

Kingdom of Thailand

FY2018 Ex-post Evaluation of Japanese Grant Aid Project

“The Flood Prevention Project of East Side of the Pasak River in Ayutthaya”

External Evaluator: Nobuyuki Kobayashi, OPMAC Corporation

## **0. Summary**

By constructing and improving floodgates in the Ayutthaya area, this project is to reduce flood damage in the area located in the south of the waterway, thereby contributing to the safety of residents as well as their assets and enhancing the foundation for the economy by attracting foreign direct investment. This project aimed for the reduction of flood damage in the south of the floodgates, and the purpose of this project was consistent with the government's plan to conduct flood control projects around Pasak River both at the time of the planning and the ex-post evaluation. The implementation of this project is consistent with Thailand's development needs and Japan's ODA policy, and its relevance is high. While the total cost of the project was within the plan, the project period exceeded the plan. Thus, the efficiency is fair. The delay of the project was caused by inundation to the site, rainfall, lack of workers, and additional work to cope with soft ground. Based on the achievement as shown by the operational indicators and the effect indicators, it is concluded that the floodgates under this project functioned as planned, and the water level was properly controlled when the water level of the Pasak River rose in October 2017. Flood protection measures (including protection measures provided by this project) have contributed to strengthening Ayutthaya Province's and Pathum Thani Province's foundation for economic investment. Therefore, the project's effectiveness and the impacts are high. In terms of the institutional/organizational aspects, there are no facilities or equipment for which operation and maintenance responsibilities were unclear, executing agency staff were always located at the floodgates, and the floodgates were operated on a 24-hour basis. The executing agency had experience operating similar facilities, and the design took basic operation and maintenance into consideration. The Ayutthaya Irrigation Project Office assumed an increase in the budget for operation and maintenance at the time of planning and necessary funds were provided. There were no serious defects to the facilities constructed and equipment provided under this project, and operation and maintenance were conducted regularly. The conclusion is that the sustainability of the project effects is high for this project.

In light of the above, this project is evaluated to be highly satisfactory.

## 1. Project Description



Project Location



Han Tra Floodgate

### 1.1 Background

The Chao Phraya River slopes gently downstream and, thus, the amount of water that can flow during flood conditions is small and overflow often occurs on its tributaries. The Pasak River is a tributary of the Chao Phraya River that flows through the urban area of Ayutthaya. The Han Tra canal and the Kra Mang canal (downstream), and the Khao Mao canal (upstream) are all located on the east bank and functioned as drainages for the swampland. The large-scale flood in 2011 caused enormous overflow in the Chao Phraya River basin and caused significant flood damage. As calculated at the beginning of November 2011, approximately 1.2 million households had been affected in the river basin, 446 people had died, and farmland damage had reached almost 17,000 km<sup>2</sup>. The area around the water canals in the project area was inundated when the water level of the Pasak River rose, causing backflow and overflowing of the dikes of the above-mentioned canals. The negative effect of the flood was felt outside Thailand as well because it damaged several industrial parks which housed production sites for global companies including Japanese companies.

The possibility of a flood of similar scale has caused concern that firms might withdraw from the project area or that new firms might refrain from entering also since 2012. For this reason, flood control in the east bank of the Pasak River became an important development issue. In order to recover from the large-scale flood, the Japan International Cooperation Agency (JICA) conducted the Project for the Comprehensive Flood Management Plan for the Chao Phraya River Basin as a technical cooperation for development planning from November 2011. This project was proposed in the abovementioned JICA study. In February 2012, the Kingdom of Thailand requested the Government of Japan for a grant aid cooperation to control flooding in the east bank of the Pasak River of the Ayutthaya District based on a proposal from the study.

## 1.2 Project Outline

The objective of this project is to reduce flood damage in the area located in the south of the waterway by the improvement and construction of floodgates in the Ayutthaya area, thereby contributing to safety of living and assets of residents and enhancement of the foundation for economy and investment for attracting foreign direct investment<sup>1</sup>.

Grant Limit / Actual Grant Amount	2,550 million yen / 1,823 million yen
Exchange of Notes Date /Grant Agreement Date	July 2012 / August 2012
Executing Agency(ies)	Royal Irrigation Department (RID), Ministry of Agriculture and Cooperatives
Project Completion	September 2015
Target Area	Phra Nakhon Si Ayutthaya District
Main Contractor(s)	(Constriction) Maeda Corporation (Equipment) Kubota Corporation
Main Consultant(s)	CTI Engineering International
Preparatory Survey	December 2011 – October 2012
Related Projects	Technical Cooperation “Project for the Comprehensive Flood Management Plan for the Chao Phraya River Basin,” Grant Aid “The Rehabilitation Project of the Outer Bangkok Ring Road”

## 2. Outline of the Evaluation Study

### 2.1 External Evaluator

Nobuyuki Kobayashi, OPMAC Corporation

### 2.2 Duration of Evaluation Study

This ex-post evaluation study was conducted with the following schedule.

Duration of the Study: August 2018 – October 2019

Duration of the Field Study: December 3, 2018 – December 28, 2018

### 2.3 Constraints during the Evaluation Study

The project stakeholders agreed that the area directly affected by this project included the areas near the Han Tra canal, the Kra Mang canal, and the Khao Mao floodgate (which includes the Rojana industrial park where many Japanese-affiliated companies have operation sites). Due to

<sup>1</sup> As the ex-ante evaluation sheet for this project does not mention the project effect corresponding to the impacts, “safety of living and assets of residents” and “enhancement of the foundation for economy and investment for attracting foreign direct investment”, but both were goals mentioned in the preparatory survey for this project (p. 3-1), they were added as impacts.

the difficulty in clearly defining the largest geographical area affected by this project, the judgment of effectiveness and impact was based on the achievement of the targets directly related to the function of the floodgates and did not reflect the benefits in the southern part of Ayutthaya Province or Patun Thani Province.

### **3. Results of the Evaluation (Overall Rating: A<sup>2</sup>)**

#### 3.1 Relevance (Rating: ③<sup>3</sup>)

##### 3.1.1 Consistency with the Development Plan of Thailand

At the planning phase of the project, the Thai government approved the Master Plan on Water Resource Management<sup>4</sup> (formulated in 2012) as an urgent and long-term measure for the 2011 flood. The master plan consisted of two major components, one of which was the “Action Plan of Integrated and Sustainable Flood Mitigation in the Chao Phraya River Basin” that included the development of the waterways from the Pasak and Chao Phraya rivers. In addition, the Strategy for Reconstruction and Future Development<sup>5</sup> (2012) set long-term goals such as the reduction of flood risk by comprehensive investment in target areas that included investing THB 317.1 billion in water resource management in line with the above-mentioned “Master Plan on Water Resource Management.”

At the time of ex-post evaluation, the plan that succeeded the Master Plan on Water Resource Management was manipulated to the 20-year National Water Resources Management Master Plan (2018-2037) and still in the process of government approval. Thus, the Master Plan on Water Resource Management was considered as an effective development plan. In 2013, (during the project implementation), the Flood Management Plan for the Chao Phraya River Basin was formulated. This plan proposed flood control projects such as the construction of diversion channels and dams for areas that the Thai government selected as a high-priority protection area including Bangkok and its surrounding areas in the lower area of the Chao Phraya River Basin (south of the Pasak River). Based on the same plan, and at the time of the ex-post evaluation, the Royal Irrigation Department (RID) implemented the flood control project on the south side of the project area (the east bank of the Chao Phraya River). At the end of 2018, six gates were completed or planned to be built.

The purpose of this project was to develop a floodgate for disaster prevention in Ayutthaya area and aimed to reduce flood damage in the area south of the floodgates. At the planning phase and the ex-post evaluation, the purpose of this project was consistent with the government's plan to implement flood control projects around the Pasak River. The Flood Management Plan for the Chao Phraya River Basin, which was formulated during project implementation, included

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<sup>2</sup> A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

<sup>3</sup> ③: High, ②: Fair, ①: Low

<sup>4</sup> The Master Plan on Water Resource Management is the title for the English version of the master plan.

<sup>5</sup> The plan was prepared by the National Economic and Social Development Board.

the target area of this project in its target area. Thus, it is concluded that the development plan continued to prioritize disaster prevention around the Pasak River.

### 3.1.2 Consistency with the Development Needs of Thailand

At the planning phase of this project, the 2011 large-scale flood caused devastating damage. In the project area, the Han Tra canal, the Kra Mang canal, and the upstream Khao Mao canal functioned as drainage for the lowland area east of the Pasak River. The large-scale flood in 2011 caused backflow from the Pasak River, and overflow occurred because the height of the Khao Mao floodgate installed in the canal was insufficient. The Khao Mao floodgate was at risk of breaking. Opening the floodgate resulted in dike breaks of the canals and caused damage to the industrial area on the south side of the canals.

At the time of the ex-post evaluation, the water level of the Pasak River rose in the rainy season. When the amount of precipitation was high, backflow occurred in the Han Tra canal, the Kra Mang canal, and the Khao Mao canal. The precipitation in central Thailand for 2017 was approximately 30% higher than the average for the past 30 years (2017: 1,649 mm, average: 1,276

mm) causing the water level of the Pasak River to rise significantly triggering the Han Tra and Kra Mang floodgates to control the water level of the channel.

At the planning phase, the height of the Khao Mao floodgate was not high enough, and the large-scale flood in 2011 resulted in significant damage to the project area. The Han Tra and Kra Mang floodgates constructed by this project had enough height to prevent the flood damage in the project area even if a flood of a similar size in 2011 occurred. While Ayutthaya is located



Figure 1: Location of Chao Phraya River Basin and the Project

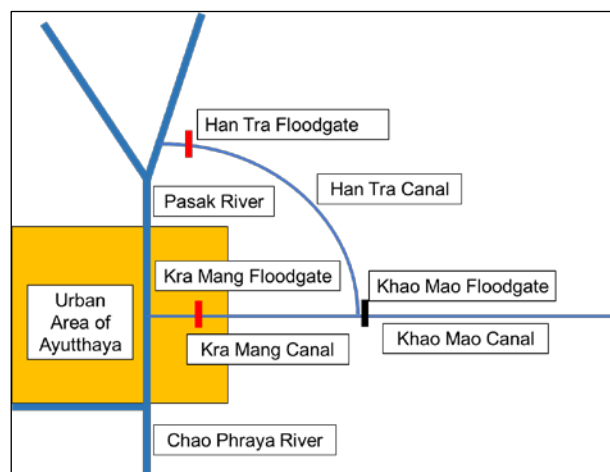


Figure 2: Map of the Project Area

approximately 100 km from the river mouth of the Chao Phraya River, its elevation is about 7m. Thus, its slope is less than one permyriad. Due to the gentleness of the river slope, the water level of the Pasak River rose in the rainy season at the project site, and this situation often caused flooding.

In Ayutthaya Province and its southern area Patun Thani Province, from among the major industrial parks<sup>6</sup> damaged by the flood in 2011, information was available at five locations (Rojana, Hi-tech, Bang Pa-In, Saha Rattana Nakorn, and Nava Nakorn). The number of companies with operational sites in these industrial parks increased from 638 at the planning phase (2011) to 707 at the time of ex-post evaluation (2015 and 2018). Japanese-affiliated companies slightly increased from 373 at the planning phase (2011) to 378 companies at the ex-post evaluation (2015 and 2018).

As the project built floodgates and developed infrastructure that could withstand floods similar in scale to the large-scale flood in 2011, the project met a significant need for disaster prevention. The development needs of this project was based on the geographical conditions of the Chao Phraya River Basin, and the conditions remained unchanged from the planning phase to the time of the ex-post evaluation. At the times of both the planning and the ex-post evaluation, the major industrial parks in Ayutthaya Province and Patun Thani Province were important production sites for Thai and global companies and, thus, the flood control of both provinces was important for the Thai economy.

### 3.1.3 Consistency with Japan's ODA Policy

At the planning phase of this project, the Ministry of Foreign Affairs' Country Assistance Policy for the Kingdom of Thailand (2012) mentioned Thailand and Japan's strong economic ties. For Thailand, the fact that Japan was the No.1 country in terms of both the total amount of trade and foreign investment was used to highlight "the significance of assistance" to the country (Thailand). Furthermore, one of the priority areas was the "sustainable economic development and responses to a matured society" including the promotion of flood countermeasures based on the 2011 flood. In addition, one of the issues to be addressed in terms of the maturation of Thailand's society was the "environment and climate change issue."

In light of the fact that this project was a flood control project and Japanese-affiliated companies with operations in Ayutthaya benefitted from this project, this project is relevant with the strong economic ties between Thailand and Japan, which was mentioned as being significant in terms of the Country Assistance Policy. Furthermore, the policy emphasized measures for the 2011 flood, and regarded "environmental and climate change issue" as a task. This project constructed floodgates in the canal in a tributary of the Pasak River, and carried out

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<sup>6</sup> Seven industrial parks: Rojana, Hi-tech, Bang Pa-In, Saha Rattana Nakorn, Factory Land, Nava Nakorn, and Bangkadi

an urgent measure to deal with flooding, and also contributed to Thailand's preparations for climate change.

This project has been highly relevant to the country's development plan and development needs, as well as Japan's ODA policy. Therefore its relevance is high.

### 3.2 Efficiency (Rating: ②)

#### 3.2.1 Project Outputs

This project newly constructed two floodgates (Han Tra floodgate and Kra Mang floodgate) that can withstand a large-scale flood such that occurred in 2011 (EL 6m MSL) and also implemented revetment work for the canal and provision of drainage pump vehicles. The planned and actual outputs of this project are as shown in the following table.

Table 1: Output of this Project (Plan and Actual)

Plan	Actual
a) Construction, Equipment Procurement <ul style="list-style-type: none"> <li>• Construction of floodgate structures (Han Tra and Kra Mang Floodgates)</li> <li>• Manufacturing and installment of gates</li> <li>• Related facilities such as construction of canal revetment</li> <li>• Provision of drainage pump vehicles (10 vehicles)</li> </ul> b) Consulting Services <ul style="list-style-type: none"> <li>• Tender assistance</li> <li>• Construction supervision*</li> <li>• Capacity building program (soft component: Guidance on coordinating operation with water gates and drainage machine station, etc.)</li> </ul>	a) Construction, Equipment Procurement <ul style="list-style-type: none"> <li>• Same as the plan (left)</li> </ul> b) Consulting Services <ul style="list-style-type: none"> <li>• Same as the plan (left)</li> </ul>

Source: documents provided by JICA, the preparatory survey, answers for the questionnaire to the executing agency  
 Note: \* In consideration of the urgency of this project, the detailed design (D/D) was carried out within the preparatory survey after G/A. Therefore, the consulting service of this project did not include D/D.

In this project, major changes to the technical specification included (1) addition of gabion<sup>7</sup> removal/installment, (2) extension of pile depth, and (3) replacement to concrete ground. The addition of gabion removal/installment was necessary because other (unrelated) construction work affected the site conditions of the Kra Mang canal. Extending the pile depth in both floodgates was necessary because design based on existing works and test results



Photo 1: Revetment on Han Tra Canal

<sup>7</sup> A square basket containing crushed stones

suggested that it was necessary to drive the pile deeper than the original estimates. Soft ground was also replaced to concrete ground in a part of the construction site of the Han Tra floodgate. Neither change; however, brought about a significant change in the output.

### 3.2.2 Project Inputs

#### 3.2.2.1 Project Cost

For the total project cost, the actual amount was JPY 1,866 million which was lower than the planned amount of JPY 2,600 million (72% of the plan). Of the total amount, the planned amount for the Japanese side was JPY 2,550 million, and the actual amount was JPY 1,823 million (71% of the plan). The breakdown of the cost borne by the Japanese side was JPY1,535 million for construction, JPY193 million for equipment, and JPY 95 million for consulting services. The planned amount for the Thai side was JPY 50 million, and the actual amount was JPY 43 million (86% of the plan).

The decrease in total project cost was mainly attributed to a detailed review of the detailed design and a highly competitive tender. Since this project was a restoration project, the project cost was roughly estimated at the time of G/A. When the project cost was scrutinized at the time of detailed design, the cost to be borne by the Japanese side decreased mainly due to construction cost reductions. Moreover, eight companies bid for the floodgate construction and, due to a highly competitive tender, the winning bid amounted to JPY 1,434 million against the price estimate of JPY 1,631 million. As a result of a contract amendment during the project implementation, the contract amount at the time of project completion was JPY1,536 million.

#### 3.2.2.2 Project Period

While the planned project period for this project was 22 months (February 2013-November 2014), the actual project period was 32 months (February 2013-September 2015) and exceeded the plan (145% of the plan). The delay was mainly due to the extension of the construction period, and construction completion was extended three times (Initial contract: October 2014, First revision: February 2015, Second revision: April 2015, Third revision: September 2015). The reasons necessitating the extension of the construction period included inundation at the site, rainfall, lack of workers, and additional works related to soft ground.

Table 2: Project Period of this Project (Plan and Actual)

Plan	Actual
Project period: February 2013 - November 2014 (22 months)	Tender assistance for construction: February 2013 - June 2013 (5 months)
	Main construction: July 2013 - September 2015 (27 months)

Source: documents provided by JICA



Although the project cost was within the plan, the project period exceeded the plan. Therefore, efficiency of the project is fair.

### 3.3 Effectiveness and Impacts<sup>8</sup> (Rating: ③)

#### 3.3.1 Effectiveness

At the planning phase of this project, “Maximum Water Level for Flood Protection around the Khao Mao canal” was set as an indicator to measure the project’s quantitative effect, and the preparatory survey also mentioned the “Water Level of Ayutthaya Water Level Station at the Pasak River” as an indicator to measure the quantitative effect. For this reason, both indicators were taken into consideration as operation indicators in the evaluation judgment. Moreover, the “Yearly maximum inundation area” and “Yearly maximum number of inundated houses”, which are often used as indicators to measure the effects of disaster prevention projects, were also reflected in the evaluation judgment. For sub-ratings for effectiveness and impact, the above four indicators were equally weighted for determining the achievement level of the targets.

##### 3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

###### (1) Maximum Water Level for Flood Protection around the Khao Mao Canal

The target for the maximum water level for flood protection around the Khao Mao canal (EL 6.0m MSL) was based on the design flood level for the Han Tra and Kra Mang floodgates, and this design flood level could cope with the maximum water level of the 2011 flood (approximately 6m). The design flood level of both gates was not changed during the project period, and the completed floodgates met the technical specifications in line with the initial plan. Since no damage affected the strength of both flood gates after the project completion, the maximum flood protection water level remained the same. Therefore, it is concluded that this indicator achieved its target.

Table 3: Maximum Water Level for Flood Protection around the Khao Mao Canal

	Baseline	Target	Actual			
	2011	2017	2015	2016	2017	2018
		3 Years After Completion	Completion Year	1 Year After Completion	2 Years After Completion	3 Years After Completion
Maximum Water Level for Flood Protection around the Khao Mao canal (m)	EL 4.5m MSL	EL 6.0m MSL	EL 6.0m MSL	EL 6.0m MSL	EL 6.0m MSL	EL 6.0m MSL

Source: documents provided by JICA and the executing agency, etc.

<sup>8</sup> Sub-rating for Effectiveness is to be put with consideration of Impacts.

(2) Water Level of the Pasak River

On the Water Level of Ayutthaya Water Level Station at the Pasak River, the water level reached EL 4.09 m MSL in October 2017 and it was the highest level in the period from 2015 to 2017 (see the following table). As aforementioned, in Central Thailand, the amount of precipitation for 2017 was approximately 30% higher than the average of the past 30 years, but at the time of planning there had not been any flood that exceeded the forecast. Therefore, it is concluded that this indicator also achieved the target.

Table 4: Water Level of Ayutthaya Water Level Station at the Pasak River

	Baseline	Target*	Actual		
	2011	2016	2015	2016	2017
		2 Years After Completion	Completion Year	1 Year After Completion	2 Years After Completion
Water Level of Ayutthaya Water Level Station at the Pasak River (m)	EL 6.0m MSL	EL 6.0m MSL	EL 1.48m MSL	EL 3.76m MSL	EL 4.09m MSL

Source: documents provided by JICA and the executing agency, etc.

Note: \* Although the preparatory survey report did not set the target year for the Water Level of Ayutthaya Water Level Station at the Pasak River, the target is expected to be achieved at the time of project completion from the content of the indicator. Moreover, it is presumed that the same target continues until the ex-post evaluation.

Based on water level data from both floodgates, the difference between the water level on the Pasak river side and the water level on the Khao Mao floodgate side (water level at the Passak river side – water level at the Khao Mao floodgate side) was 1.6m in late-October 2017 the highest level after project completion (See next table). As there was no floodgate from the Pasak River to the Khao Mao floodgate before the implementation of this project, the area along the water canal had been exposed to a high risk of inundation when the water level of the Pasak River rose. The two floodgates constructed by this project could stabilize the water level of the Han Tra canal (Han Tra floodgate to Khao Mao floodgate) and the Kra Mang canal (Kra Mang floodgate to Khao Mao floodgate) in response to fluctuations in rainfall.

Table 5: Differences of Water Level of Kra Mang and Han Tra Floodgates

Date		21-Oct	22-Oct	23-Oct	24-Oct	25-Oct	26-Oct	27-Oct	28-Oct	29-Oct	30-Oct	31-Oct
Kra Mung Floodgate	Pasak River	3.84	3.80	4.00	3.86	3.95	3.96	3.90	3.90	3.80	3.75	3.70
	Khao Mao	2.60	2.52	2.50	2.62	2.66	2.55	2.44	2.44	2.20	2.22	2.24
	Difference	1.24	1.28	1.50	1.24	1.29	1.41	1.46	1.46	1.60	1.53	1.46
Han Tra Floodgate	Pasak River	3.90	3.90	3.84	4.05	4.07	4.10	4.05	4.05	3.85	3.80	3.80
	Khao Mao	2.40	2.40	2.62	2.65	2.65	2.55	2.45	2.45	2.30	2.30	2.20
	Difference	1.50	1.50	1.22	1.40	1.42	1.55	1.60	1.60	1.55	1.50	1.60

Unit: m

Source: documents provided by the executing agency

### (3) Frequency and Days for Use of Drainage Pump Vehicles

The frequency and days for use of drainage pump vehicles showed that the drainage pump vehicles provided by this project were used continuously (see the following table). According to interviews with the executing agency staff, the pump vehicles were used across Ayutthaya Province and occasionally used in nearby provinces. On the other hand, the executing agency staff pointed out that it was difficult to operate more than 3-4 vehicles



Photo 2: Drainage Pump Vehicle

out of 10 drainage pump vehicles provided by this project at the same time. The purpose of using pump vehicles is to (1) lower the water level in sunken places during rainy seasons, (2) supply water in dry seasons, or (3) release retained water that can cause strong odor in the canals. Moreover, in June 2018, two drainage pump cars provided by the project were used for the rescue mission of the boy football team that had become trapped in the Tham Luang Cave, Chiang Rai Province. JICA officials who cooperated with the rescue mission were awarded medals from the King of Thailand.

Table 6: Frequency of Drainage Pump Vehicles

Year	2015	2016	2017	2018
Frequency of Use	12	3	12	27
Days of Use	156	16	20	211

Source: documents provided by the executing agency

### (4) Yearly Maximum Inundation Area and Yearly Maximum Number of Inundated Houses

As mentioned above, the maximum water level of the Pasak River is lower than the maximum water level for flood protection of the floodgates constructed by this project. Since the project completion there has been no occurrence of floodgate overflows or dike breaks. Based on the information provided by the executing agency, in Ayutthaya District where the project constructed the floodgates, inundation occurred in 25 km<sup>2</sup> in 2017 but no flood damage occurred in the area along the Kra Mang and the Han Tra canals. Based on interviews with the executing agency staff, given the water level (4.1 m) recorded in October 2017, without the control of water level provided by both floodgates, flooding was likely to occur to the houses in the area along the canals.

Table 7: Yearly Maximum Area of Inundation and Yearly Maximum Number of Inundated Houses

	Baseline	Target*	Actual		
	2011	2016	2015	2016	2017
		2 Years After Completion	Completion Year	1 Year After Completion	2 Years After Completion
Yearly Maximum Inundation Area (km <sup>2</sup> )	-	0 km <sup>2</sup>	0 km <sup>2</sup>	0 km <sup>2</sup>	0 km <sup>2</sup>
Yearly Maximum Number of Inundated Houses (houses)	-	0 house	0 house	0 house	0 house

Source: documents provided by the executing agency, etc.

Note: \* It was assumed that flood damage due to overflow and floodgate breakage (in either of the two floodgates) does not occur in the area around the floodgates.

### 3.3.1.2 Qualitative Effects (Other Effects)

In this ex-post evaluation, the residents<sup>9</sup> around the Han Tra and the Kra Mang canals and the employees<sup>10</sup> of companies with operational sites in the industrial parks in Ayutthaya Province were interviewed to understand flood damage after the project completion. In addition, interviews with the companies were necessary to confirm assumptions regarding: expected project effects in the event of a large-scale flood; and the influence the floodgates constructed by this project had in relation to actual plans for a large-scale flood. The results of information collected are as follows.

#### (1) Flood Damage after the Project Completion

After project completion, the residents in the area around the canals have not been affected by a flood and evacuation was no longer necessary. Even before the implementation of this project, many residents only evacuated for large-scale floods, and those residents could not identify any significant change in their evacuation behavior during a flood from the time “before” and “after” the project. However, the residents alongside the canals who occasionally evacuated for relatively small floods in the past, now had the opinion that because the water level had been stabilized due to the project that they did not have to evacuate during a flood. Also, the companies in the four industrial parks in Ayutthaya Province were not affected by a flood after the project completion, and evacuation at the time of flood was not required.

#### (2) Influence on the Plan at the Time of a Large-scale Flood

As both the industrial parks themselves (including the Rojana industrial park, the High-tech industrial park, the Bang Pa-In industrial park and the Saha rattana nakorn industrial park in

<sup>9</sup> On December 20-21, 2018, key informant interviews were conducted with the residents around the Han Tra canal and the Kra Mang canal (7 males and 5 females).

<sup>10</sup> On December 12-14 and 24, 2018, key informant interviews were conducted at 13 companies (10 Japanese-affiliated companies, 2 foreign companies, 1 Thai companies) in 4 industrial parks in Ayutthaya Province (Rojana, Hi-Tech, Bang Pa-In, and Saha rattana nakorn).

Ayutthaya Province) and their occupants independently implement flood countermeasures, it was difficult to identify the effect associated only with the floodgates provided by this project and to confirm how this project influenced business continuity plans (BCP) and evacuation plans. Furthermore, the High-tech industrial park and the Bang Pa-In industrial park were not in the area that directly benefited from the project, and the floodgates itself were not recognized. However, without the floodgates provided by this project for the Saha rattana nakorn industrial park, the trunk road Route No. 32 could be disconnected in the event of a flood and, a company answered that their BCP would not function in such a situation.

### 3.3.2 Impacts

#### 3.3.2.1 Intended Impacts

At the time of planning, it was assumed that flood damage would be prevented in a wide area on the south side of the Han Tra canal, the Kra Mang canal, and the Khao Mao canal. Therefore, quantitative effects are shown by using statistical data of Ayutthaya Province and Pathum Thani Province directly southward of Ayutthaya Province. Based on the interviews with residents near the canals and employees of the companies in the industrial parks, the qualitative effects are articulated below.

#### (1) Flood Damage after the Project Completion

In Ayutthaya Province and Pathum Thani Province, rice is the largest farm crop in the area<sup>11</sup>. Therefore, rice production has substantial impact on farmers' livelihoods. By comparing the planted area and the harvested area of major rice crops (wet season, single cropping), which was very susceptible to flooding (see the following table), the extent of flood damage was assessed. The flood in 2011 had an enormous impact on rice harvesting but since 2012 the difference between planted and harvested areas had been very small.

Table 8: Planted Area and Harvested Area of Major Rice

		Unit: Rai*							
	Type	2010	2011	2012	2013	2014	2015	2016	2017**
Pathum Thani Province	Planted	340,411	322,647	338,306	328,031	313,747	317,460	311,373	317,479
	Harvested	310,989	235,085	337,476	327,567	313,532	315,904	309,279	316,545
	%	91%	73%	100%	100%	100%	100%	99%	100%
Ayutthaya Province	Planted	961,815	943,833	959,758	922,179	822,025	689,363	716,290	714,125
	Harvested	836,147	597,502	941,648	917,145	813,631	684,438	707,958	709,054
	%	87%	63%	98%	99%	99%	99%	99%	99%

Source: Office of Agricultural Economics (2011-2017) "Agricultural Statistics of Thailand"

Note 1: \* Area unit in Thailand 1 Rai = 0.16 ha

Note 2: \*\* Forecasted data for 2017

<sup>11</sup> National Statistical Office (2018) "Statistical Yearbook Thailand 2018"

In the interviews with the residents around the canals, many residents voiced opinions that after project completion, floods did not damage their assets (houses, household goods, etc.), and that they had a higher sense of security in the event of a flood. It was also confirmed that a small number of residents showed behavioral changes due to their increased confidence that flood damage would not occur again. Such behavioral changes included purchasing home appliances, purchasing furniture and refrigerators for opening a store, and resuming agriculture activities.

Conclusions are hard to make in light of the facts that there has not been a large-scale flood equivalent to the one in 2011, and that the project is not the only factor. Nevertheless, based on the rice production and the sense of security among the residents, it is concluded that this project partially contributed to the security of residents' lives and assets.

(2) Strengthening of the Foundation for Economic Investment to Attract Foreign Direct Investment

It is difficult to directly measure the strengthening the foundation for economic investment. For this reason, the consequences from strengthening the foundation for economic investment (number of companies in the industrial parks and opening of new factories) is analyzed instead. First, on the number of companies in the industrial parks, the number of companies with operational sites in the industrial parks of Ayutthaya Province and Pathum Thani Province, (those which were affected by the flood in 2011), increased and Japanese companies also slightly increased (see Table 9). Despite initial concerns after the flood in 2011, companies did not withdraw from the industrial estates. In addition, after the flood in 2011 (from 2012 to 2015) the investment amount for opening new plants in both provinces remained high (see Table 10).

Table 9: Number of Companies in the Industrial Parks of Ayutthaya Province and Pathum Thani Province

	Provinces	Total Companies		Japanese Companies	
		2011	2018	2011	2018
Saha Rattana Nakorn	Ayutthaya	90	96	32	36
Hi-tech	Ayutthaya	115	143	74	72
Bang Pa-In	Ayutthaya	25	36	16	20
Rojana	Ayutthaya	218	242	147	150
Nava Nakorn*	Pathum Thani	190	190	104	100
Total		638	707	373	378

Source: JETRO, Industrial Estate Authority of Thailand, Rojana Industrial Park

Note: \* Data for 2015

Table 10: Investment Amount for Opening New Plants

unit: million baht

Province	2010	2011	2012	2013	2014	2015	2016	2017
Pathum Thani	7,779	16,935	6,078	24,939	29,366	35,429	10,418	26,115
Ayutthaya	10,755	11,827	47,980	32,963	17,226	27,138	14,791	18,941
Total	18,534	28,762	54,058	57,902	46,592	62,567	25,209	45,056

Source: Department of Industrial Works

Note: Based on the approval data from Department of Industrial Works

Interviews with companies showed that the decisions on investment and scale of operation were based primarily on customers' needs and global production plans. In Rojana Industrial Park, however, the project indirectly impacted one company's operations. The company convinced customers concerned about the interruption of supply due to floods, that they are taking measures against floods by showing the company the floodgates constructed by the project. As a result, the orders from those companies continue. Some companies have now also recognized the importance of the floodgates as flood protection given that after the 2011 flood, companies have faced higher insurance premium payments and lower insurance coverage.

As mentioned above, the industrial parks and resident companies were independently implementing flood protection measures. Operations and investment were affected by factors other than the flood protection measures. Therefore, it was difficult to identify the effects of this project alone on the operations and investment of the companies in the industrial parks. However, it is presumed that various measures against floods including this project contributed to the sense of security among companies and that such sense of security indirectly affected company decisions to continue business operations and investment after the floods in Ayutthaya and Pathum Thani Provinces.

### 3.3.2.2 Other Positive and Negative Impacts

#### (1) Impacts on the Natural Environment

At the time of planning, the project was classified as a Category B<sup>12</sup> project based on "Guidelines for Environmental and Social Consideration" of Japan International Cooperation Agency (2010). Due to domestic regulations, the construction work of this project did not require both Initial Environmental Examination (IEE)<sup>13</sup> and Environmental Impact Assessment (EIA). Environmental checklists were prepared, and air quality, water quality, and noise were monitored every three months. Based on the answers to the executing agency's questionnaire and the interview with the construction supervision consultant, no environmental issue occurred during project implementation. At the time of the ex-post evaluation, the

<sup>12</sup> For Category B projects, the impact affects the site itself in general, there is little irreversible impact, and ordinary measures can deal with environmental impact.

<sup>13</sup> The construction supervision consultant prepared a draft IEE. However, the domestic regulations did not require an IEE for the construction of this project's floodgates because the floodgates did not face the Pasak river.

executing agency had not collected data on air quality, water quality, and noise near the floodgates and therefore relevant information after the project completion could also not be obtained. In the interviews with the executing agency staff, the environmental authority had not pointed out any problems. The residents voiced an opinion that household drainage flowing into the canals occasionally caused odor when the floodgates were closed at the time of high water-level but they did not claim that it caused a health hazard.

## (2) Resettlement and Land Acquisition

Based on the answers on the questionnaire to the executing agency, land acquisition of 1,412 square meters was conducted for the construction of the floodgates, revetment, and access roads, and 26 households were relocated. Although no resettlement action plan was prepared, in accordance with domestic regulations, the amount of compensation was decided by the committee established by the provincial government, and monetary compensation was provided to affected people. Monitoring of resettled people after the project completion was not carried out. In the project completion report and the interview with the construction supervision consultant, affected residents did not complain and there were no problems with land acquisition and resettlement.

## (3) Coordination scheme between the executing agency and the municipal governments

In the project area, in addition to RID, municipal governments also operated floodgates. Thus, it was necessary to coordinate floodgate operation among RID and the municipal governments in the event of a flood. The soft component of this project supported the establishment of a coordination scheme among RID's Ayutthaya Irrigation Project Office, Ayutthaya city, and Ayothaya town, and implemented a joint training exercise assuming specific scenarios in line with the requests from RID. At the time of the ex-post evaluation, this coordination scheme was maintained, and information sharing was being carried out on water levels and openings/closings of the four floodgates supervised by RID (Kra Mang, Han Tra, Khao Mao, Dusit). Ayutthaya City, and Ayothaya town operate floodgates with this information as a reference. In addition, when the water level at the floodgate rose, joint site inspections were conducted at important locations on the canals.

This project has achieved its objectives. Therefore effectiveness and impacts of the project are high.



### 3.4 Sustainability (Rating: ③)

#### 3.4.1 Institutional / Organizational Aspect of Operation and Maintenance

At the time of the ex-post evaluation, the executing agency of the project RID was also in charge of the operation and maintenance of the facilities and equipment after the project completion. The Ayutthaya Irrigation Project Office under the 10th Regional Irrigation Office in RID was directly engaged in the operation and maintenance of the facilities and equipment provided by this project (Han Tra floodgates, Kra Mang floodgates, and drainage pump vehicles). The staff of Ayutthaya Irrigation Project Office carried out routine works excluding large-scale repairs, and, when necessary, large-scale repairs were outsourced to private companies. However, after the project completion, no major repairs were conducted on the facilities provided by this project.

The number of RID employees remained almost the same from 2016 to 2018 (2016: 6,095 persons, 2018: 6,052 persons), and the number of engineers increased during the same period (2016: 1,450 persons, 2018: 1,627 persons). According to the staff of the Ayutthaya Irrigation Project Office, the operation and maintenance team of the two floodgates consisted of five people (1 electric engineer, 2 mechanical engineers, 2 operators), and one of the staff stationed on a 24-hour basis in the floodgates.

At the time of the ex-post evaluation, the responsibilities of operation and maintenance were clearly defined, and the responsibility for operation and maintenance was clear for all facilities and equipment. The number of executing agency staff was stable for the past three years. Executing agency staff are always stationed at the floodgates and operating the floodgates on a 24-hour basis. Therefore, it is thought that there is no problem affecting the sustainability of the project effects in terms of the institutional and organizational aspect.

#### 3.4.2 Technical Aspect of Operation and Maintenance

RID had their own track record of design, construction, operation and maintenance of facilities. For the floodgates constructed by this project, simple electrical equipment (incoming panel, operation panel, motor, etc.) and availability of spare parts were taken into consideration. It was possible to obtain replacement parts locally even after the project completion. In addition, the floodgates were made of stainless steel for prevention of corrosion. Since the procurement of chassis and installation for drainage pump vehicles were carried out in Thailand, spare parts and repair service were available even after the project completion.

After the project completion, soft copies of the operation and maintenance manuals (English version and Thai version) of the floodgates and drainage pump vehicles were provided and the staff of Ayutthaya Irrigation Project Office printed necessary sections and used them at the time of operation. Furthermore, at the time of ex-post evaluation, the construction supervision consultant responded to technical inquiries.

Based on the executing agency's explanation, recruitment of new staff was decided in three stages of (1) examination of general education, (2) examination of expertise fields (technical knowledge for relevant fields), and (3) interviews. After identifying the technical level through this process, RID staff members were employed. The staff training at Ayutthaya Irrigation Office depended mainly on OJT but four times a year the staff also participated in training in which they found interesting among the training courses provided by RID.

RID operated similar facilities, and this project's design considerations paid attention to easy operation and maintenance. Therefore, it was considered that the operation and maintenance of the floodgates and drainage pump vehicles under this project could be technically doable. The operation and maintenance manuals were used by the departments in charge of operation and maintenance, and recruitment and the training were conducted to ensure the technical level of the staff. From the above, it is concluded that there are no problems affecting the sustainability of the project effects in terms of the technical aspect.

#### 3.4.3 Financial Aspect of Operation and Maintenance

Regarding RID's budget, both the allocation and expenditure for operation and maintenance decreased in the past two years whereas construction and studies increased significantly (see the table below). As the construction and studies were expensed for construction of new infrastructure, the maintenance budget of the existing facilities was likely to be tight for RID.

For the expenditures at Ayutthaya Irrigation Project Office, the expenditures for operation and maintenance for FY 2017 and FY 2018 decreased in line with the budget allocated to the operation and maintenance for RID. However, comparing the operation and maintenance expenditure for "before" and "after" of the project completion, the average over the past two years of the operation and maintenance expenditure at the Ayutthaya Irrigation Project Office (FY2017-FY2018: 2,144 thousand baht) increased by 778 thousand baht from 1,366 thousand baht for the year before the project completion (2014). This amount was almost equivalent to an increase of the annual expenses for O & M estimated at the time of planning (805 thousand baht)<sup>14</sup>. Based on the interviews with the staff of the executing agency, they did not face any problem with the recurring expenses for the operation and maintenance of the floodgates. As for the drainage pump vehicles, under the current budget it was difficult to operate more than 3 - 4 vehicles simultaneously for a long period of time because personnel required for the operation are also assigned to other duties within the Ayutthaya Irrigation Project Office.

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<sup>14</sup> Excluding extraordinary expenses caused by flood

Table 11: Allocation and Expenditure in the budget for RID

unit: million baht

Year	2014		2015		2016	
	Allocation	Expenditure	Allocation	Expenditure	Allocation	Expenditure
Human Resources	6,832.52	6,331.44	6,623.94	6,623.91	6,722.14	6,653.43
Operation & Maintenance	17,945.01	16,147.84	18,792.53	18,450.94	18,381.35	17,241.88
Construction & Studies	15,115.62	9,767.62	17,464.99	15,433.74	20,831.66	17,775.02
Subsidies	0.82	0.78	0.79	0.48	0.77	0.72
Others	161.02	142.57	248.57	225.44	174.31	148.17
Total	40,054.99	32,390.26	43,130.82	40,734.51	46,110.23	41,819.23

Year	2017		2018	
	Allocation	Expenditure	Allocation	Expenditure
Human Resources	6,665.37	6,665.33	6,592.65	6,564.08
Operation & Maintenance	8,320.39	7,989.71	2,846.58	2,685.17
Construction & Studies	31,808.84	25,952.19	44,800.38	34,458.88
Subsidies	0.35	0.34	0.47	0.34
Others	209.32	186.79	136.80	128.73
Total	47,004.27	40,794.36	54,376.88	43,837.20

Source: documents provided by the executing agency

Table 12: Expenditures of Ayutthaya Irrigation Project Office

unit: million baht

	2014	2015	2016	2017	2018
Operation & Maintenance	1.37	2.65	5.24	1.77	2.52
Construction & Studies	29.91	72.59	122.25	315.52	66.88
Others	0.07	0.05	0.06	0.11	0.09

Source: documents provided by the executing agency

While the construction expenses of RID increased in the past two years, budget allocation to operation and maintenance decreased significantly. The expansion of the water channel network led to an increase in the construction expenses and tight budgets for existing operation and maintenance for RID. However, as the operation and maintenance expenses borne by the Ayutthaya Irrigation Project Office covered the increase assumed at the time of planning, there was no serious impact on the operation and maintenance activities of the office. From the above, it is concluded that there are no problems affecting the sustainability of the project effects in terms of the financial aspect.

#### 3.4.4 Status of Operation and Maintenance

Based on the information provided by the executing agency and the interviews with the staff of Ayutthaya Irrigation Project Office, inspection of the floodgates (testing opening/closing of gates, inspection of hydraulic equipment, etc.) was conducted regularly once a week. It is checked for malfunction every 2 weeks. Moreover, test runs of the stand-by generator was held

once every four weeks and lubrication was carried out once a year. At the time of the site survey, both floodgates remained operational. The gates of both facilities were made of stainless steel and serious rusting had not occurred. Although there were minor cracks on the concrete structure, large cracks and chips which may affect the strength of the structure were not found. Fences were provided for the prevention of equipment theft and hatches for workers were constructed.



Photo 3: Kra Mang Floodgate

Based on the information provided by the executing agency, the drainage pump vehicles were inspected daily, and parts and batteries were replaced as necessary. Out of 10 drainage pump vehicles at the Ayutthaya Irrigation Project Office, all were stored in the garage except one operating outside the office at the time of the site survey. Regular inspections and cleanings were conducted, and all vehicles were ready to operate.

In the facilities and equipment constructed or provided under this project, no defects that could prevent the attainment of the project effects were found. Operation and maintenance were conducted properly. Therefore, it is concluded that in the current status, no problems exist that could affect the sustainability of the project effects.

No major problems have been observed in the institutional / organizational, technical, financial aspects and current status of the operation and maintenance system. Therefore sustainability of the project effects is high.

#### **4. Conclusion, Lessons Learned and Recommendations**

##### 4.1 Conclusion

By constructing and improving floodgates in the Ayutthaya area, this project is to reduce flood damage in the area located in the south of the waterway, thereby contributing to the safety of residents as well as their assets and enhancing the foundation for the economy by attracting foreign direct investment. This project aimed for the reduction of flood damage in the south of the floodgates, and the purpose of this project was consistent with the government's plan to conduct flood control projects around Pasak River both at the time of the planning and the ex-post evaluation. The implementation of this project is consistent with Thailand's development needs and Japan's ODA policy, and its relevance is high. While the total cost of the project was within the plan, the project period exceeded the plan. Thus, the efficiency is fair. The delay of the project was caused by inundation to the site, rainfall, lack of workers, and additional work to cope

with soft ground. Based on the achievement as shown by the operational indicators and the effect indicators, it is concluded that the floodgates under this project functioned as planned, and the water level was properly controlled when the water level of the Pasak River rose in October 2017. Flood protection measures (including protection measures provided by this project) have contributed to strengthening Ayutthaya Province's and Pathum Thani Province's foundation for economic investment. Therefore, the project's effectiveness and the impacts are high. In terms of the institutional/organizational aspects, there are no facilities or equipment for which operation and maintenance responsibilities were unclear, executing agency staff were always located at the floodgates, and the floodgates were operated on a 24-hour basis. The executing agency had experience operating similar facilities, and the design took basic operation and maintenance into consideration. The Ayutthaya Irrigation Project Office assumed an increase in the budget for operation and maintenance at the time of planning and necessary funds were provided. There were no serious defects to the facilities constructed and equipment provided under this project, and operation and maintenance were conducted regularly. The conclusion is that the sustainability of the project effects is high for this project.

In light of the above, this project is evaluated to be highly satisfactory.

## 4.2 Recommendations

### 4.2.1 Recommendations to the Executing Agency

#### Effective Use of Drainage Pump Vehicles

This project provided 10 drainage pump vehicles to RID Ayutthaya Irrigation Project Office and these vehicles were used continuously after the project completion. Due to budget constraints, however, the employment of new staff is insufficient. For this reason, of the 10 drainage pump vehicles provided by this project the Ayutthaya Irrigation Project Office can only operate 3-4 drainage pump vehicles at the same time. Thus, there is room for more effective use of pump vehicles. It is desirable for the Ayutthaya Irrigation Project Office to consider measures (such as promoting use in wider areas, reallocate some vehicles to other area where Japanese-affiliated companies benefit, etc.) for effective use of pump vehicles.

### 4.2.2 Recommendations to JICA

#### Monitoring of operation and maintenance activities

In the budget allocation of RID, whereas the budget for construction and studies increased the operation and maintenance budget decreased. On the other hand, the expenditure for the operation and maintenance of Ayutthaya Irrigation Project Office (on average of 2017 and 2018), which is responsible for operation and maintenance, was sufficiently allocated budget to meet the increase in the expenditure assumed before the project. Nevertheless, any further reduction in the budget for operation and maintenance costs will affect the operation and maintenance

activities for the facilities constructed by this project. Therefore, it is desirable to regularly monitor the operation and maintenance activities of Ayutthaya Irrigation Project Office, and, if the lack of budget does not allow sufficient activities, encourage the executing agency to allocate the budget.

### 4.3 Lessons Learned

#### Public Relations for Realization of Impact

In regards to the prevention of flood damage and reduction of damage, the main effect of a flood control project, it is difficult to be clearly recognized by beneficiaries other than the neighbors of the project site. However, wider recognition of the project effect is expected to indirectly affect corporate investment. The executing agency carried out public relation activities to the tenant companies in the surrounding industrial parks during the project implementation. However, the number of companies recognizing the project effect decreased at the time of the ex-post evaluation. Since the effect of flood control project is hard for beneficiaries to recognize, the effect on corporate investment due to increased disaster prevention provided by the floodgates presumably faded away after the project completion. For the sustainability of project effect, it is desirable for the executing agency to undertake ongoing public relations after project completion.