation), and increase the country's GDP.

The comparison of these individual alternatives involved the analysis of outcomes, benefits, as well as positive and negative impacts, as summarized below:

Results: The results of the alternatives were considered in relation to solving the basic problems, environmental management, mitigation of drought and flooding, the development of water source projects in the river basin, and the Mekong River diversion.

Benefits: An analysis was conducted on the benefits of the respective alternatives in relation to solving the problems, increase in agricultural areas, increase in farmer incomes, flooding mitigation, and development of the economy in the Chi River Basin area.

Positive and negative impacts: An analysis was conducted on potential environmental, social, and environmental impacts of the respective alternatives.

To select the appropriate alternative, not only participation but factors/variables were considered in three dimensions, namely economic, social and environmental. Ranks and solution demand were evaluated through participation process and the Multi Criteria Analysis. The analysis of problems in each area based on benefit use involves factors/variables in three dimensions: economic, social and environment. Two variables, namely primary and secondary variables were considered as follows:

Main variables refer to the percentage of social and environmental weights. At the 2nd focus group meeting, environmental weight is 0.40, social weight is 0.30 and economic weight is 0.30.

Secondary variables consist of environmental, social and economic variables as follows:

1) Economic dimension comprises changeable water availability, benefit areas, GPP per capita, the number of trade and service business premises.

2) Social dimension comprises households that are likely to receive benefits, and to be affected by drought and floods, as well as participation in proposing alternatives, and the number of affected cultural and natural heritages.

3) Environmental dimension comprises recycled water, affected forest areas, rehabilitated deteriorated forest areas, the IUCN Red List of Threatened Species, the number of obstructions in waterways and the distance of dredging.

As for the analysis of main and secondary variables using the Multi Criteria Analysis (MCA), Alternative 5: The development of business agriculture as the center of the Mekong Subregion has the highest scores. Thus, Alternative 5 was selected to solve problems and develop economy in the Chi River Basin so that local people are wealthy and sustainable. Development plans for Alternative 5 are summarized as follows:

1) Development which meets basic needs and ensures thorough development distribution.

2) Management of the Chi River Basin area to solve the flooding, drought and wastewater issues.

3) Economic development in the Chi River Basin area based on the potential of water in the Chi River Basin.

4) Economic development by increasing water availability in the Chi River Basin to ensure water use stability.

Alternative 5: The development of business agriculture as the center of the Mekong Subregion is shown in **Figure 2.2-2**.

Figure 2.2-2 Alternative 5: Development of Business Agriculture as the Center of the Greater Mekong Subregion

2.3 Chi River Basin Water Resource Development Plans

Water resource development plans for the Chi River Basin involve the solution to social, environmental and economic problems in order to increase the income and peoples' quality of life in the Chi River Basin.

2.3.1 Development Goals

Concerning water resource development plans in the Chi River Basin, the following goals were determined:

1) Basic problem-solving in the Chi River Basin on consumption-based water and agriculture

2) Environmental management related to watershed forest conservation and wastewater solution

3) Drought and flood mitigation

4) River basin water resource development for developing agricultural industries in the Chi River Basin

5) Adequate water provision for development of business agriculture, industry and tourism to develop the Chi River Basin area as the center of the Greater Mekong Subregion

2.3.2 Water Resource Development Planning

To formulate Chi River Basin integrated development plans, peoples' demand is considered through public hearings at 10 forums. Options for developing the Chi River Basin areas are considered in economic, social and environmental dimensions. There are short-, medium- and long-term development plans as follows:

1) Short-term plans (Years 4-5) and medium-term plans (Years 6-10) of the national strategic plan include goals to solve social and environmental problems to achieve the goals of 1-3. Alternative 3 was determined as the Chi River Basin development plan in line with most people's demand from the public hearing in the Chi River Basin area.

2) Medium-term and long-term plans (Years 9-20) of the national strategic plan were determined in line with the goals of 4 and 5. Alternative 5 was determined to increase peoples' income and provide them opportunity to develop economy in the Chi River Basin and nearby basins, to provide water for agriculture, tourism and industry so that people in the river basin have a good quality of life as well as have stable and sustainable income.

2.3.2.1 Short-term and medium-term plans

Short- and medium-term plans involve development plans in line with Alternative 3 in Years 4-10 (2021-2027) of the national strategic plan, which can be implemented immediately. They consist of the following plans to solve social and environmental problems:

1) Basic problem-solving program

Aspect 1 Consumption-based water management

1.1 Consumption-based water provision

1.2 Local administrative organizations' water supply system improvement projects

1.3 Local administrative organizations' water source development projects

Aspect 2 Water security creation in the manufacturing sector
2.1 Rainfed agricultural area management
2.2 Water source management in rainfed agricultural areas
Aspect 4 Water quality management and water resource conservation
4.1 Recycled water utilization
Aspect 5 Degraded watershed forest conservation and soil erosion prevention
5.1 Forestation
5.2 Watershed weirs (permanent weirs)
Aspect 6 Management

2) Drought, flood and wastewater mitigation program
Aspect 2 Water security creation in the manufacturing sector
2.1 Water efficiency enhancement in irrigation areas
2.2 Project improvement, maintenance and efficiency enhancement
2.3 Small-scale water source development and pumping projects
Aspect 3 Flood management
3.1 Flood prevention, e.g. river improvement
drainage system and water obstruction improvement
3.2 Bank erosion prevention in accordance with local needs
3.3 Monkey cheek development in lowland floodplain forests
3.4 Floodways
Aspect 4 Water quality management and water resource conservation
4.1 Wastewater solution
Aspect 6 Management

2.3.2.2 Medium- and long-term plans

Medium- and long-term plans involve development plans in line with Alternative 5 in Years 9-20 (2026-2037) of the national strategic plan because it takes time to prepare the feasibility study, environmental impact assessment and detailed design in Years 4-17 (2021-2027). They are plans developed from Alternative 3 to increase peoples' income and provide them opportunity to develop economy in the Chi River Basin for security and sustainability.

1) Drought, flood and wastewater mitigation program
Aspect 3 Flood management
3.1 Flood prevention in community areas
3.2 Water diversion to solve floods
Aspect 6 Management
2) Water resource development program for economic development
Aspect 2 Water security creation in the manufacturing sector
2.1 Water resource project development in the basin at full potential
1) Medium- and large-scale project development
2) Water distribution system development
3) Domestic water network development
2.2 Chi River Basin water availability through Mekong River diversion (Huai Luang Regulator)
Aspect 6 Management

Integrated water resource development plans in the Chi River Basin consist of three groups in accordance with appropriate development alternatives, as shown in **Table 2.3.2-1**. Water resource development plans were grouped into six aspects according to the 20-year master plan for water resource management, as shown in **Table 2.3.2-2**. However, projects specified in the development plans are some plans collected from relevant state agencies and peoples' needs in the areas in the study period only.

Table 2.3.2-1 Integrated Water Resource Development Plans in the Chi River Basin (Three-Group Plans in Line with Appropriate Development Alternatives)

No	Plans	Number of projects	Development plans, year																	
			Short-term plans		Medium-term plans					Long-term plans										
			4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	
1.	**Basic problem-solving program**																			
	Aspect 1 Consumption-based water management																			
	1.1 Consumption-based water provision	615																		
	1.2 Local administrative organizations' water supply system improvement projects	876																		
	1.3 Local administrative organizations' water source development projects	3,396																		
	Aspect 2 Water security creation in the manufacturing sector																			
	2.1 Rainfed agricultural area management (economic forest cultivation 66,062 rai)	-																		
	2.2 Water source provision in rainfed agricultural areas	1,149																		
	Aspect 4 Water quality management and water resource conservation																			
	4.1 Recycled water utilization	-																		
	Aspect 5 Degraded watershed forest conservation and soil erosion prevention																			
	5.1 Forestation (831,406 rai)	-																		
	5.2 Watershed weirs (permanent weirs)	148																		
	Aspect 6 Management																			
2.	**Drought, flood and wastewater mitigation program**																			
	Aspect 2 Water security creation in the manufacturing sector																			
	2.1 Water use efficiency enhancement in irrigation areas (increasing an cultivation area of 66,460 rai)	-																		
	2.2 Project maintenance improvement and efficiency enhancement	444																		
	2.3 Small-scale water source development and pumping projects	546																		
	Aspect 3 Flood management																			
	3.1 Flood prevention, e.g. river, drainage and waterway obstruction improvement	350																		
	3.2 Bank erosion prevention in accordance with local needs	76																		
	3.3 Monkey cheek development in lowland floodplain forests	264																		
	3.4 Floodways *	-																		
	3.5 Flood prevention in community areas	32																		
	3.6 Water diversion to solve floods	4																		
	Aspect 4 Water quality management and water resource conservation																			
	4.1 Wastewater solution	36																		
	Aspect 6 Management																			
3.	**Water source project development program for economic development**																			
	Aspect 2 Water security creation in the manufacturing sector																			
	2.1 Water source project development in the Chi River Basin at full potential																			
	1) Medium- and large-scale project development	158																		
	2) Water distribution system development	46																		
	3) Domestic water network development	16																		
	2.2 Water availability increase in the Chi River Basin by Mekong diversion																			
	1) Mekong diversion (Huai Luang Regulator)	1																		
	Aspect 6 Management																			
	Total **	**8,008**																		

Remark : *Preliminary study/**Excluding economic forest cultivation areas (66,062 rai), reforestation for conservation of watershed forests (831,406 rai), watershed weirs (148 locations) and Mekong diversion (Huai Luang Regulator) for one project

Study and design Construction Management

Source: Analyzed by the consultants, 20109

Table 2.3.2-2 Integrated Water Resource Development Plans in the Chi River Basin (Six-Aspect Plans According to the 20-Year Water Resource Management Master Plan)

No	Aspect/plan	Number of projects	Plan, year																	
			Short-term plans		Medium-term plans					Long-term plans										
			4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	
1.	**Aspect 1 Consumption-based water management**																			
	1.1 Consumption-based water provision	615																		
	1.2 Local administrative organizations' water supply system improvement projects	876																		
	1.3 Local administrative organizations' water source development projects	3,396																		
2.	**Aspect 2 Water security creation in the manufacturing sector**																			
	2.1 Rainfed agricultural area management (economic forest cultivation 66,062 rai)	-																		
	2.2 Water source provision in rainfed agricultural areas	1,149																		
	2.3 Water use efficiency enhancement in irrigation areas (increasing an cultivation area of 66,460 rai)	-																		
	2.4 Project maintenance improvement and efficiency enhancement	444																		
	2.5 Small-scale water source development and pumping projects	546																		
	2.6 Water source project development in the Chi River Basin at full potential																			
	1) Medium- and large-scale project development	158																		
	2) Water distribution system development	46																		
	3) Domestic water network development	16																		
	2.7 Water availability increase in the Chi River Basin by Mekong diversion																			
	1) Mekong diversion (Huai Luang Regulator)	1																		
3.	**Aspect 3 Flood management**																			
	3.1 Flood prevention, e.g. river, drainage and waterway obstruction improvement	350																		
	3.2 Bank erosion prevention in accordance with local needs	76																		
	3.3 Monkey cheek development in lowland floodplain forests	264																		
	3.4 Floodways *	-																		
	3.5 Flood prevention in community areas	32																		
	3.6 Water diversion to solve floods	4																		
4.	**Aspect 4 Water quality management and water resource conservation**																			
	4.1 Recycled water utilization	-																		
	4.2 Wastewater solution	36																		
5.	**Aspect 5 Degraded watershed forest conservation and soil erosion prevention**																			
	5.1 Forestation (831,406 rai)	-																		
	5.2 Watershed weirs (permanent weirs)	148																		
6.	**Aspect 6 Management**																			
	Total **	**8,008**																		

Remark : *Preliminary study/**Excluding economic forest cultivation areas (66,062 rai), reforestation for conservation of watershed forests (831,406 rai), watershed weirs (148 locations) and Mekong diversion (Huai Luang Regulator) for one project

Study and design Construction Management

Source: Analyzed by the consultants, 20109

2.3.3 Strategic and Integrated Development Planning

Following the water resource development plans for the Chi River Basin including short-, medium- and long-term plans, strategic and integrated river basin development plans will be formulated comprising plans/projects in the master plan for the 20-year water resource management in the following six aspects:

1) Consumption-based water management
2) Water security creation in the manufacturing sector
3) Flood management
4) Water quality management and water resource conservation
5) Degraded watershed forest conservation and soil erosion prevention
6) Management

To solve social and environmental problems, and to increase income and create an opportunity for economic development in the Chi River Basin to be secure and sustainable, plans/projects will be prioritized based on factors for solving problems in each area.

1) Plans/projects required by local people
2) Development of environmentally-friendly projects
3) Problems in each area can be solved.
4) Specified goals are met with project success indicators
5) Integrated and sustainable water management
6) Urgency in problem solving
7) Project costs
8) Project construction period
9) Project impacts

The prioritized plans/projects will be formulated as strategic and integrated development programs in six aspects as short-, medium- and long-term plans.

Chapter 3

Plans in Line with Strategic Integrated River Basin Development Approach

Chapter 3
Plans in Line with Strategic Integrated River Basin Development Approach

The preparation of plans according to the Chi River Basin strategic integrated development approach has taken public participation and solutions in social, environmental and economic development into consideration so that the master plan for water management under the national strategy and has achievements and responds to national necessity and situations and public demands under the allocation and utilization of limited resources. Development plans have been formulated in accordance with 15 urgent issues covering key plans/projects in terms of missions, strategies and areas. They are classified into four groups: 1) solution to national basic problems so that Thailand is strong in terms of structures and management, as well as further development, 2) upgrading the quality of life of people so that they are self-reliant, 3) supporting growth in a systematic and sustainable manner to develop infrastructure and target economic areas systematically and to attract and serve country's growth and 4) generating national income to drive the economic sector based on sustainable development. The 20-year master plan for water resource management was promulgated in the Royal Gazette and has been enforced since September 18, 2019.

3.1 Chi River Basin Strategic Integrated Development Plans

The formulation of Chi River Basin strategic integrated development plans covers the master plan for water resource management in the following six aspects:1) Consumption-based water management, 2) Water security creation in the manufacturing sector, 3) Flood management, 4) Water quality management and water resource conservation, 5) Degraded watershed forest conservation and soil erosion prevention, and 6) Management.

To formulate integrated development plans for the Chi River Basin, the six water resource management plans have been used to solve social, environmental and economic problems in short- and long- terms in the following five areas: 1) Social problems on inequality and migration, 2) Environmental problems on watershed forest and wetland encroachment, and wastewater, 3) Economic and farmers' poverty problems in rainfed agricultural areas, income gap between rainfed agricultural areas and irrigation areas, as well as income gap between rural and urban people

As for the formulation of Chi River Basin integrated development plans, the following programs are determined to solve social, environmental and economic issues:

1) Basic problem-solving program
   - Aspect 1 Consumption-based water management
     - 1.1 Consumption-based water provision
     - 1.2 Local administrative organizations' water supply system improvement projects
     - 1.3 Local administrative organizations' water source development projects
   - Aspect 2 Water security creation in the manufacturing sector
     - 2.1 Rainfed agricultural area management
     - 2.2 Water source provision in rainfed agricultural areas
   - Aspect 4 Water quality management and water resource conservation
     - 4.1 Recycled water utilization
     - 4.2 Wastewater solution
   - Aspect 5 Degraded watershed forest conservation and soil erosion prevention
     - 5.1 Forestation (rai)
     - 5.2 Watershed weirs (permanent weirs)
   - Aspect 6 Management

2) Drought, flood and wastewater mitigation programs comprise:
   Aspect 2 Water security creation in the manufacturing sector
      2.1 Water use efficiency enhancement in irrigation areas
      2.2 Project improvement, maintenance and efficiency enhancement
      2.3 Small-scale water resource development and pumping projects
   Aspect 3 Flood management
      3.1 River improvement, drainage system and waterway obstruction improvement
      3.2 Bank erosion prevention according to local needs
      3.3 Monkey cheek development in lowland floodplain forests
      3.4 Floodways
      3.5 Flood protection in community areas
      3.6 Water diversion to solve floods
   Aspect 4 Water quality management and water resource conservation
      4.1 Wastewater solution
   Aspect 6 Management

3) Water resource project development plans for economic development to generate more income and provide an opportunity for economic development in the Chi River Basin to be stable, wealthy and sustainable.
   Aspect 2 Water security creation in the manufacturing sector
      2.1 Water resource project development in the basin at full potential
         1) Medium- and large-scale project development
         2) Water distribution system development
         3) Domestic water network development
      2.2 Chi River Basin water availability through Mekong River diversion (Huai Luang Regulator)
   Aspect 6 Management

3.2 Criteria for Project Prioritization in Plans and Budget Plans

3.2.1 Prioritization Criteria

Projects according to plans in appropriate alternatives of various agencies, namely the Community Development Department, the Department of Water Resources, the Provincial Waterworks Authority, the Royal Irrigation Department, the Department of Groundwater Resources, the Land Development Department, the Department of Disaster Prevention and Mitigation, the Royal Forest Department, the Department of National Parks, Wildlife and Plant Conservation, the Marine Department, the Department of Public Works and Town & Country Planning, the Regional Environmental Office 9 (Udonthani), the Regional Environmental Office 10 (Khon Kaen), the Regional Environmental Office 11 (Nakhon Ratchasima), and the Regional Environmental Office 12 (Ubon Ratchathani) were prioritized to formulate short-, medium- and long-term plans and prepare a budget as summarized in **Table 3.2.1-1**.

Table 3.2.1-1 Priority and Demand in Problem Solving in Each Area

Area	Solution priority		
	Priority 1	Priority 2	Priority 3
1. Chi and Phong watershed	Watershed area conservation	Agricultural water management	Flood prevention and mitigation
2. Southwestern highland agriculture	Agricultural water management	Flood prevention and mitigation	Wastewater solution
3. Midstream economy	Agricultural water management	Flood prevention and mitigation	Wastewater solution
4. Lam Pao watershed	Watershed area conservation	Agricultural water management	Wastewater solution
5. Downstream	Flood prevention and mitigation	Agricultural water management	Wastewater solution

Projects are divided into two groups to solve problems.

Group 1 can be immediately carried out. The following issues will be considered:

1) Solution urgency
2) Development difficulty
3) Period of project development

Group 2 requires a preparation period of five years or more, such as environmental impact assessment and report consideration by the Office of Natural Resources and Environmental Policy and Planning and detailed design. The following topics will be considered.

1) Solution urgency is considered based on urgent issues in the first five years of the 20-year national strategy comprising 15 issues in four groups.
2) Development difficulty
3) Period of project development
4) Project budget
5) Project benefits

3.2.2 Criteria for Plan and Budget Plan Formulation

The National Water Resource Committee determined the framework for the water resource management policy of 22 river basins across the country in accordance with the 20-year master plan for water resource management (2018-2037) so that the River Basin Committee formulates the master plan for water resource management at the basin level, and action plans. Agencies concerned should also prepare their master plan in accordance with missions, and action plans to link the master plan for river basin water resource management. In addition, provincial offices should prepare provincial/cluster development plans. The master plan for river basin water resource management and agencies will connect in line with provincial development plans to integrate plans at the basin, regional and central levels.

To serve as a framework and implement the plans according to the Chi River Basin strategic integrated development plans into practice, the plans and budget plans, as well as project development period must be clear. Plans and budget plans are divided into three phases:

1) Short-term plans, Years 4-5 of the national strategic plan
2) Medium-term plans, Years 6-10 of the national strategic plan
3) Long-term plans, Years 11-20 of the national strategic plan

Project plans, development plans and budget plans are integrated. There are responsible agencies so that such plans can be developed in the Chi River Basin as planned and problems can be solved according to priority and urgency in each area to meet the objectives and to audit in accordance with the determined indicators. Responsible agencies should drive the operation and integrate plans with agencies concerned.

3.3 Chi River Basin Integrated Development Plans

Chi River Basin areas are different in terms of physical and natural resources. Thus, the Chi River Basin areas are divided into five areas in order to analyze problems and suggest solutions to be consistent with environmental, social and economic problems in five areas. Chi River Basin integrated development plans are formulated to solve problems.

To formulate Chi River Basin integrated development plans, peoples' demand is considered through public hearings at 10 forums. Options for developing the Chi River Basin areas are considered in economic, social and environmental dimensions. There are short-, medium- and long-term development plans as follows:

1) Short-term plans (Years 4-5) and medium-term plans (Years 6-10) of the national strategic plan include goals to solve social, environmental and economic problems as Chi River Basin development plans.

2) Medium-term (Years 9-10) and long-term plans (Years 11-20) of the national strategic plan involve economic development by increasing peoples' income and provide them opportunity to develop economy in the Chi River Basin and nearby basins, to provide water for agriculture, tourism and industry so that people in the river basin have a good quality of life as well as have stable and sustainable income.

3.3.1 Summary of Projects in the Chi River Basin Integrated Development Plans

Chi River Basin integrated development plans are formulated by taking into account project plans to solve problems according to the five area conditions in the Chi River Basin. Project plans are divided into three groups in line with appropriate development alternatives and six aspect planning in accordance with the 20-year water resource management plan, as shown in **Table 3.3-1** to **Table 3.3-4**. In addition, project plans and provincial budgets are prepared, as shown from **Table 3.3-5** to **Table 3.3-8**.

According to the above tables, Chi River Basin integrated development plans are concluded to solve social, environmental and economic problems as follows:

1) Basic problem-solving program

Short- and medium-term plans		No. of projects	Budget (million baht)
Aspect 1	Consumption-based water management		
1.1	Consumption-based water provision	615	-
1.2	Local administrative organizations' water supply system improvement projects	876	3,255.94
1.3	Local administrative organizations' water source development projects	3,396	28,271.36
Aspect 2	Water security creation in the manufacturing sector		
2.1	Rainfed agricultural area management		
	1) Cropping to suit areas		
	2) Economic forestation (rai)	66,062	-
2.2	Water source management in rainfed agricultural areas	1,149	5,933.85
Aspect 4	Water quality management and water resource conservation		
4.1	Recycled water utilization		
Aspect 5	Degraded watershed forest conservation and soil erosion prevention		
	1) Forestation (rai)	831,406	5,587.00
	2) Watershed weir construction (permanent weirs)	148	7.40
Aspect 6	Management		
6.1	Provincial/local waterworks management		
6.2	Agency delay management		
6.3	Information development for decision-making		
6.4	Wastewater management		
6.5	Environmental management		

2) Drought, flood and wastewater mitigation program

Short-term plans		No. of projects	Budget (million baht)
Aspect 2	Water security creation in the manufacturing sector		
2.1	Water efficiency enhancement in irrigation areas (rai) to increase farming areas	66,460	-
2.2	Project improvement, maintenance and efficiency enhancement	444	24,890.71
2.3	Small-scale water source development and pumping projects	546	21,129.33

Short-term plans		No. of projects	Budget (million baht)
Aspect 3	Flood management		
3.1	Flood prevention, e.g. river, drainage system and water obstruction improvement	350	3,251.65
3.2	Bank erosion prevention in accordance with local needs	76	-
3.3	Monkey cheek development in lowland floodplain forests	264	7,199.32
Medium-term plans			
3.4	Floodways (preliminary study)	-	-
3.5	Flood prevention in community areas	32	10,036.50
3.6	Water diversion to solve floods	4	3,630.00
Aspect 4	Water quality management and water resource conservation		
4.1	Wastewater solution	36	-
Aspect 6	Management		
6.1	Soil management due to dredging		
6.2	Non-structural measures to solve floods		
	- Warning and preparedness prior to floods		
	- Management during floods		
	- Public relations		
	- Flood risk area identification		
	- Urban planning measures		
	- Post-flood rehabilitation		

3) Project and water resource development program for economic development in the Chi River Basin areas

Medium-term plans		No. of projects	Budget (million baht)
Aspect 2	Water security creation in the manufacturing sector		
2.1	Water resource project development in the Chi River Basin at full potential		
	1) Medium- and large-scale project development	158	60,417.31
	2) Water distribution system construction	46	8,990.38
	3) Domestic water network development	16	1,668.81
Short-term plans			
2.2	Chi River Basin water availability Mekong River diversion (Huai Luang Regulator)	1	44,687.00*
Aspect 6	Management		
6.1	Large-scale reservoir management		
6.2	Participation		
6.3	Agency's delay management		

Remark : *Project values 43,597 million baht and construction management cost 2.50 percent. The total cost is 44,687 million baht.

Programs and budget plans for a total of 8,008 projects costing 178,675.16 million baht are summarized, excluding the water availability increase in the Chi River Basin by Mekong River Diversion (Huai Luang Regulator Project, which was previously studied) and watershed forest conservation. The highest number of projects (1,061 projects) with a budget of 65,196.97 million baht is in Chaiyaphum Province, followed by Khon Kaen (797 projects) with a budget 37,427.29 million baht.

Table 3.3-1 Summary of Plans/Projects for Each Area in the Chi River Basin (Three-Group Plans in Line with Appropriate Development Alternatives)

Program	Plans/aspects	Number of projects					
		Area 1	Area 2	Area 3	Area 4	Area 5	Total
1.	**Basic problem solving program**						
	Short- and medium-term programs						
	Aspect 1 Consumption-based water management						
	1.1 Consumption-based water provision	237	86	148	66	78	**615** /1
	1.2 Local administrative organizations' water supply system improvement projects	223	138	239	133	143	**876** /2
	1.3 Local administrative organizations' water source development projects	1,074	637	765	473	447	**3,396** /3
	Aspect 2 Water security creation in the manufacturing sector						
	2.1 Rainfed agricultural area management						
	1) Cropping to suit areas	Agricultural areas are grouped according to rainfall and groundwater potential into eight zones.					
	2) Economic forestation (rai)	63,539	-	20	1,876	627	**66,062** /4
	2.2 Water source provision in rainfed agricultural areas	396	143	234	131	245	**1,149** /5
	Aspect 4 Water quality management and water resource conservation						
	4.1 Recycled water utilization	Wastewater is treated and recycled in the industrial and agricultural sectors.					
	Aspect 5 Degraded watershed forest conservation and soil erosion prevention						
	5.1 Forestation (rai)	579,725	-	74,501	149,833	27,347	**831,406** /6
	5.2 Watershed weirs (permanent weirs)	128	-	5	15	-	**148** /7
	Aspect 6 Management	Comprised of provincial waterworks/local water supply management, agency's delay, information development for decision-making wastewater management and environmental management.					
2.	**Drought, flood and wastewater mitigation program**						
	Short-term program						
	Aspect 2 Water security creation in the manufacturing sector						
	2.1 Water use efficiency enhancement in irrigation areas	Cultivation areas are adjusted to reduce 133.22 MCM of water use and increase 66,460 rai of cultivation areas.					
	2.2 Project maintenance improvement and efficiency enhancement	198	53	91	57	45	**444** /8
	2.3 Small-scale water source development and pumping projects	295	41	95	40	75	**546** /9
	Aspect 3 Flood management						
	3.1 Flood prevention, e.g. river, drainage and waterway obstruction improvement	75	41	129	53	52	**350** /10
	3.2 Bank erosion prevention in accordance with local needs	12	12	30	-	22	**76** /11
	3.3 Monkey cheek development in lowland floodplain forests	87	15	58	26	78	**264** /12
	Medium-term program						
	3.4 Floodways *	Floods are mitigated by increasing floodways and draining floods into the Mekong River.					
	3.5 Flood prevention in community areas	9	5	14	-	4	**32** /13
	3.6 Water diversion to solve floods	1	1	-	-	2	**4** /14
	Aspect 4 Water quality management and water resource conservation						
	4.1 Wastewater solution	6	6	17	1	6	**36** /15
	Aspect 6 Management	Comprised of soil management due to dredging and non-structural measure use for flood management					
3.	**Water source project development program for economic development**						
	Medium-term program						
	Aspect 2 Water security creation in the manufacturing sector						
	2.1 Water source project development in the Chi River Basin at full potential						
	1) Medium- and large-scale project development	107	14	20	12	5	**158** /16
	2) Water distribution system development	19	5	17	1	4	**46** /17
	3) Domestic water network development	6	-	4	4	2	**16** /18
	Long-term program						
	2.2 Water availability increase in the Chi River Basin by Mekong diversion (Huai Luang Regulator)	1					
	Aspect 6 Management	Comprised of large-scale reservoir management, parrticipation and agency's delay management					
	Total **	**2,745**	**1,197**	**1,861**	**997**	**1,208**	**8,008**

Remark : *Preliminary study /**Excluding economic forest cultivation areas (66,062 rai), reforestation for conservation of watershed forests (831,406 rai), watershed weirs (148 locations) and Mekong diversion (Huai Luang Regulator) for one project

Sources :
/1 The Community Development Department, 2015 (544 projects)
The Provincial Waterworks Authority, 2019 (71 projects)
/2 Local administrative organizations, 2019 (876 projects)
/3 Local administrative organizations, 2019 (3,396 projects)
/4 Analyzed by the consultants based on suitable soil analysis in economic forestation, 2019
/5 The Department of Water Resources, 2018-2019 (115 projects)
The Royal Irrigation Department, 2018 (19 projects)
The Department of Groundwater Resources, 2019 (216 projects)
The Land Development Department, 2018-2020 (798 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)
/6 Adapted from legal conservation forest area database, the Department of National Parks, Wildlife and Plant Conservation, 2019 and adapted from the Royal Forest Department's databases of maps showing the classification of land resource and forest land in national reserved forests, 1992
/7 The Department of National Parks, Wildlife and Plant Conservation, 2019 (148 projects)
/8 The Royal Irrigation Department, 2018 (441 projects)
The Department of Water Resources, 2018-2019 (two projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)
/9 The Royal Irrigation Department, 2018 (521 projects)
The Department of Water Resources, 2018-2019 (23 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (two projects)
/10 The Royal Irrigation Department, 2018 (90 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (260 projects)
/11 The Marine Department, 2019 (76 projects)
/12 The Royal Irrigation Department, 2018 (264 projects)
/13 The Royal Irrigation Department, 2018 (two projects)
The Department of Public Works and Town & Country Planning, 2018-2020 (30 projects)
/14 The Royal Irrigation Department, 2018 (four projects)
/15 Analyzed by the consultants based on the analysis of suitable areas for construction of new wastewater treatment systems, 2019 (28 projects)
The Regional Environmental Office 9 (Udonthani), 2017 (one project)
The Regional Environmental Office 10 (Khon Kaen), 2017 (five projects)
The Regional Environmental Office 11 (Nakhon Ratchasima), 2017 (one project)
The Regional Environmental Office 12 (Ubon Ratchathani), 2017 (one project)
/16 The Royal Irrigation Department, 2018 (158 projects)
/17 The Royal Irrigation Department, 2018 (46 projects)
/18 The Royal Irrigation Department, 2018 (16 projects)

Table 3.3-2 Summary of Plans/Projects for Each Area in the Chi River Basin (Six-Aspect Plans According to the 20-Year Water Resource Management Master Plan)

No.	Plans/aspects	Number of projects						
		Area 1	Area 2	Area 3	Area 4	Area 5	Total	
1.	**Aspect 1 Consumption-based water management**							
	1.1 Consumption-based water provision	237	86	148	66	78	**615**	/1
	1.2 Local administrative organizations' water supply system improvement projects	223	138	239	133	143	**876**	/2
	1.3 Local administrative organizations' water source development projects	1,074	637	765	473	447	**3,396**	/3
2.	**Aspect 2 Water security creation in the manufacturing sector**							
	2.1 Rainfed agricultural area management							
	1) Cropping to suit areas	Agricultural areas are grouped according to rainfall and groundwater potential into eight zones.						
	2) Economic forestation (rai)	63,539	-	20	1,876	627	**66,062**	/4
	2.2 Water source provision in rainfed agricultural areas	396	143	234	131	245	**1,149**	/5
	2.3 Water use efficiency enhancement in irrigation areas	Cultivation areas are adjusted to reduce 133.22 MCM of water and increase 66,460 rai of cultivation areas.						/6
	2.4 Project maintenance improvement and efficiency enhancement	198	53	91	57	45	**444**	/7
	2.5 Small-scale water source development and pumping projects	295	41	95	40	75	**546**	/8
	2.6 Water source project development in the Chi River Basin at full potential							
	1) Medium- and large-scale project development	107	14	20	12	5	**158**	/9
	2) Water distribution system development	19	5	17	1	4	**46**	/10
	3) Domestic water network development	6	-	4	4	2	**16**	/11
	2.7 Water availability increase in the Chi River Basin by Mekong diversion (Huai Luang Regulator)	1						
3.	**Aspect 3 Flood management**							
	3.1 Flood prevention, e.g. river, drainage and waterway obstruction improvement	75	41	129	53	52	**350**	/12
	3.2 Water diversion to solve floods	1	1	-	-	2	**4**	/13
	3.3 Flood prevention in community areas	9	5	14	-	4	**32**	/14
	3.4 Bank erosion prevention in accordance with local needs	12	12	30	-	22	**76**	/15
	3.5 Monkey cheek development in lowland floodplain forests	87	15	58	26	78	**264**	/16
	3.6 Floodways **	Floods are mitigated by increasing floodways and draining floods into the Mekong River.						
4.	**Aspect 4 Water quality management and water resource conservation**							
	4.1 Recycled water utilization	Wastewater is treated and recycled in the industrial and agricultural sectors.						
	4.2 Wastewater solution	6	6	17	1	6	**36**	/17
5.	**Aspect 5 Degraded watershed forest conservation and soil erosion prevention**							
	5.1 Forestation (rai)	579,725	-	74,501	149,833	27,347	**831,406**	/18
	5.2 Watershed weirs (permanent weirs)	128	-	5	15	-	**148**	/19
6.	**Aspect 6 Management**	Comprised of provincial waterworks/local water supply management, agency's delay, information development for decision-making, wastewater management, environmental management, soil disposal due to dredging and non-structural measure use for flood management						
	Total **	**2,745**	**1,197**	**1,861**	**997**	**1,208**	**8,008**	

Remark : *Preliminary study /**Excluding economic forest cultivation areas (66,062 rai), reforestation for conservation of watershed forests (831,406 rai), watershed weirs (148 locations) and Mekong diversion (Huai Luang Regulator) for one project

Sources :

/1 The Community Development Department, 2015 (544 projects)
The Provincial Waterworks Authority, 2019 (71 projects)
/2 Local administrative organizations, 2019 (876 projects)
/3 Local administrative organizations, 2019 (3,396 projects)
/4 Analyzed by the consultants based on suitable soil analysis in economic forestation, 2019
/5 The Department of Water Resources, 2018-2019 (115 projects)
The Royal Irrigation Department, 2018 (19 projects)
The Department of Groundwater Resources, 2019 (216 projects)
The Land Development Department, 2018-2020 (798 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)
/6 Analyzed by the consultants based on model-based water balance calculation, 2019
/7 The Royal Irrigation Department, 2018 (441 projects)
The Department of Water Resources, 2018-2019 (two projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)
/8 The Royal Irrigation Department, 2018 (521 projects)
The Department of Water Resources, 2018-2019 (23 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (two projects)
/9 The Royal Irrigation Department, 2018 (158 projects)
/10 The Royal Irrigation Department, 2018 (46 projects)
/11 The Royal Irrigation Department, 2018 (16 projects)
/12 The Royal Irrigation Department, 2018 (90 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (260 projects)
/13 The Royal Irrigation Department, 2018 (four projects)
/14 The Royal Irrigation Department, 2018 (two projects)
The Department of Public Works and Town & Country Planning, 2018-2020 (30 projects)
/15 The Marine Department, 2019 (76 projects)
/16 The Royal Irrigation Department, 2018 (264 projects)
/17 Analyzed by the consultants based on the analysis of suitable areas for construction of new wastewater treatment systems, 2019 (28 projects)
The Regional Environmental Office 9 (Udonthani), 2017 (one project)
The Regional Environmental Office 10 (Khon Kaen), 2017 (five projects)
The Regional Environmental Office 11 (Nakhon Ratchasima), 2017 (one project)
The Regional Environmental Office 12 (Ubon Ratchathani), 2017 (one project)
/18 Adapted from legal conservation forest area database, the Department of National Parks, Wildlife and Plant Conservation, 2019 and adapted from the Royal Forest Department's databases of maps showing the classification of land resource and forest land in national reserved forests, 1992
/19 The Department of National Parks, Wildlife and Plant Conservation, 2019 (148 projects)

Table 3.3-3 Budget Plans for Integrated Water Resource Development in the Chi River Basin (Three-Group Plans in Line with Appropriate Development Alternatives)

Program	Plans/aspects	Budget (millon bant)						
		Area 1	Area 2	Area 3	Area 4	Area 5	Total	
1.	**Basic problem solving program**							
	Short- and long-term programs							
	Aspect 1 Consumption-based water management							
	1.1 Consumption-based water provision	-	-	-	-	-	-	/1
	1.2 Local administrative organizations' water supply system improvement projects	547.00	518.68	1,190.26	492.66	507.34	**3,255.94**	/2
	1.3 Local administrative organizations' water source development projects	8,983.92	1,928.55	9,676.77	1,406.41	6,275.70	**28,271.36**	/3
	Aspect 2 Water security creation in the manufacturing sector							
	2.1 Rainfed agricultural area management							
	1) Cropping to suit areas	Agricultural areas are grouped according to rainfall and groundwater potential into eight zones.						
	2) Economic forestation (rai)	-	-	-	-	-	-	/4
	2.2 Water source provision in rainfed agricultural areas	1,275.03	222.83	2,113.69	91.51	2,230.79	**5,933.85**	/5
	Aspect 4 Water quality management and water resource conservation							
	4.1 Recycled water utilization	Wastewater is treated and recycled in the industrial and agricultural sectors.						
	Aspect 5 Degraded watershed forest conservation and soil erosion prevention							
	5.1 Forestation (rai)	5,587.00 /6						
	5.2 Watershed weirs (permanent weirs)	7.40 /7						
	Aspect 6 Management	Comprised of provincial waterworks/local water supply management, agency's delay, information development for decision-making, wastewater management and environmental management.						
2.	**Drought, flood and wastewater mitigation program**							
	Short-term program							
	Aspect 2 Water security creation in the manufacturing sector							
	2.1 Water use efficiency enhancement in irrigation areas	Cultivation areas are adjusted to reduce 133.22 MCM of water and increase 66,460 rai of cultivation areas.						
	2.2 Project maintenance improvement and efficiency enhancement	11,279.15	3,064.82	3,311.63	4,907.07	2,328.04	**24,890.71**	/8
	2.3 Small-scale water source development and pumping projects	10,421.76	2,534.85	4,924.20	1,583.08	1,665.44	**21,129.33**	/9
	Aspect 3 Flood management							
	3.1 Flood prevention, e.g. river, drainage and waterway obstruction improvement	566.12	344.06	1,296.18	155.64	889.64	**3,251.65**	/10
	3.2 Bank erosion prevention in accordance with local needs	-	-	-	-	-	-	/11
	3.3 Monkey cheek development in lowland floodplain forests	2,203.94	592.04	1,601.48	674.45	2,127.42	**7,199.32**	/12
	Medium-term program							
	3.4 Floodways *	Floods are mitigated by increasing floodways and draining floods into the Mekong River.						
	3.5 Flood prevention in community areas	4,231.50	1,640.00	3,420.00	-	745.00	**10,036.50**	/13
	3.6 Water diversion to solve floods	3,440.00	30.00	-	-	160.00	**3,630.00**	/14
	Aspect 4 Water quality management and water resource conservation							
	4.1 Wastewater solution	-	-	-	-	-	-	/15
	Aspect 6 Management	Comprised of soil disposal due to dredging and non-structural measure use for flood management						
3.	**Water source project development program for economic development**							
	Medium-term program							
	Aspect 2 Water security creation in the manufacturing sector							
	2.1 Water source project development in the Chi River Basin at full potential							
	1) Medium- and large-scale project development	36,725.40	7,255.24	13,591.91	1,544.76	1,300.00	**60,417.31**	/16
	2) Water distribution system development	216.06	418.01	7,807.75	1.80	546.76	**8,990.38**	/17
	3) Domestic water network development	1,359.33	-	163.12	123.24	23.12	**1,668.81**	/18
	Long-term program							
	2.2 Water availability increase in the Chi River Basin by Mekong diversion (Huai Luang Regulator)	44,687.00 **						
	Aspect 6 Management	Comprised of large-scale reservoir management, parrticipation and agency's delay management						
	Total ***	**81,249.20**	**18,549.08**	**49,096.99**	**10,980.63**	**18,799.25**	**178,675.16**	

Remark : * Preliminary study/**Project value 43,597 million baht including 2.50% construction cost 44,687 million baht in total

***Excluding budget for water availability increase in the Chi River Basin by Mekong diversion and watershed forest conservation (forestation and watershed weirs)

Sources :

/1 The Community Development Department, 2015 (544 projects)
The Provincial Waterworks Authority, 2019 (71 projects)

/2 Local administrative organizations, 2019 (876 projects)

/3 Local administrative organizations, 2019 (3,396 projects)

/4 Analyzed by the consultants based on suitable soil analysis in economic forestation, 2019

/5 The Department of Water Resources, 2018-2019 (115 projects)
The Royal Irrigation Department, 2018 (19 projects)
The Department of Groundwater Resources, 2019 (215 projects)
The Land Development Department, 2018-2020 (31,508 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/6 Adapted from legal conservation forest area database as the Department of National Parks, Wildlife and Plant Conservation, 2019 and adapted from the Royal Forest Department's databases of maps showing the classification of land resource and forest land in national reserved forests, 1992

/7 The Department of National Parks, Wildlife and Plant Conservation, 2019 (148 projects)

/8 The Royal Irrigation Department, 2018 (441 projects)
The Department of Water Resources, 2018-2019 (two projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/9 The Royal Irrigation Department, 2018 (521 projects)
The Department of Water Resources, 2018-2019 (23 projects)
The Department of Disaster Prevention and Mitigation, 2018-2019 (two projects)

/10 The Royal Irrigation Department, 2018 (90 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (260 projects)

/11 The Marine Department, 2019 (76 projects)

/12 The Royal Irrigation Department, 2018 (264 projects)

/13 The Royal Irrigation Department, 2018 (two projects)
The Department of Public Works and Town & Country Planning, 2018-2020 (30 projects)

/14 The Royal Irrigation Department, 2018 (four projects)

/15 Analyzed by the consultants based on the analysis of suitable areas for construction of new wastewater treatment systems, 2019 (28 projects)
The Regional Environmental Office 9 (Udonthani), 2017 (one project)
The Regional Environmental Office 10 (Khon Kaen), 2017 (five projects)
The Regional Environmental Office 11 (Nakhon Ratchasima), 2017 (one project)
The Regional Environmental Office 12 (Ubon Ratchathani), 2017 (one project)

/16 The Royal Irrigation Department, 2018 (158 projects)

/17 The Royal Irrigation Department, 2018 (46 projects)

/18 The Royal Irrigation Department, 2018 (16 projects)

Table 3.3-4 Budget Plans for Integrated Water Resource Development in the Chi River Basin

(Six-Aspect Plans According to the 20-Year Water Resource Management Master Plan)

No	Plans/aspects	Number of projects						
		Area 1	Area 2	Area 3	Area 4	Area 5	Total	
1.	**Aspect 1 Consumption-based water management**							
	1.1 Consumption-based water provision	-	-	-	-	-	-	/1
	1.2 Local administrative organizations' water supply system improvement projects	547.00	518.68	1,190.26	492.66	507.34	**3,255.94**	/2
	1.3 Local administrative organizations' water source development projects	8,983.92	1,928.55	9,676.77	1,406.41	6,275.70	**28,271.36**	/3
2.	**Aspect 2 Water security creation in the manufacturing sector**							
	2.1 Rainfed agricultural area management							
	1) Cropping to suit areas	Agricultural areas are grouped according to rainfall and groundwater potential into eight zones.						
	2) Economic forestation (rai)	-	-	-	-	-	-	/4
	2.2 Water source provision in rainfed agricultural areas	1,275.03	222.83	2,113.69	91.51	2,230.79	**5,933.85**	/5
	2.3 Water use efficiency enhancement in irrigation areas	Cultivation areas are adjusted to reduce 133.22 MCM of water and increase 66,460 rai of cultivation areas.						/6
	2.4 Project maintenance improvement and efficiency enhancement	11,279.15	3,064.82	3,311.63	4,907.07	2,328.04	**24,890.71**	/7
	2.5 Small-scale water source development and pumping projects	10,421.76	2,534.85	4,924.20	1,583.08	1,665.44	**21,129.33**	/8
	2.6 Water source project development in the Chi River Basin at full potential							
	1) Medium- and large-scale project development	36,725.40	7,255.24	13,591.91	1,544.76	1,300.00	**60,417.31**	/9
	2) Water distribution system development	216.06	418.01	7,807.75	1.80	546.76	**8,990.38**	/10
	3) Domestic water network development	1,359.33	-	163.12	123.24	23.12	**1,668.81**	/11
	2.7 Water availability increase in the Chi River Basin by Mekong diversion (Huai Luang Regulatc	44,687.00 *						
3.	**Aspect 3 Flood management**							
	3.1 Flood prevention, e.g. river, drainage and waterway obstruction improvement	566.12	344.06	1,296.18	155.64	889.64	**3,251.65**	/12
	3.2 Water diversion to solve floods	3,440.00	30.00	-	-	160.00	**3,630.00**	/13
	3.3 Flood prevention in community areas	4,231.50	1,640.00	3,420.00	-	745.00	**10,036.50**	/14
	3.4 Bank erosion prevention in accordance with local needs	-	-	-	-	-	-	/15
	3.5 Monkey cheek development in lowland floodplain forests	2,203.94	592.04	1,601.48	674.45	2,127.42	**7,199.32**	/16
	3.6 Floodways**	Floods are mitigated by increasing floodways and draining floods into the Mekong River.						
4.	**Aspect 4 Water quality management and water resource conservation**							
	4.1 Recycled water utilization	Wastewater is treated and recycled in the industrial and agricultural sectors.						
	4.2 Wastewater solution	-	-	-	-	-	-	/17
5.	**Aspect 5 Degraded watershed forest conservation and soil erosion prevention**							
	5.1 Forestation (rai)	5,587.00 /18						
	5.2 Watershed weirs (permanent weirs)	7.40 /19						
6.	**Aspect 6 Management**	Comprised of provincial waterworks/local water supply management, agency's delay, information development for decision-making, wastewater management, environmental management, soil disposal due to dredging and non-structural measure use for flood management.						
	Total ***	**81,249.20**	**18,549.08**	**49,096.99**	**10,980.63**	**18,799.25**	**178,675.16**	

Remark : *Project value 43,597 million baht including 2.50% construction cost 44,687 million baht in total/**Preliminary study

***Excluding budget for water availability increase in the Chi River Basin by Mekong diversion and watershed forest conservation (forestation and watershed weirs)

Sources : /1 The Community Development Department, 2015 (544 projects)
The Provincial Waterworks Authority, 2019 (71 projects)
/2 Local administrative organizations, 2019 (876 projects)
/3 Local administrative organizations, 2019 (3,396 projects)
/4 Analyzed by the consultants based on suitable soil analysis in economic forestation, 2019
/5 The Department of Water Resources, 2018-2019 (115 projects)
The Royal Irrigation Department, 2018 (19 projects)
The Department of Groundwater Resources, 2019 (216 projects)
The Land Development Department, 2018-2020 (798 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)
/6 Analyzed by the consultants based on model-based water balance calculation, 2019
/7 The Royal Irrigation Department, 2018 (441 projects)
The Department of Water Resources, 2018-2019 (two projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)
/8 The Royal Irrigation Department, 2018 (521 projects)
The Department of Water Resources, 2018-2019 (23 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (two projects)
/9 The Royal Irrigation Department, 2018 (158 projects)
/10 The Royal Irrigation Department, 2018 (46 projects)
/11 The Royal Irrigation Department, 2018 (16 projects)
/12 The Royal Irrigation Department, 2018 (90 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (260 projects)
/13 The Royal Irrigation Department, 2018 (four projects)
/14 The Royal Irrigation Department, 2018 (two projects)
The Department of Public Works and Town & Country Planning, 2018-2020 (30 projects)
/15 The Marine Department, 2019 (76 projects)
/16 The Royal Irrigation Department, 2018 (264 projects)
/17 Analyzed by the consultants based on the analysis of suitable areas for construction of new wastewater treatment systems, 2019 (28 projects)
The Regional Environmental Office 9 (Udonthani), 2017 (one project)
The Regional Environmental Office 10 (Khon Kaen), 2017 (five projects)
The Regional Environmental Office 11 (Nakhon Ratchasima), 2017 (one project)
The Regional Environmental Office 12 (Ubon Ratchathani), 2017 (one project)
/18 Adapted from legal conservation forest area database, the Department of National Parks, Wildlife and Plant Conservation, 2019 and adapted from the Royal Forest Department's databases of maps showing the classification of land resource and forest land in national reserved forests, 1992
/19 The Department of National Parks, Wildlife and Plant Conservation, 2019 (148 projects)

Table 3.3-5 Summary of Plans/Projects by Province in the Chi River Basin (Three-Group Plans in Line with Appropriate Development Alternatives)

No.	Plans/aspects	Number of projects													
		Chaiyaphum	Nakhon Ratchasima	Phetchabun	Loei	Nong Bua Lam Phu	Khon Kaen	Maha Sarakham	Udon Thani	Kalasin	Roi Et	Yasothon	Si Sa Ket	Ubon Ratchathani	Total
1.	**Basic problem solving program**														
	Short- and medium-term programs														
	Aspect 1 Consumption-based water management														
	1.1 Consumption-based water provision	111	3	11	4	66	128	74	14	102	69	32	-	1	**615** /1
	1.2 Local administrative organizations' water supply system improvement projects	154	23	-	40	47	55	121	75	155	120	45	1	40	**876** /2
	1.3 Local administrative organizations' water source development projects	783	98	-	66	370	256	424	155	650	393	123	7	71	**3,396** /3
	Aspect 2 Water security creation in the manufacturing sector														
	2.1 Rainfed agricultural area management														
	1) Cropping to suit areas	Agricultural areas are grouped according to rainfall and groundwater potential into eight zones.													
	2) Economic forestation (rai)	66,062 /4													
	2.2 Water source provision in rainfed agricultural areas	210	26	8	29	83	212	88	55	159	147	84	17	31	**1,149** /5
	Aspect 4 Water quality management and water resource conservation														
	4.1 Recycled water utilization	Wastewater is treated and recycled in the industrial and agricultural sectors.													
	Aspect 5 Degraded watershed forest conservation and soil erosion prevention														
	5.1 Forestation (rai)	831,406 /6													
	5.2 Watershed weirs (permanent weirs)	148 /7													
	Aspect 6 Management	Comprised of provincial waterworks/local water supply management, agency's delay, information development for decision-making, wastewater management and environmental management.													
2.	**Drought, flood and wastewater mitigation program**														
	Short-term program														
	Aspect 2 Water security creation in the manufacturing sector														
	2.1 Water use efficiency enhancement in irrigation areas	Cultivation areas of Lam Pao and Nong Wai projects are adjusted to reduce 133.22 MCM of water use and increase 66,460 rai of cultivation areas.													
	2.2 Project maintenance improvement and efficiency enhancement	161	3	-	3	4	98	30	9	72	55	7	-	2	**444** /8
	2.3 Small-scale water source development and pumping projects	191	2	-	12	44	118	33	13	48	44	17	1	23	**546** /9
	Aspect 3 Flood management														
	3.1 Flood prevention, e.g. river, drainage and waterway obstruction improvement	53	12	-	4	10	57	44	27	67	48	26	1	1	**350** /10
	3.2 Bank erosion prevention in accordance with local needs	8	9	-	-	-	18	9	-	4	18	2	-	8	**76** /11
	3.3 Monkey cheek development in lowland floodplain forests	55	1	-	5	7	52	15	15	32	27	14	-	41	**264** /12
	Medium-term program														
	3.4 Floodways*	Floods are mitigated by increasing floodways and draining floods into the Mekong River.													
	3.5 Flood prevention in community areas	7	-	-	-	2	3	4	-	8	6	2	-	-	**32** /13
	3.6 Water diversion to solve floods	1	-	-	-	-	-	1	-	-	2	-	-	-	**4** /14
	Aspect 4 Water quality management and water resource conservation														
	4.1 Wastewater solution	3	1	-	-	2	14	6	-	3	3	3	-	1	**36** /15
	Aspect 6 Management	Comprised of soil management due to dredging and non-structural measure use for flood management.													
3.	**Water source project development program for economic development**														
	Medium-term program														
	Aspect 2 Water security creation in the manufacturing sector														
	2.1 Water source project development in the Chi River Basin at full potential														
	1) Medium- and large-scale project development	79	3	1	6	5	37	6	5	10	5	1	-	-	**158** /16
	2) Water distribution system development	22	2	-	-	-	4	-	-	14	-	3	-	1	**46** /17
	3) Domestic water network development	6	-	-	-	-	1	1	1	5	1	-	-	1	**16** /18
	Long-term program														
	2.2 Water availability increase in the Chi River Basin by Mekong diversion (Huai Luang Regulator)	1													
	Aspect 6 Management	Comprised of large-scale reservoir management, parrticipation agency's and delay management.													
	Total **	1,061	85	20	103	270	797	432	214	679	545	236	20	150	**8,008**

Remark : *Preliminary study /**Excluding economic forest cultivation areas (66,062 rai), reforestation for conservation of watershed forests (831,406 rai), watershed weirs (148 locations) and Mekong diversion (Huai Luang Regulator) for one project

Sources :

/1 The Community Development Department, 2015 (544 projects)
The Provincial Waterworks Authority, 2019 (71 projects)

/2 Local administrative organizations, 2019 (876 projects)

/3 Local administrative organizations, 2019 (3,396 projects)

/4 Analyzed by the consultants based on suitable soil analysis in economic forestation, 2019

/5 The Department of Water Resources, 2018-2019 (115 projects)
The Royal Irrigation Department, 2018 (19 projects)
The Department of Groundwater Resources, 2019 (216 projects)
The Land Development Department, 2018-2020 (798 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/6 Adapted from legal conservation forest area database, the Department of National Parks, Wildlife and Plant Conservation, 2019 and adapted from the Royal Forest Department's databases of maps showing the classification of land resource and forest land in national reserved forests, 1992
The Department of National Parks, Wildlife and Plant Conservation, 2019 (148 projects)

/7 The Royal Irrigation Department, 2018 (441 projects)

/8 The Department of Water Resources, 2018-2019 (two projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/9 The Royal Irrigation Department, 2018 (521 projects)
The Department of Water Resources, 2018-2019 (23 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (two projects)

/10 The Royal Irrigation Department, 2018 (90 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (260 projects)

/11 The Marine Department, 2019 (76 projects)

/12 The Royal Irrigation Department, 2018 (264 projects)

/13 The Royal Irrigation Department, 2018 (two projects)
The Department of Public Works and Town & Country Planning, 2018-2020 (30 projects)

/14 The Royal Irrigation Department, 2018 (four projects)

/15 Analyzed by the consultants based on the analysis of suitable areas for construction of new wastewater treatment systems, 2019 (28 projects)
The Regional Environmental Office 9 (Udonthani), 2017 (one project)
The Regional Environmental Office 10 (Khon Kaen), 2017 (five projects)
The Regional Environmental Office 11 (Nakhon Ratchasima), 2017 (one project)
The Regional Environmental Office 12 (Ubon Ratchathani), 2017 (one project)

/16 The Royal Irrigation Department, 2018 (158 projects)

/17 The Royal Irrigation Department, 2018 (46 projects)

/18 The Royal Irrigation Department, 2018 (16 projects)

Table 3.3-6 Summary of Plans/Projects by Province in the Chi River Basin (Six-Aspect Plans According to the 20-Year Water Resource Management Master Plan)

No.	Plans/aspects	Number of projects													
		Chaiyaphum	Nakhon Ratchasima	Phetchabun	Loei	Nong Bua Lam Phu	Khon Kaen	Maha Sarakham	Udon Thani	Kalasin	Roi Et	Yasothon	Si Sa Ket	Ubon Ratchathani	Total
1.	**Aspect 1 Consumption-based water management**														
	1.1 Consumption-based water provision	111	3	11	4	66	128	74	14	102	69	32	-	1	**615** /1
	1.2 Local administrative organizations' water supply system improvement projects	154	23	-	40	47	55	121	75	155	120	45	1	40	**876** /2
	1.3 Local administrative organizations' water source development projects	783	98	-	66	370	256	424	155	650	393	123	7	71	**3,396** /3
2.	**Aspect 2 Water security creation in the manufacturing sector**														
	2.1 Rainfed agricultural area management														
	1) Cropping to suit areas	Agricultural areas are grouped according to rainfall and groundwater potential into eight zones.													
	2) Economic forestation (rai)	66,062 /4													
	2.2 Water source provision in rainfed agricultural areas	210	26	8	29	83	212	88	55	159	147	84	17	31	**1,149** /5
	2.3 Water use efficiency enhancement in irrigation areas	Cultivation areas of Lam Pao and Nong Wai projects are adjusted to reduce 133.22 MCM of water use and increase 66,460 rai of cultivation areas.													/6
	2.4 Project maintenance improvement and efficiency enhancement	161	3	-	3	4	98	30	9	72	55	7	-	2	**444** /7
	2.5 Small-scale water source development and pumping projects	191	2	-	12	44	118	33	13	48	44	17	1	23	**546** /8
	2.6 Water source project development in the Chi River Basin at full potential														
	1) Medium- and large-scale project development	79	3	1	6	5	37	6	5	10	5	1	-	-	**158** /9
	2) Water distribution system development	22	2	-	-	-	4	-	-	14	-	3	-	1	**46** /10
	3) Domestic water network development	6	-	-	-	-	1	1	1	5	1	-	-	1	**16** /11
	2.7 Water availability increase in the Chi River Basin by Mekong diversion (Huai Luang Regulato	1													
3.	**Aspect 3 Flood management**														
	3.1 Flood prevention, e.g. river, drainage and waterway obstruction improvement	53	12	-	4	10	57	44	27	67	48	26	1	1	**350** /12
	3.2 Water diversion to solve floods	1	-	-	-	-	-	1	-	-	2	-	-	-	**4** /13
	3.3 Flood prevention in community areas	7	-	-	-	2	3	4	-	8	6	2	-	-	**32** /14
	3.4 Bank erosion prevention in accordance with local needs	8	9	-	-	-	18	9	-	4	18	2	-	8	**76** /15
	3.5 Monkey cheek development in lowland floodplain forests	55	1	-	5	7	52	15	15	32	27	14	-	41	**264** /16
	3.6 Floodways*	Floods are mitigated by increasing floodways and draining floods into the Mekong River.													
4.	**Aspect 4 Water quality management and water resource conservation**														
	4.1 Recycled water utilization	Wastewater is treated and recycled in the industrial and agricultural sectors.													
	4.2 Wastewater solution	3	1	-	-	2	14	6	-	3	3	3	-	1	**36** /17
5.	**Aspect 5 Degraded watershed forest conservation and soil erosion prevention**														
	5.1 Forestation (rai)	831,406 /18													
	5.2 Watershed weirs (permanent weirs)	148 /19													
6.	**Aspect 6 Management**	Comprised of provincial waterworks/local water supply management, agency's delay and information development for decision-making, wastewater management due to dredging and non-structural measure use for flood management, large-scale reserveir managent and participation.													
	Total **	1,061	85	20	103	270	797	432	214	679	545	236	20	150	**8,008**

Remark : *Preliminary study /**Excluding economic forest cultivation areas (66,062 rai), reforestation for conservation of watershed forests (831,406 rai), watershed weirs (148 locations) and Mekong diversion (Huai Luang Regulator) for one project

Sources :

/1 The Community Development Department, 2015 (544 projects)
The Provincial Waterworks Authority, 2019 (71 projects)

/2 Local administrative organizations, 2019 (876 projects)

/3 Local administrative organizations, 2019 (3,396 projects)

/4 Analyzed by the consultants based on suitable soil analysis in economic forestation, 2019
The Department of Water Resources, 2018-2019 (115 projects)

/5 The Royal Irrigation Department, 2018 (19 projects)
The Department of Groundwater Resources, 2019 (216 projects)
The Land Development Department, 2018-2020 (798 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/6 Analyzed by the consultants based on model-based water balance calculation, 2019

/7 The Royal Irrigation Department, 2018 (441 projects)
The Department of Water Resources, 2018-2019 (two projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/8 The Royal Irrigation Department, 2018 (521 projects)
The Department of Water Resources, 2018-2019 (23 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (two projects)

/9 The Royal Irrigation Department, 2018 (158 projects)

/10 The Royal Irrigation Department, 2018 (46 projects)

/11 The Royal Irrigation Department, 2018 (16 projects)

/12 The Royal Irrigation Department, 2018 (90 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (260 projects)

/13 The Royal Irrigation Department, 2018 (four projects)

/14 The Royal Irrigation Department, 2018 (two projects)
The Department of Public Works and Town & Country Planning, 2018-2020 (30 projects)

/15 The Marine Department, 2018 (76 projects)

/16 The Royal Irrigation Department, 2018 (264 projects)

/17 Analyzed by the consultants based on the analysis of suitable areas for construction of new wastewater treatment systems, 2019 (28 projects)
The Regional Environmental Office 9 (Udonthani), 2017 (one project)
The Regional Environmental Office 10 (Khon Kaen), 2017 (five projects)
The Regional Environmental Office 11 (Nakhon Ratchasima), 2017 (one project)
The Regional Environmental Office 12 (Ubon Ratchathani), 2017 (one project)

/18 Adapted from legal conservation forest area database, the Department of National Parks, Wildlife and Plant Conservation, 2019 and adapted from the Royal Forest Department's databases of maps showing the classification of land resource and forest land in national reserved forests, 1992

/19 The Department of National Parks, Wildlife and Plant Conservation, 2019 (148 projects)

Table 3.3-7 Budget Plans for Integrated Water Resource Development in the Chi River Basin by Province (Three-Group Plans in Line with Appropriate Development Alternatives)

No.	Plans/aspects	Budget (Millon bant)													
		Chaiyaphum	Nakhon Ratchasima	Phetchabun	Loei	Nong Bua Lam Phu	Khon Kaen	Maha Sarakham	Udon Thani	Kalasin	Roi Et	Yasothon	Si Sa Ket	Ubon Ratchathani	Total
1.	**Basic problem solving program**														
	Short- and medium-term programs														
	Aspect 1 Consumption-based water management														
	1.1 Consumption-based water provision	-	-	-	-	-	-	-	-	-	-	-	-	-	- /1
	1.2 Local administrative organizations' water supply system improvement projects	488.86	97.87	-	79.95	64.00	83.80	849.42	225.74	610.76	424.88	105.17	10.00	215.50	**3,255.94** /2
	1.3 Local administrative organizations' water source development projects	6,680.75	282.91	-	1,441.74	1,332.04	752.51	8,094.76	279.76	2,167.95	5,346.67	917.04	473.90	501.34	**28,271.36** /3
	Aspect 2 Water security creation in the manufacturing sector														
	2.1 Rainfed agricultural area management														
	1) Cropping to suit areas	Agricultural areas are grouped according to rainfall and groundwater potential into eight zones.													
	2) Economic forestation (rai)	-													
	2.2 Water source provision in rainfed agricultural areas	1,138.12	41.72	2.09	23.45	73.59	1,544.69	149.03	24.79	702.74	1,871.00	250.18	30.26	82.19	**5,933.85** /5
	Aspect 4 Water quality management and water resource conservation														
	4.1 Recycled water utilization	Wastewater is treated and recycled in the industrial and agricultural sectors.													
	Aspect 5 Degraded watershed forest conservation and soil erosion prevention														
	5.1 Forestation (rai)	5,587.00 /6													
	5.2 Watershed weirs (permanent weirs)	7.40 /7													
	Aspect 6 Management	Comprised of provincial waterworks/local water supply management, agency's delay, information development for decision-making, wastewater management and environmental management.													
2.	**Drought, flood and wastewater mitigation program**														
	Short-term program														
	Aspect 2 Water security creation in the manufacturing sector														
	2.1 Water use efficiency enhancement in irrigation areas	Cultivation areas are adjusted to reduce 133.22 MCM of water and increase 66,460 rai of cultivation areas.													
	2.2 Project maintenance improvement and efficiency enhancement	9,393.97	910.00	-	258.15	265.61	4,702.13	673.38	2,940.00	2,375.70	2,675.11	631.67	-	65.00	**24,890.71** /8
	2.3 Small-scale water source development and pumping projects	6,747.53	48.00	-	284.96	1,361.68	7,891.63	741.56	621.00	1,377.84	1,221.14	409.00	10.00	415.00	**21,129.33** /9
	Aspect 3 Flood management														
	3.1 Flood prevention, e.g. river, drainage and waterway obstruction improvement	435.18	106.30	-	26.31	100.24	590.24	648.51	51.69	332.31	713.95	231.93	3.00	12.00	**3,251.65** /10
	3.2 Bank erosion prevention in accordance with local needs	-	-	-	-	-	-	-	-	-	-	-	-	-	- /11
	3.3 Monkey cheek development in lowland floodplain forests	1,566.58	67.50	-	43.00	62.00	1,805.43	345.89	269.00	796.55	741.38	268.63	-	1,233.36	**7,199.32** /12
	Medium-term program														
	3.4 Floodways*	Floods are mitigated by increasing floodways and draining floods into the Mekong River.													
	3.5 Flood prevention in community areas	3,641.50	-	-	-	590.00	760.00	1,030.00	-	1,930.00	1,665.00	420.00	-	-	**10,036.50** /13
	3.6 Water diversion to solve floods	3,440.00	-	-	-	-	-	30.00	-	-	160.00	-	-	-	**3,630.00** /14
	Aspect 4 Water quality management and water resource conservation														
	4.1 Wastewater solution	-	-	-	-	-	-	-	-	-	-	-	-	-	- /15
	Aspect 6 Management	Comprised of soil management due to dredging and non-structural measure use for flood management.													
3.	**Water source project development program for economic development**														
	Medium-term program														
	Aspect 2 Water security creation in the manufacturing sector														
	2.1 Water source project development in the Chi River Basin at full potential														
	1) Medium- and large-scale project development	30,080.11	702.98	250.00	2,466.24	1,504.78	19,009.55	2,036.89	420.09	2,566.68	1,130.00	250.00	-	-	**60,417.31** /16
	2) Water distribution system development	225.06	409.01	-	-	-	266.20	-	-	7,543.35	-	516.76	-	30.00	**8,990.38** /17
	3) Domestic water network development	1,359.33	-	-	-	-	21.12	44.00	21.12	200.12	13.12	-	-	10.00	**1,668.81** /18
	Long-term program														
	2.2 Water availability increase in the Chi River Basin by Mekong diversion (Huai Luang Regulator	44,687.00**													
	Aspect 6 Management	Comprised of large-scale reservoir management, parrticipation and agency's delay management.													
	Total ***	65,196.97	2,666.29	252.09	4,623.78	5,353.94	37,427.29	14,643.44	4,853.19	20,603.99	15,962.25	4,000.39	527.16	2,564.38	**178,675.16**

Remark : *Preliminary study /**Project value 43,597 million baht including 2.50% construction cost 44,687 million baht in total

***Excluding budget for water availability increase in the Chi River Basin by Mekong diversion and watershed forest conservation (forestation and watershed weirs)

Sources :

/1 The Community Development Department, 2015 (544 projects)
The Provincial Waterworks Authority, 2019 (71 projects)

/2 Local administrative organizations, 2019 (876 projects)

/3 Local administrative organizations, 2019 (3,396 projects)

/4 Analyzed by the consultants based on suitable soil analysis in economic forestation, 2019
The Department of Water Resources, 2018-2019 (115 projects)

/5 The Royal Irrigation Department, 2018 (19 projects)
The Department of Groundwater Resources, 2019 (216 projects)
The Land Development Department, 2018-2020 (798 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/6 Adapted from legal conservation forest area database the Department of National Parks, Wildlife and Plant Conservation, 2019 and adapted from the Royal Forest Department's databases of maps showing the classification of land resource and forest land in national reserved forests, 1992
The Department of National Parks, Wildlife and Plant Conservation, 2019 (148 projects)

/7 The Royal Irrigation Department, 2018 (441 projects)

/8 The Department of Water Resources, 2018-2019 (two projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)
The Royal Irrigation Department, 2018 (521 projects)

/9 The Department of Water Resources, 2018-2019 (23 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (two projects)

/10 The Royal Irrigation Department, 2018 (90 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (260 projects)

/11 The Marine Department, 2019 (76 projects)

/12 The Royal Irrigation Department, 2018 (264 projects)

/13 The Royal Irrigation Department, 2018 (two projects)
The Department of Public Works and Town & Country Planning, 2018-2020 (30 projects)

/14 The Royal Irrigation Department, 2018 (four projects)

/15 Analyzed by the consultants based on the analysis of suitable areas for construction of new wastewater treatment systems, 2019 (28 projects)
The Regional Environmental Office 9 (Udonthani), 2017 (one project)
The Regional Environmental Office 10 (Khon Kaen), 2017 (five projects)
The Regional Environmental Office 11 (Nakhon Ratchasima), 2017 (one project)
The Regional Environmental Office 12 (Ubon Ratchathani), 2017 (one project)

/16 The Royal Irrigation Department, 2018 (158 projects)

/17 The Royal Irrigation Department, 2018 (46 projects)

/18 The Royal Irrigation Department, 2018 (16 projects)

Table 3.3-8 Budget Plans for Integrated Water Resource Development in the Chi River Basin by Province (Six-Aspect Plans According to the 20-Year Water Resource Management Master Plan)

No.	Plans/aspects	Budget (Millon baht)													
		Chaiyaphum	Nakhon Ratchasima	Phetchabun	Loei	Nong Bua Lam Phu	Khon Kaen	Maha Sarakham	Udon Thani	Kalasin	Roi Et	Yasothon	Si Sa Ket	Ubon Ratchathani	Total
1.	**Aspect 1 Consumption-based water management**														
	1.1 Consumption-based water provision	-	-	-	-	-	-	-	-	-	-	-	-	-	- /1
	1.2 Local administrative organizations' water supply system improvement projects	488.86	97.87	-	79.95	64.00	83.80	849.42	225.74	610.76	424.88	105.17	10.00	215.50	**3,255.94** /2
	1.3 Local administrative organizations' water source development projects	6,680.75	282.91	-	1,441.74	1,332.04	752.51	8,094.76	279.76	2,167.95	5,346.67	917.04	473.90	501.34	**28,271.36** /3
2.	**Aspect 2 Water security creation in the manufacturing sector**														
	2.1 Rainfed agricultural area management														
	1) Cropping to suit areas	Agricultural areas are grouped according to rainfall and groundwater potential into eight zones.													
	2) Economic forestation (rai)	66,062.00 /4													
	2.2 Water source provision in rainfed agricultural areas	1,138.12	41.72	2.09	23.45	73.59	1,544.69	149.03	24.79	702.74	1,871.00	250.18	30.26	82.19	**5,933.85** /5
	2.3 Water use efficiency enhancement in irrigation areas	Cultivation areas are adjusted to reduce 133.22 MCM of water and increase 66,460 rai of cultivation areas. /6													
	2.4 Project maintenance improvement and efficiency enhancement	9,393.97	910.00	-	258.15	265.61	4,702.13	673.38	2,940.00	2,375.70	2,675.11	631.67	-	65.00	**24,890.71** /7
	2.5 Small-scale water source development and pumping projects	6,747.53	48.00	-	284.96	1,361.68	7,891.63	741.56	621.00	1,377.84	1,221.14	409.00	10.00	415.00	**21,129.33** /8
	2.6 Water source project development in the Chi River Basin at full potential														
	1) Medium- and large-scale project development	30,080.11	702.98	250.00	2,466.24	1,504.78	19,009.55	2,036.89	420.09	2,566.68	1,130.00	250.00	-	-	**60,417.31** /9
	2) Water distribution system development	225.06	409.01	-	-	-	266.20	-	-	7,543.35	-	516.76	-	30.00	**8,990.38** /10
	3) Domestic water network development	1,359.33	-	-	-	-	21.12	44.00	21.12	200.12	13.12	-	-	10.00	**1,668.81** /11
	2.7 Water availability increase in the Chi River Basin by Mekong diversion (Huai Luang Regulator)	44,687.00*													
3.	**Aspect 3 Flood management**														
	3.1 Flood prevention, e.g. river, drainage and waterway obstruction improvement	435.18	106.30	-	26.31	100.24	590.24	648.51	51.69	332.31	713.95	231.93	3.00	12.00	**3,251.65** /12
	3.2 Water diversion to solve floods	3,440.00	-	-	-	-	-	30.00	-	-	160.00	-	-	-	**3,630.00** /13
	3.3 Flood prevention in community areas	3,641.50	-	-	-	590.00	760.00	1,030.00	-	1,930.00	1,665.00	420.00	-	-	**10,036.50** /14
	3.4 Bank erosion prevention in accordance with local needs	-	-	-	-	-	-	-	-	-	-	-	-	-	- /15
	3.5 Monkey cheek development in lowland floodplain forests	1,566.58	67.50	-	43.00	62.00	1,805.43	345.89	269.00	796.55	741.38	268.63	-	1,233.36	**7,199.32** /16
	3.6 Floodways**	Floods are mitigated by increasing floodways and draining floods into the Mekong River.													
4.	**Aspect 4 Water quality management and water resource conservation**														
	4.1 Recycled water utilization	Wastewater is treated and recycled in the industrial and agricultural sectors.													
	4.2 Wastewater solution	-	-	-	-	-	-	-	-	-	-	-	-	-	- /17
5.	**Aspect 5 Degraded watershed forest conservation and soil erosion prevention**														
	5.1 Forestation (rai)	5,587.00 /18													
	5.2 Watershed weirs (permanent weirs)	7.40 /19													
6.	**Aspect 6 Management**	Comprised of provincial waterworks/local water supply management, agency's delay and information development for decision-making, wastewater management due to dredging and non-structural measure use for flood management, large-scale reserveir managent and participation.													
	Total ***	**65,196.97**	**2,666.29**	**252.09**	**4,623.78**	**5,353.94**	**37,427.29**	**14,643.44**	**4,853.19**	**20,603.99**	**15,962.25**	**4,000.39**	**527.16**	**2,564.38**	**178,675.16**

Remark : *Project value 43,597 million baht including 2.50% construction cost 44,687 million baht in total/**Preliminary study

***Excluding budget for water availability increase in the Chi River Basin by Mekong diversion and watershed forest conservation (forestation and watershed weirs)

Sources :

/1 The Community Development Department, 2015 (544 projects)
The Provincial Waterworks Authority, 2019 (71 projects)

/2 Local administrative organizations, 2019 (876 projects)

/3 Local administrative organizations, 2019 (3,396 projects)

/4 Analyzed by the consultants based on suitable soil analysis in economic forestation, 2019
The Department of Water Resources, 2018-2019 (115 projects)

/5 The Royal Irrigation Department, 2018 (19 projects)
The Department of Groundwater Resources, 2019 (216 projects)
The Land Development Department, 2018-2020 (798 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/6 Analyzed by the consultants based on model-based water balance calculation, 2019

/7 The Royal Irrigation Department, 2018 (441 projects)
The Department of Water Resources, 2018-2019 (two projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/8 The Royal Irrigation Department, 2018 (521 projects)
The Department of Water Resources, 2018-2019 (23 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (two projects)

/9 The Royal Irrigation Department, 2018 (158 projects)

/10 The Royal Irrigation Department, 2018 (46 projects)

/11 The Royal Irrigation Department, 2018 (16 projects)

/12 The Royal Irrigation Department, 2018 (90 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (260 projects)

/13 The Royal Irrigation Department, 2018 (four projects)

/14 The Royal Irrigation Department, 2018 (two projects)
The Department of Public Works and Town & Country Planning, 2018-2020 (30 projects)

/15 The Marine Department, 2018 (76 projects)

/16 The Royal Irrigation Department, 2018 (264 projects)

/17 Analyzed by the consultants based on the analysis of suitable areas for construction of new wastewater treatment systems, 2019 (28 projects)
The Regional Environmental Office 9 (Udonthani), 2017 (one project)
The Regional Environmental Office 10 (Khon Kaen), 2017 (five projects)
The Regional Environmental Office 11 (Nakhon Ratchasima), 2017 (one project)
The Regional Environmental Office 12 (Ubon Ratchathani), 2017 (one project)

/18 Adapted from legal conservation forest area database, the Department of National Parks, Wildlife and Plant Conservation, 2019 and adapted from the Royal Forest Department's databases of maps showing the classification of land resource and forest land in national reserved forests, 1992

/19 The Department of National Parks, Wildlife and Plant Conservation, 2019 (148 projects)

3.3.2 Summary of Work Plans and Budget Plans for Developing Chi River Basin Areas

Work plans and budget plans for plans/projects were prepared as short-, medium- and long-term plans for the Chi River Basin integrated development plans in accordance with three-group plans and appropriate development alternatives, as shown in **Table 3.3-9**. They are also prepared in six aspects according to the 20-year water resource management master plan, as shown in **Table 3.3-10**.

1) Basic problem-solving plans comprise short- and long-term plans:

1.1) Short-term plans are plans/projects that can be implemented immediately.

Aspect 1 Consumption-based water management involves plans for water provision for domestic use (PWA), water supply improvement and local administrative organizations' water source development.

Aspect 2 Water security creation in the manufacturing sector refers to rainfed agricultural area management plans and water source provision in rainfed agricultural areas.

Aspect 4 Water quality management and water resource conservation involve recycled water utilization plans.

Aspect 5 Degraded watershed forest conservation involves watershed forestation and weir construction.

Aspect 6 Management

2) Drought, flood and wastewater mitigation plans consist of short- and medium-term plans.

2.1) Short-term plans are plans/projects that can be implemented immediately.

Aspect 2 Water security creation in the manufacturing sector refers to efficiency enhancement plans for irrigation areas, project maintenance improvement and efficiency enhancement, as well as small-scale water source development and pumping projects.

Aspect 3 Flood management includes flood prevention plans (non-structural measures, river as well as water drainage and obstruction improvement), bank erosion protection according to local needs and monkey cheek development in lowland floodplain forests.

2.2) Medium-term plans include projects that require the study and design preparation.

Aspect 3 Flood management consists of flood drainage and floodways, flood prevention in community areas and water diversion to solve floods.

Aspect 4 Water quality management and water resource conservation are wastewater solution plans.

Aspect 6 Management

3) Water source project development plans for economic development in the Chi River Basin involve construction of water availability sources to increase income to farmers and people to provide an opportunity for economic development and water stabilization in the Chi River Basin comprising the following medium- and long-term plans:

3.1) Medium-term plans include projects that require the study and design preparation.

Aspect 2 Water security in the manufacturing sector and water source development at full potential in the Chi River Basin, such as medium- and large-scale project development, water distribution system development and domestic water network development.

3.2) Long-term plans include projects that require the study and design preparation. They also require high construction costs for diverting the Mekong River (Huai Luang Regulator). They relate to Aspect 2 water security creation in the manufacturing sector.

Table 3.3-9 Budget Plans for Integrated Water Resource Development in the Chi River Basin (Three-Group Plans in Line with Appropriate Development Alternatives)

No.	Plans/aspects	No of projects	Total budget (million baht)	Work plans and budget (million baht)/year																
				Short-term plans		Medium-term plans					Long-term plans									
				4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
				2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
1.	**Basic problem solving program**																			
	Short- and long-term programs																			
	Aspect 1 Consumption-based water management																			
	1.1 Consumption-based water provision	615 /1	-																	
	1.2 Local administrative organizations' water supply system improvement projects	876 /2	3,255.94	1,823.6	654.6	392.2	385.7													
	1.3 Local administrative organizations' water source development projects	3,396 /3	28,271.36	13,188.2	5,729.0	4,815.8	4,538.4													
	Aspect 2 Water security creation in the manufacturing sector																			
	2.1 Rainfed agricultural area management (economic forest cultivation 66,082 rai)	-	-																	
	2.2 Water source provision in rainfed agricultural areas	1,149 /4	5,933.85	2,324.91	3,533.32	72.53	3.09													
	Aspect 4 Water quality management and water resource conservation																			
	4.1 Recycled water utilization	-	-																	
	Aspect 5 Degraded watershed forest conservation and soil erosion prevention																			
	5.1 Forestation (831,406 rai)	831,406 /5	5,587.00																	
	5.2 Watershed weirs (permanent weirs)	148 /6	7.40																	
	Aspect 6 Management																			
2.	**Drought, flood and wastewater mitigation program**																			
	Short-term program																			
	Aspect 2 Water security creation in the manufacturing sector																			
	2.1 Water use efficiency enhancement in irrigation areas (increasing an cultivation area of 66,460 rai)	-	-																	
	2.2 Project maintenance improvement and efficiency enhancement	444 /7	24,890.71	4,287.63	2,364.06	5,685.67	9,164.55	3,388.81												
	2.3 Small-scale water source development and pumping projects	546 /8	21,129.33	5,255.09	1,261.12	2,123.98	10,334.24	2,154.90												
	Aspect 3 Flood management																			
	3.1 Flood prevention, e.g. river, drainage and waterway obstruction improvement	350 /9	3,251.65	508.44	417.50	760.95	889.76	675.00												
	3.2 Bank erosion prevention in accordance with local needs	76 /10	-																	
	3.3 Monkey cheek development in lowland floodplain forests	264 /11	7,199.32	2,078.60	48.82	1,786.33	2,237.71	1,047.86												
	Medium-term program																			
	3.4 Floodways*	-	-																	
	3.5 Flood prevention in community areas	32 /12	10,036.50	-	-	-	-	495.73	6,056.20	2,871.70	612.88									
	3.6 Water diversion to solve floods	4 /13	3,630.00	-	-	-	-	35.00	843.00	1,204.00	1,548.00									
	Aspect 4 Water quality management and water resource conservation																			
	4.1 Wastewater solution	36 /14	-																	
	Aspect 6 Management																			
3.	**Water source project development program for economic development**																			
	Medium-term program																			
	Aspect 2 Water security crection in the manufacturing sector																			
	2.1 Water source project development in the Chi River Basin at full potential																			
	1) Medium- and large-scale project development	158 /15	60,417.31	-	-	-	3,495.03	13,749.38	25,088.39	7,008.10	5,664.14	2,078.91	1,114.43	1,837.38	213.46	168.10				
	2) Water distribution system development	46 /16	8,990.38	-	-	-	50.38	50.38	60.45	1,743.00	1,669.65	1,970.26	1,845.51	1,550.38	50.38					
	3) Domestic water network development	16 /17	1,668.81	-	-	-	-	-	-	108.09	154.43	97.42	977.47	50.47	230.47	50.47				
	Total **	**8,008**	**178,675.16**	**29,466.43**	**14,008.34**	**15,637.45**	**31,098.78**	**21,597.05**	**32,048.04**	**12,934.89**	**9,649.10**	**4,146.59**	**3,937.40**	**3,438.22**	**494.30**	**218.56**	-	-	-	-
	Long-term program																			
	2.2 Water availability increase in the Chi River Basin by Mekong diversion (Huai Luang Regulator)	1	44,687.00	-	-	-	108.99	174.39	174.39	174.39	174.39	174.39	108.99	4,048.29	6,228.14	6,228.14	6,228.14	6,228.14	7,318.07	7,318.07
	Aspect 6 Management																			

Remark : *Preliminary study /**Excluding economic forest cultivation areas (66,062 rai), reforestation for conservation of watershed forests (831,406 rai) and watershed weirs (148 locations) and excluding budget for water availability increase in the Chi River Basin by Mekong diversion and watershed forest conservation (forestation and watershed weirs)

Study and design | Construction | Management

Sources :

/1 The Community Development Department, 2015 (544 projects)
The Provincial Waterworks Authority, 2019 (71 projects)

/2 Local administrative organizations, 2019 (876 projects)

/3 Local administrative organizations, 2019 (3,396 projects)

/4 The Department of Water Resources, 2018-2019 (115 projects)
The Royal Irrigation Department, 2018 (19 projects)
The Department of Groundwater Resources, 2019 (215 projects)
The Land Development Department, 2018-2020 (31,508 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/5 Adapted from legal conservation forest area database, the Department of National Parks, Wildlife and Plant Conservation, 2019 and adapted from the Royal Forest Department's databases of maps showing the classification of land resource and forest land in national reserved forests, 1992

/6 The Department of National Parks, Wildlife and Plant Conservation, 2019 (148 projects)

/7 The Royal Irrigation Department, 2018 (441 projects)
The Department of Water Resources, 2018-2019 (two projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/8 The Royal Irrigation Department, 2018 (521 projects)
The Department of Water Resources, 2018-2019 (23 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (two projects)

/9 The Royal Irrigation Department, 2018 (90 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (260 projects)

/10 The Marine Department, 2018 (76 projects)

/11 The Royal Irrigation Department, 2018 (264 projects)

/12 The Royal Irrigation Department, 2018 (two projects)
The Department of Public Works and Town & Country Planning, 2018-2020 (30 projects)

/13 The Royal Irrigation Department, 2018 (four projects)

/14 Analyzed by the consultants based on the analysis of suitable areas for construction of new wastewater treatment systems, 2019 (28 projects)
The Regional Environmental Office 9 (Udonthani), 2017 (one project)
The Regional Environmental Office 10 (Khon Kaen), 2017 (five projects)
The Regional Environmental Office 11 (Nakhon Ratchasima), 2017 (one project)
The Regional Environmental Office 12 (Ubon Ratchathani), 2017 (one project)

/15 The Royal Irrigation Department, 2018 (158 projects)

/16 The Royal Irrigation Department, 2018 (46 projects)

/17 The Royal Irrigation Department, 2018 (16 projects)

Table 3.3-10 Budget Plans for Integrated Water Resource Development in the Chi River Basin (Six-Aspect Plans According to the 20-Year Water Resource Management Master Plan)

NO.	Plans/aspects	No of projects	Total budget (million baht)	Work plans and budget (million baht)/year																
				Short-term plans		Medium-term plans					Long-term plans									
				4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
				2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
1.	**Aspect 1 Consumption-based water management**																			
	1.1 Consumption-based water provision	615 /1	-																	
	1.2 Local administrative organizations' water supply system improvement projects	876 /2	3,255.94	1,823.6	654.6	392.2	385.7													
	1.3 Local administrative organizations' water source development projects	3,396 /3	28,271.36	13,188.2	5,729.0	4,815.8	4,538.4													
2.	Aspect 2 Water security creation in the manufacturing sector																			
	2.1 Rainfed agricultural area management (economic forest cultivation 66,062 rai)	-	-																	
	2.2 Water source provision in rainfed agricultural areas	1,149 /4	5,933.85	2,324.91	3,533.32	72.53	3.09													
	2.3 Water use efficiency enhancement in irrigation areas (increasing cultivation area of 66,460 rai)	-	-																	
	2.4 Project maintenance improvement and efficiency enhancement	444 /5	24,890.71	4,287.63	2,364.06	5,685.67	9,164.55	3,388.81												
	2.5 Small-scale water source development and pumping projects	546 /6	21,129.33	5,255.09	1,261.12	2,123.98	10,334.24	2,154.90												
	2.6 Water source project development in the Chi River Basin at full potential																			
	1) Medium- and large-scale project development	158 /7	60,417.31	-	-	-	3,495.03	13,749.38	25,088.39	7,008.10	5,664.14	2,078.91	1,114.43	1,837.38	213.46	168.10				
	2) Water distribution system development	46 /8	8,990.38	-	-	-	50.38	50.38	60.45	1,743.00	1,669.65	1,970.26	1,845.51	1,550.38	50.38					
	3) Domestic water network development	16 /9	1,668.81	-	-	-	-	-	-	108.09	154.43	97.42	977.47	50.47	230.47	50.47				
	2.7 Water availability increase in the Chi River Basin by Mekong diversion (Huai Luang Regulator)	1	44,687.00	-	-	-	108.99	174.39	174.39	174.39	174.39	174.39	108.99	4,048.29	6,228.14	6,228.14	6,228.14	6,228.14	7,318.07	7,318.07
3.	**Aspect 3 Flood management**																			
	3.1 Flood prevention, e.g. river, drainage and waterway obstruction improvement	350 /10	3,251.65	508.44	417.50	760.95	889.76	675.00												
	3.2 Water diversion to solve floods	4 /11	3,630.00	-	-	-	-	35.00	843.00	1,204.00	1,548.00									
	3.3 Flood prevention in community areas	32 /12	10,036.50	-	-	-	-	495.73	6,056.20	2,871.70	612.88									
	3.4 Bank erosion prevention in accordance with local needs	76 /13	-																	
	3.5 Monkey cheek development in lowland floodplain forests	264 /14	7,199.32	2,078.60	48.82	1,786.33	2,237.71	1,047.86												
	3.6 Floodways*	-	-																	
4.	**Aspect 4 Water quality management and water resource conservation**																			
	4.1 Recycled water utilization	-	-																	
	4.2 Wastewater solution	36 /15	-																	
5.	**Aspect 5 Degraded watershed forest conservation and soil erosion prevention**																			
	5.1 Forestation (831,406 rai)/16	-	5,587.00																	
	5.2 Watershed weirs (permanent weirs)	148 /17	7.40																	
6.	**Aspect 6 Management**																			
	Total **	**8,008**	**178,675.16**	**29,466.43**	**14,008.34**	**15,637.45**	**31,098.78**	**21,597.05**	**32,048.04**	**12,934.89**	**9,649.10**	**4,146.59**	**3,937.40**	**3,438.22**	**494.30**	**218.56**	-	-	-	-

Remark : *Preliminary study /**Excluding economic forest cultivation areas (66,062 rai), reforestation for conservation of watershed forests (831,406 rai) and watershed weirs (148 locations) and excluding budget for water availability increase in the Chi River Basin by Mekong diversion and watershed forest conservation (forestation and watershed weirs)

Study and design | Construction | Management

Sources :

/1 The Community Development Department, 2015 (544 projects)
The Provincial Waterworks Authority, 2019 (71 projects)

/2 Local administrative organizations, 2019 (876 projects)

/3 Local administrative organizations, 2019 (3,396 projects)

/4 The Department of Water Resources, 2018-2019 (115 projects)
The Royal Irrigation Department, 2018 (19 projects)
The Department of Groundwater Resources, 2019 (215 projects)
The Land Development Department, 2018-2020 (31,508 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/5 The Royal Irrigation Department, 2018 (441 projects)
The Department of Water Resources, 2018-2019 (two projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (one project)

/6 The Royal Irrigation Department, 2018 (521 projects)
The Department of Water Resources, 2018-2019 (23 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (two projects)

/7 The Royal Irrigation Department, 2018 (158 projects)

/8 The Royal Irrigation Department, 2018 (46 projects)

/9 The Royal Irrigation Department, 2018 (16 projects)

/10 The Royal Irrigation Department, 2018 (90 projects)
The Department of Disaster Prevention and Mitigation, 2018-2020 (260 projects)

/11 The Royal Irrigation Department, 2018 (four projects)

/12 The Royal Irrigation Department, 2018 (two projects)
The Department of Public Works and Town & Country Planning, 2018-2020 (30 projects)

/13 The Marine Department, 2019 (76 projects)

/14 The Royal Irrigation Department, 2018 (264 projects)

/15 Analyzed by the consultants based on the analysis of suitable areas for construction of new wastewater treatment systems, 2019 (28 projects)
The Regional Environmental Office 9 (Udonthani), 2017 (one project)
The Regional Environmental Office 10 (Khon Kaen), 2017 (five projects)
The Regional Environmental Office 11 (Nakhon Ratchasima), 2017 (one project)
The Regional Environmental Office 12 (Ubon Ratchathani), 2017 (one project)

/16 Adapted from legal conservation forest area database, the Department of National Parks, Wildlife and Plant Conservation, 2019 and adapted from the Royal Forest Department's databases of maps showing the classification of land resource and forest land in national reserved forests, 1992

/17 The Department of National Parks, Wildlife and Plant Conservation, 2019 (148 projects)

3.4 Impact Assessment and Impact Mitigation Measures

Project impacts were assessed in accordance with infrastructure development plans, drought and flood mitigation plans, and water source development plans for river basin economic development by developing water sources at their full capacity and increase water availability in the Chi River Basin. Both positive and negative impacts were assessed for diversion of the Mekong River, including mitigation measures, as shown in **Table 3.4-1.**

1) Basic problem-solving plans comprise Aspect 1: consumption-based water management, Aspect 2: water security in the manufacturing sector, Aspect 4: water quality management and water source conservation, Aspect 5: watershed forest conservation and soil erosion prevention and Aspect 6: management.

Short-term plans/projects (Years 4-5) and medium-term plans (Years 6-7) can be implemented immediately. Their impacts are limited. Positive and negative impacts, as well as impact mitigation measures are summarized below.

1.1) Impacts

Positive impacts

(1) Water quality meets the standard.

(2) More water supply service areas and sufficient water provided to people for consumption

(3) Increasing water availability sources for domestic use

(4) Reducing cultivation risks, increasing farmers' income and providing occupations and additional income with better livelihood

(5) Increasing forest areas, generating income from growing perennial trees and conserving soil and water

(6) Water availability sources in rainfed agricultural areas and enhancing efficiency in water storage in farmers' areas

(7) More inclusive water distribution systems

(8) Decreasing water discharge into waterways and increasing water quality

(9) Preventing soil erosion

(10) Increasing biodiversity and rehabilitating the watershed ecology

(11) Storing sediments flowing and reducing sediments in downstream areas

Negative impacts

(1) The consumption-based water distribution expansion may lead to decreasing pipe pressure.

(2) Water source development may affect farmland.

(3) Water quality will be deteriorated due to cropping changes if soils are not improved.

(4) There will be no income during crop changes to suit soil conditions.

(5) Cultivation costs will be higher.

(6) Water source development costs will be higher, e.g. permanent weir construction, maintenance costs, etc.

1.2) Impact mitigation measures comprise the following operations:

(1) Public relations to create an understanding among local people of consumption-based water and provide knowledge to local farmers on economic cropping and maintenance, cropping promotion to suit soil conditions, low-water use crop cultivation and water source area encroachment.

(2) Minimum use of areas to develop water sources in order to mitigate farmland

(3) Monitoring of operation to mitigate impacts that may arise

(4) Identification of economic forestation areas

(5) Promotion and support of research and development on clean technology use to reduce waste and pollution

Table 3.4-1 Impacts and Mitigation Measures in Accordance with Project Development Plans

Plan	Work plan	Impacts according to development plans		Mitigation measures
		Positive	Negative	
1. Basic problem solving program **Short-and medium-term programs** **Aspect 1 Consumption-based water management** 1.1) Consumption-based water provision	1. Develop, expand and increase the efficiency of village water supply systems 2. Develop urban water supply systems and economic areas	1. Water quality meets the standard. 2. Water supply service areas are more inclusive.	1. Water pressure may decrease due to the expansion of water distribution areas	1. Publicize and create an understanding among local people 2. Monitor the operation to mitigate impacts
1.2) Water supply system improvement for consumption-based water	1. Construct, improve, repair and expand water supply and groundwater systems 2. Groundwater bank project	1. Water quality meets the standard. 2. More water availability sources for consumption		1. Publicize informtion to people
1.3) Water source development for consumption-based water	1. Develop water sources for consumption, e.g. construction, repair, dredging, well digging for agriculture, water source development, etc.	1. Increasing water availability sources for domestic use 2. People have water for consumption throughly	1. Impacts on farmland	1. Use minimum water sources to mitigate impacts on farmland 2. Create an understanding among local people
Aspect 2 Water security creation in the manufacturing sector 2.1) Rainfed agricultural area management	1. Plant crops to suit area conditions 2. Plant economic forests	1. Reduce risks in cultivation 2. Create people's occupations so that communities have additional income and have better living standards 3. Increase forest areas, generate income from perennial trees and conserve soils and water	1. Soil quality may be deteriorated if soils are not improved and maintained. 2. No income while waiting for products from perennial trees	1. Create an understanding among local farmers 2. Provide knowledge and promote cropping to suit soils 3. Identify cultivation areas for economic forests 4. Train farmers on economic forestation and maintenance
2.2) Water source provision in rainfed agricultural areas	1. Conserve and rehabilitate water sources in rainfed agricultural areas 2. Develop groundwater for agriculture 3. Develop water sources to conserve soils and water, and develop water sources in communities and farms 4. Make artificial rain	1. Water availability sources for growing plants in rainfed agricultural areas 2. Reduce risks in cultivation and generate more farmers' income 3. Water distribution systems cover more agricultural areas. 4. Enhance efficiency of water storage for farmers' farming	1. Farmland is affected. 2. Maintenance costs	1. Use minimum water sources by taking into consideration impacts on community area use 2. Create an understanding among farmers who encroached water sources 3. Promote cropping to suit soil conditions 4. Promote cropping that use low water
Aspect 4 Water quality management and water resource conservation 4.1) Recycled water utilization	1. Utilize recycled water	1. Reduce wastewater release into water sources 2. Better water quality of water sources 3. Maintain the ecosystem	1. Higher plantation costs	1. Promote research and development on clean technology use to reduce waste and pollution
Aspect 5 Degraded watershed forest conservation and soil erosion prevention 5.1) Forestation 5.2) Watershed weirs (permanent weirs)	1. Plant forest 2. Watershed weirs (permanent weirs)	1. Increasing forest areas 2. Prevent soil erosion 3. Increase biodiversity, and rehabilitate and improve the watershed ecosystem 4. Watershed weirs help store sediments flowing into streams and reduce sediments in downstream areas.	1. Permancent weir construction may increase costs. 2. In case of discontinuous weir mantenance, weirs may be damaged.	1. Maintain forest plots to restore watershed ecosystems 2. Identify buffer zones to prevent wildfire 3. Promote conservation networks and prevent forest eneroachment by people sector and communities 4. Participation of communities and private organizations in construction and maintenance of watershed weirs.
2. Drought and flood mitigation plans **Short-term program** **Aspect 2 Water security creation in the manufacturing sector** 2.1) Water use efficiency enhancement in irrigation areas	1. Reduce dry season rice farming and grow economic crops in the dry season	1. Increasing water availability sources 2. Reduce water use or save water 3. Increase dry season crop cultivation areas	1. Farmers learn and adjust themselves to crop plantation	1. Create an understanding among farmers in irrigation areas 2. Promote dry season crop cultivation to suit market demands 3. Promote farmers to plant economic crops that require low water and economic crops instead of dry season rice 4. Provide markets
2.2) Project improvement, maintenance and efficiency enhancement	1. Improve projects and water distribution systems 2. Enhance efficiency of projects and water distribution systems 3. Increase water in the current water resource projects	1. Increase water volume 2. Mitigate water shortage for agriculture 3. Increase farmers' income	1. People's farmland may be affected. 2. Learn and adjust to crop cultivation 3. Affect farmland	1. Create an understanding among local people 2. Establish water user organizations and promote efficient water use of members 3. Pay fair compensation 4. Promote farmers to plant economic crops that require low water 5. Provide markets to serve crop plantation
2.3) Small-scale water source project development and pumping projects	1. Develop small-scale water resource and pumping projects	1. Increase water storage sources for various activities 2. Mitigate water shortage for agriculture 3. Increase farmers' income	1. Pay energy costs for pumping water 2. Affect farmland	1. Create an understanding among local people 2. Provide knowledge on crop cultivation to suit soil conditions 3. Pay fair compensation 4. Provide markets
Aspect 3 Flood management 3.1) Flood prevention	1. Improve rivers, e.g. construct dikes and dredge rivers 2. Improve drainage systems and water obstruction 3. Divert water to solve floods 4. Prevent floods in community areas 5. Floodways	1. Enhance efficiency in releasing water into waterway 2. Prevent floods in community areas 3. Mitigate impacts and accelerate drainage into the Mekong River 4. Reduce water levels and flood period 5. Water is released into the Mekong River rapidly. 6. Use water from drainage channels for agriculture	1. Areas outside dikes will be flooded in case of poor drainage. 2. Farmland is are affected. 3. Some community areas are on the other side of drainage channels.	1. Watch during pre-flood period 2. Coordinate with agencies and private organizations in flood prevention and assistance 3. Use minimum construction areas 4. Create an understanding among local people 5. Pay fair compensation 6. Publicize project information to local people
3.2) Bank erosion prevention according to local needs	1. Bank erosion prevention according to local needs	1. Protect farmland along the rivers 2. Accelerate drainage more quickly 3. Reduce damages related to agriculture, housing and public facilities	1. Loss of areas for bank erosion prevention structures 2. Farmland is affected.	1. Create an understanding among people in bank erosion areas 2. Use minimum construction areas 3. Pay fair compensation
3.3) Monkey cheek development in lowland floodplain forests	1. Monkey cheek development in lowland floodplain forests	1. Increase water storage areas 2. Increase catchment areas to mitigate floods 3. Water sources for dry season crop cultivation 4. Rehabilitate the ecosystem	1. Farmland is affected and lowland floodplain forests are encroached.	1. Create an understanding among local people, especially those encroaching lowland floodplain forests 2. Provide soil disposal sites and prevent soil erosion 3. Develop monkey cheek areas to suit the ecosystem 4. Promote cultivation around monkey cheek areas 5. Promote and provide knowledge to communities on ecosystem rehabilitation in lowland floodplain forests to store water and to serve as a water source for agriculture and consumption
Aspect 4 Water quality management and water resource conservation **Medium-term program** 4.1) Wastewater solution	1. Construct new treatment systems 2. Enhance efficiency in wastewater treatment systems	1. Reduce deteriorated water quality in the rivers 2. Better water quality of water surface sources 3. Reduce water discharge into water sources	1. High expenses 2. Farmland and residential areas are affected.	1. Create an understanding and acceptance among people affected 2. Pay fair compensation 3. Monitor wastewater treatment systems
3. Water resource project development plans for economic development **Medium-and long-term programs** **Aspect 2 Water security creation in the manufacturing sector** 2.1) Water resource project development at full potential (Medium-term program)	1. Moderate- and large-scale water resource project development 2. Water distribution system construction 3. Domestic water network development	1. Increase water storage sources for various activities 2. Enhance efficiency in water distribution 3. Mitigate drought (water shortage) and flood problems 4. Increase cultivation areas	1. Affect conservation forests 2. Affect watershed class 1A 3. Affect farmland and residential areas	1. Double forestation of lost forests as defined by laws 2. Structural design/project operation that does not affect upstream areas 3. Pay fair compensation
2.2) Chi River Basin inflow augmentation by Mekong diversion (Long-term program)	Huai Luang Regulator	1. Increase water availability in the Chi River Basin 2. Mitigate water shortage problems 3. Increase cultivation areas 4. Stabilize water security and water use for different activities	1. Affect conservation forests 2. Affect watershed class 1A 3. Affect farmland and residential areas 4. Affect soil disposal sites due to canal dredging 5. Require high budget	1. Create an understanding and acceptance among people affected 2. Double forestation of lost forests as defined by laws 3. Structural design/project operation that does not affect upstream areas 4. Fair compensation 5. Waste disposal area preparation and improvement to suit the ecosystem
Short-medium-and long-term programs **Aspect 6 Management**	1. Large-scale reservoir management 2. Provincial waterworks/local waterworks management 3. Agency's delay 4. Dredging soil problems 5. Wastewater management 6. Environmental management 7. Data development for decision-making 8. Participation	1. Strengthen cooperation from all agencies in management 2. Reduce conflicts 3. Enhance efficiency in water management		1. Develop database systems integrated between agencies concerned to support decision-making 2. Revise and amend laws and regulations on water resource management 3. Publicize and listen to local peoples' comments 4. Support and promote local administrative organizations and communities to participate in formulating water resource management guidelines

Remark : * The total number of projects including water source development for soil and water conservation, community and farm water source development of the Land Development Department is 31,858.

Source : Analyzed by the consultants, 2019

(6) Maintenance of forestation areas to rehabilitate watershed ecosystems

(7) Determination of buffer areas to prevent forest fires

(8) Promotion of forest encroachment conservation and prevention networks of the people sector and communities

(9) Participation of communities and NGOs in construction and maintenance of watershed weirs

2) Drought, flood and wastewater mitigation plans consist of: Aspect 2 Water security creation in the manufacturing sector, Aspect 3 Flood management and Aspect 6: management.

Short- and medium-term plans (Years 4-10) and long-term plans (Year 11): Plans/projects to be carried out require additional small investment and have more impacts but at low level. Positive and negative impacts, as well as impact mitigation measures are summarized as follows:

2.1) Impacts

Positive impacts

(1) Increase water stored in both water availability sources and areas

(2) Decrease water use and save more water

(3) Maintain water sources for dry season cultivation and increase dry season cultivation areas

(4) Mitigate water shortage for agriculture

(5) Increase farmers' income

(6) Have increasing water storage sources for various activities and increase water storage areas for agriculture

(7) Increase drainage efficiency

(8) Reduce loss due to floods (prevent floods in community areas, farmland and riverside areas)

(9) Mitigate floods (accelerate drainage into the Mekong River, reduce water levels and flooding periods, speed up drainage and increase catchment areas)

(10) Decrease releasing water into waterways and reduce deteriorated water quality to improve the quality of surface water sources

(11) Rehabilitate the ecology

Negative impacts

(1) Farmers learn and adjust themselves to cultivation.

(2) Project development will affect farmland and residential areas (water sources for agriculture and bank erosion prevention).

(3) Farmland will be impacted and lowland floodplain forests will be encroached upon.

(4) Pumping and wastewater treatment construction costs are high.

(5) Areas outside flood protection dikes may be flooded.

2.2) Impact mitigation measures include the following operations:

(1) Create an understanding of low-water use crop cultivation, dry season cropping, cropping in accordance with soil conditions and market provision to farmers in irrigation areas/project areas

(2) Create an understanding among people of the project areas, e.g. bank erosion areas, flooded areas, encroachment of lowland floodplain forest areas, etc

(3) Publicize project information to local people

(4) Promote and educate communities on lowland floodplain forest area rehabilitation to store water for agriculture and consumption

(5) Pay a fair compensation

(6) Establish water user organizations and promote members to use water efficiently

(7) Develop monkey cheek areas in line with the ecology and promote cultivation around monkey cheek areas

(8) Promote and support research and development on clean technology use to reduce waste and pollution and monitor wastewater treatment system utilization

(9) Formulate impact prevention and mitigation measures, e.g. minimum use of construction areas, pre-flood monitoring, coordination with agencies and NGO in flood prevention and assistance after floods, soil disposal area provision and erosion prevention, etc.

3) Water source development plans for economic development comprise Aspect 2 water security creation in the manufacturing sector, namely:

- Water source project development in the river basins at full potential, e.g. medium- and large-scale water source project development, water distribution system development and domestic water network development.
- Water availability increase in the river basins through Mekong diversion (Huai Luang Regulator)

The implementation of projects as planned must prepare the study and design, which requires high construction costs and construction period. They are, therefore, medium-term plans, while Mekong Diversion Project is a long-term plan. The impacts and impact mitigation measures are summarized below.

3.1) Positive and negative impacts are summarized as follows:

Positive impacts

(1) Increase water storage sources to be used for different activities
(2) Enhance the efficiency in water distribution
(3) Mitigate drought and flood problems
(4) Increase cultivation areas
(5) Increase water availability in the Chi River Basin
(6) Stabilize water use for different activities

Negative impacts

(1) Impacts on conservation forests and watershed class 1A
(2) Impacts on farmland and residential areas
(3) Impacts on soil disposal areas due to canal dredging
(4) High budget

3.2) Impact mitigation measures include:

(1) Create an understanding among local people and people affected
(2) Double reforestation of lost forests as defined by laws
(3) Design the structure/projects to have minimum impacts on watershed and community areas
(4) Pay a fair compensation
(5) Material disposal preparation and improvement in line with the ecosystem, etc.

Chapter 4

Conclusions and Recommendations

Chapter 4
Conclusions and Recommendations

4.1 Conclusions

1) The Chi River Basin spans approximately 49,130 km^2, which is approximately 30,706,152 rai (30.71 million rai). It covers 13 provinces, namely Kalasin, Khon Kaen, Chaiyaphum, Nakhon Ratchasima, Phetchabun, Maha Sarakham, Yasothon, Roi Et, Si Sa Ket, Nong Bua Lam Phu, Udon Thani, and Ubon Ratchathani. Almost all the river basin area is in Chaiyaphum, Khon Kaen, Kalasin and Roi Et provinces, respectively. The Chi River Basin comprises a total forest area of 5,091,486 rai (5.09 million rai), which represents 16.58 percent of the river basin area, and comprises a total agricultural area of approximately 20,436,852 rai (20.44 million rai), representing 66.56 percent. The total area composed of soils which is suitable for crop cultivation spans 19,564,531 rai (19.56 million rai), representing 63.72 percent of the entire river basin area. It has an average annual rainfall of 1,188 mm and an average annual runoff of 11,994 MCM. It has a population of approximately 5,953,334 (5.95 million people). The water demand by all sectors amounts to 5,068 MCM, however, the water storage capacity of local large- and medium-scale projects is only 5,687 MCM.

2) Forecast for the next 20 years in the Chi River Basin in relation to water resources and water use, e.g. increase in the population, tourists, factories and agricultural areas, as well as climate change.

2.1) Population – In 2017, the Chi River Basin had a population of 5,953,334 (5.95 million people), and it is expected to reach 6,386,218 (6.38 million people) in 2037.

2.2) Tourists – This year, the local area was visited by 4,267,102 (4.27 million tourists), which is forecast to increase to 8,975,513 (8.98 million) in 20 years.

2.3) Industry – Currently, there are 16,055 factories in the local area. Based on the GPP growth, it is expected that the industrial sector will enjoy 3.4-percent growth rate per year.

2.4) Agricultural areas – The Chi River Basin comprises agricultural areas spanning 20,436,852 rai (20.44 million rai), with irrigation areas and beneficiary areas spanning 4,601,179 rai (4.60 million rai). Additional 4,949,136 rai (4.95 million rai) land has the potential to be developed to be new irrigation areas and beneficiary areas. If the water source projects in the Chi River Basin are developed at their full potential, additional 2,887,380 rai (2.89 million rai) can be developed to be new irrigation areas and beneficiary areas**.** If Mekong River diversion occurs, additional 2,061,756 rai (2.06 million rai) can be developed to be new irrigation areas and beneficiary areas. The size of the expected new irrigation areas and beneficiary areas will cover 9,550,315 rai (9.55 million rai).

2.5) Climate change – The study on the climate change reveals that the Chi River Basin will tend to have higher temperature, decreasing annual accumulative rainfall, decreasing runoff, and more serious water shortage in the future.

3) Current and future water demand – The assessment of current water demand considers different activities, e.g. domestic use, industry and tourism, agriculture, and livestock. The assessment in the next 20 years takes into account the increase in population and in the number of tourists in different provinces located in the Chi River Basin, urbanization, water demand in the agricultural and livestock sectors, and water demand in the industrial sector. The water demand in different cases – development of water source projects at their full potential and Mekong River diversion is assessed as shown in **Table 4.1-1**.

Table 4.1-1 Assessment of Water Demand for Various Activities

Water use activity	Current condition (2019)		Future 20 years (2039)			
	Irrigation and benefiting areas (rai)	Water demand (MCM/year)	In case of water source project development in the Chi River Basin at full potential		In case of water source project development in the Chi River Basin at full potential and Mekong River diversion	
			Irrigation and benefiting areas (rai)	Water demand (MCM/year)	Irrigation and benefiting areas (rai)	Water demand (MCM/year)
1 Agriculture[1/]	4,601,179	4,899.66	7,488,559	7,822.73	9,550,315	12,193.69
2 Domestic use	-	125.67	-	129.11	-	129.11
3 Tourism	-	1.12	-	2.34	-	2.34
4 Industry	-	33.07	-	55.38	-	55.38
5 Livestock	-	9.16	-	15.92	-	15.92
Total[2/]	**4,601,179**	**5,068.67**	**7,488,559**	**8,025.48**	**9,550,315**	**12,396.44**

Remark : [1/] Water demand for agriculture : water flowing back is deducted.
[2/] Water for maintaining the ecosystem is water discharged from large-scale reservoirs, whereby water can be reused, so it is not included in the water demand.
Source : Analyzed by the consultants, 2019

4) Water source projects and irrigation projects – Currently, there are 2,765 water source projects and irrigation projects located in the Chi River Basin area which are completed projects**.** They consist of large**-**, medium**-**, and small**-**scale water source projects and electrical pumping projects. The main responsible agencies consist of the Royal Irrigation Department, the Department of Water Resources, and the Electricity Generating Authority of Thailand. Their total storage capacity is approximately 5,687.26 MCM, with irrigation area spanning approximately 3,446,187 rai (3.44 million rai) and beneficiary areas spanning 1,154,992 rai (1.15 million rai).

5) Conditions of problems in the Chi River Basin area are outlined below**:**

5.1) Conditions of problems in the Chi River Basin area **–** Currently, the Chi River Basin area experiences the issues of flooding, drought and wastewater frequently, which have impacts on the living conditions and lead to a huge loss of incomes and property of local people each year, especially drought, which often occurs in the dry season of every year. This leads to connected socio-economic issues – low incomes earned by local farmers and people, labor migration, and average household income in the Chi River Basin area being lower than the country's averages.

5.2) The conditions of the issues of drought, flooding and wastewater for the above reasons will be aggravated in the future due to the increase in population and in the number of tourists, urbanization, a lack of wastewater treatment sources, increase in water consumption for agriculture, as well as climate change, which causes the increase in temperatures and decrease in rainfall and runoff**.**

6) The selection of alternatives for the development of the Chi River Basin area to solve the issues of drought, flooding and water quality requires systematic planning for the development and integration of responsible agencies. The followings were five proposed alternatives for the development in the Chi River Basin to address these problems and ensure economic development**:**

Alternative 1: Business as usual – It is an alternative with no implementation of policy recommendations, plans or programs or no actions which are deviant from existing directions or guidelines.

Alternative 2: The development for basic necessities and development of sustainable agricultural areas – Supplying high-standard quality water for domestic use for living of local people; providing sufficient water bodies in rainfed agricultural areas to ensure self-dependence, conserving soils and rehabilitating watershed forests, reducing poverty in rural areas, and develop the Sufficiency Agriculture Model or the Khok Nong Na Model.

Alternative 3: The management of water resource-related risks at the area level and the development of related agricultural industries – Processing and adding the value to agricultural products, organic farming, and provision of water to support existing industries. This alternative aims to address the issues of drought, flood and wastewater, especially protection of floods in main cities to reduce the income gap between rural and urban people.

Alternative 4: The development of agroindustry in the northeast region – This focuses on water resource development at its full potential and provision of water to support new industries and tourism (ecotourism and prehistoric tourism). This alternative aims to increase the incomes of people in the river basin, reducing social inequality, and increase the GRP of the northeast region.

Alternative 5: The development of business agriculture as the center of the Greater Mekong Subregion – This alternative involves the diversion of water from the Mekong River to increase irrigated agricultural areas to respond to the expansion of all types of industries, create the stability and security of water for agriculture, especially in the dry season, and add the value of water in production (business agriculture and exportation), and increase the country's GDP.

Following the participation in selecting alternatives at the forum meeting among 10 water user groups in the Chi Sub-basin (covering 27 Chi sub-basins), nine groups selected Alternative 3 and only one group (Mueang District, Khon Kaen Province) selected Alternative 5. The selected alternative, which is suitable in the economic, social and environmental dimensions, is Alternative 5: Economic development by increasing water availability in the Chi River Basin. Alternative 3 was selected as short- and medium-term plans and Alternative 5 as medium- and long-term plans to address these issues and develop the economy in the Chi River Basin area to ensure that local people enjoy prosperity and sustainable development**.** The development plans for Alternative 5 include the followings:

- Development which meets basic needs and ensures thorough development distribution.
- Environmental management for watershed forest conservation and rehabilitation.
- Management of the Chi River Basin area to solve the flooding, drought and wastewater issues.
- Economic development in the Chi River Basin area based on the potential of water in the Chi River Basin.
- Economic development by increasing water availability in the Chi River Basin to ensure water use stability.

7) **Programs in line with the Chi River Basin integrated development approach** consist of:

7.1) **Basic problem solving program** comprises Aspect 1 consumption-based water management, Aspect 2 water security creation in the manufacturing sector, Aspect 4 water quality management and water resource conservation and Aspect 5 soil and soil conservation as well as soil erosion prevention. Projects/plans are short-term plans that can be implemented immediately and have low impacts. Impact mitigation measures must be publicized and local people must understand them.

7.2) **Drought, flood and wastewater mitigation program** consists of Aspect 2 manufacturing stabilization, Aspect 3 flood management, and Aspect 6 management**.** There are short- and medium-term plans, such as small-scale water resource development projects, pumping projects, lowland floodplain forests, community flood prevention project, as well as flood diversion and floodway project affecting farmland, residential areas and wastewater solutions.

As for impact mitigation measures, an understanding among local people and people affected should be fostered**.** Fair compensation should also be made, etc.

7.3) **Water resource project development program for economic development** consists of Plan 2 manufacturing stabilization**.** The following projects require the study and design, as well as budget for construction and the construction period**.** They are medium-term plans.

1) Water resource project development at full potential comprise medium- and large-scale water resource development, water distribution and domestic water network development projects.

2) Chi River Basin water availability increase involves water availability increase to be sufficient for different activities. They have high impacts and require high construction budgets, as well as a long construction period as they are long-term plans.

Impacts and mitigation impacts for water resource development and Mekong diversion projects include:

- Project impacts consist of positive impacts, e.g. river basin inflow augmentation, drought and flood solution, farmers' and peoples' income increase, economic opportunity provision for urban and industrial development, and negative impacts, e.g. impacts on forest areas, residential areas, farmland and waste disposal areas.
- Impact mitigation includes public relations among local people and affected people, fair compensation, mitigation measures and monitoring measure formulation, etc.

As for Aspect 6 Management, management in short-, medium- and long-term plans related to management will be implemented in accordance with three project development plans, which will strengthen cooperation from all sectors in management, reduce conflicts and enhance efficiency in water management, including relevant measures, e.g. development of database integrated by agencies concerned to support decision-making, law and regulation amendment on water resource management, public relations and public participation, as well as promotion of local administrative organizations and communities to participate in formulating the guideline for water resource management.

8) Integrated water resource development plans in the river basin areas comprise 3,736 projects with a total budget of 147,148 million baht excluding Mekong Diversion and Huai Luang Regulator projects costing 41,905 million baht. According to the report study, the Office of Project Management, RID, 2016, the irrigation area in the Chi River Basin amounted to 0.84 million rai (costs from the Huai Luang Regulator Project Report). The watershed forest conservation indicated that Chaiyaphum Province had the most projects (907) with a budget of 58,027 million baht, followed by Khon Kaen Province (742 projects) with a budget of 36,591 million baht.

9) Programs in accordance with integrated strategic development approaches in the Chi River Basin require an understanding of relevant agencies, improvement and addition of programs/projects that can solve problems in five areas of the Chi River Basin according to local needs, as well as urgent serious and continuous implementation of plans/projects into practice.

4.2 Recommendations

To drive the plans in line with the integrated strategic development approach in the Chi River Basin, the following operations should be conducted:

1) Cooperation and understanding with agencies concerned
2) Cooperation with agencies responsible for improving/adding plans/projects to solve problems in the five areas of the Chi River Basin to suit peoples' needs
3) Understanding with the River Basin Committee and local people
4) An approval of plans/projects to implement them into practice
5) Coordination with responsible agencies to accelerate the operation of plans/projects and to solve basic problems
6) Feasibility study and environmental impact assessment of water resource development, flood diversion and drought and flood mitigation projects
7) Comparative study of options and selection of the optimum diversion alternative for further feasibility study and environmental impact assessment of the selected Mekong diversion alternative
8) Continuous impact assessment and monitoring
9) The Office of the National Water Resources shall monitor project operation and assess project performance.