Thailand

FY2016 Ex-Post Evaluation of Technical Cooperation Project (SATREPS[1])

"Integrated Study Project on Hydro-Meteorological Prediction and Adaptation to Climate Change in Thailand (IMPAC-T)"

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0. Summary

This project aimed at establishing a system to provide broadly useful information based on the development of simulation models and technology for river flow predictions together with the proof of their usability as scientific evidence. Also, it aimed at use for plans of water control and utilization as well as the consideration of countermeasures against floods and droughts in the agriculture sector and disaster control against floods and landslides in the disaster management sector. The project was consistent with the development policies of Thailand for improvement of weather forecast capacity and the development of databases and models for the assessment of the impact of climate change on water resources. It was also consistent with Japan's ODA policy prioritizing support for environmental management. The project was consistent with the development needs of Thailand in policy planning for adaptation to climate change and for decision making based on appropriate information about water source management. Thus, its relevance is high. By the time of project completion, the project had developed hydrological and meteorological data observation systems and produced research outputs such as hydrological cycle models and water-related risk assessment methodologies. A "Climate Change Data Center", an integrated system for hydrological cycle information was also established in order to support preparation of adaptation measures to mitigate water-related risks. In addition, as a part of actions for "utilization of research outcomes", the implementing agencies of the project have continued research work using the research outputs and models developed by the project and analytical techniques were transferred by Japanese researchers for work including hydrological and meteorological data analysis. These research and analytical outputs have been utilized and reflected in the policy and program planning of the relevant government agencies responsible for considering and implementing water resource management, flood and drought control, and adaptation to climate change. In addition, the research outputs produced by the project and the research equipment provided by the project have been utilized by young researchers for writing their Ph.D. dissertations. Furthermore, there have been some spillover effects on the improvement of research capacity and the scientific literacy of government officers as well as on the promotion of actions for utilization of research outcomes towards policy planning by government agencies based on scientific evidence. For example, even after project completion, government officers on the Thai side who had participated in the project activities were writing Ph.D. dissertations on improvement of the models developed by the project in order to consider more appropriate water

[1] SATREPS stands for "Science and Technology Research Partnership for Sustainable Development".

use for more effective farming. All these indicate a high level of effectiveness and impact of the project. Efficiency of the project is high as the project cost was within the plan and the project period was as planned. The implementing agencies of this project, the Kasetsart University (KU), the Royal Irrigation Department (RID) and the Thai Meteorological Department (TMD) have sustained and strengthened their research system and their organizational arrangements for the utilization of the models and data analytical techniques. Researchers and officers engaged in these activities have also sustained their research capacity and skills in data analysis. Each of the implementing agencies has ensured a budget to cover the maintenance costs for the systems and the equipment installed by the project and for the personnel necessary for research work and related data analysis. Therefore, the sustainability of the project effects is high.

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

1. Project Description

Project Location

Data servers and displays showing results in the Climate Change Data Center (CCDC)

1.1 Background

In Thailand, there is concern that the impacts of climate change, such as unstable weather, droughts in the dry season and floods in the rainy season, will increase. In particular, these conditions will mean an increased necessity for appropriate water resource management as there are predicted increases in the frequency and size of water-related disasters. However, there has been insufficient long-term monitoring of climate change and systems for the hydrological and meteorological observation of hydrological cycles affected by climate change. The country has also lacked hydrological cycle and water resource models. Research to contribute to the planning of appropriate adaptation to climate change has therefore been necessary. With this background

the project supported the development of necessary technology for the prediction of river flow, the height of water in the Chao Phraya River basin and so on, together with verification of their usability in order to establish a system to provide useful information for broad purposes that copes with climate change including the planning of water control and flood and landslide warnings.

The project was approved as a project in the Science and Technology Research Partnership for Sustainable Development (SATREPS) program and was implemented in collaboration with the Japan Science and Technology Agency (JST) and the Japan International Cooperation Agency (JICA). The program aims at coping with global development issues (such as the environment, energy, disaster control, and the control of infectious diseases), through joint research with developing countries, and thus to improve the capacity of the recipient countries[2]. In the SATREPS program, JST established a committee of academics for the evaluation of academic importance and it was this committee that decided to implement the projects. Even after the adoption of the projects, JST and academics have continued to provide guidance for the projects under the SATREPS program.

1.2 Project Outline

At the time of the ex-ante evaluation, although there was no obligation for the SATREPS project to prepare a Project Design Matrix (PDM), a PDM was prepared for this project, was shared between both Thailand and Japan and was used for project management. This ex-post evaluation is based on the PDM which was revised after the mid-term review in May, 2012. The Overall Goal was set forth even though setting it had been optional. However, verifiable indicators for the Overall Goal were not specified. Also, it was confirmed that there had not been clear agreement on the Overall Goal among the stakeholders of the project during the project implementation. Therefore, in this ex-post evaluation, the achievement level the Overall Goal was verified on a trial base as a part of the impacts of the project in accordance with target values specified by the external evaluator.

[2] JST website(https://www.jst.go.jp/global/about.html)

Overall Goal		The developed system by the Project contributed for Thai authorities concerned to make decisions and develop adaptation measures against risks under climate change impact.
Project Purpose		A prototype of the Integrated System to help decision-making on the adaptation for water-related risks under climate change impact is established.
Output(s)	Output 1	Monitoring capacity in the field of hydro-meteorology of climate change impact is enhanced.
	Output 2	An integrated model is developed in consistence with natural hydrological cycle and anthropogenic activities are enhanced.
	Output 3	Methodology of water-related risk assessment incorporating climate change impact with anthropogenic activities are developed.
	Output 4	The methodologies and outputs are promoted in order to be applied or incorporated into coping strategy to the climate change impact in Thailand.
Total cost (Japanese Side)		439 million yen
Period of Cooperation		April 2009 – March 2014
Implementing Agency		Kasetsart University (KU), Thai Meteorological Department (TMD), Royal Irrigation Department (RID)
Other Relevant Agencies / Organizations		King Mongkut's University of Technology Thonburi (KMUTT), Naresuan Unviversity (NU), University of Phayao (UP), Chulalongkorn University (CU)
Supporting Agency/Organization(s) in Japan		University of Tokyo, Kyoto University, Tohoku University, Hokkaido University, Tokyo Institute of Technology, Fukushima University, Nagasaki University, National Institute for Environmental Studies
Related Projects		• JICA "*The Project on Comprehensive Flood Management Plan for the Chao Phraya River Basin*" (Technical Cooperation for Development Study and Master Planning (February 2011-June 2013)) • JICA "*Advancing Co-Design of Integrated Strategies with Adaptation to Climate Change in Thailand (ADAP-T)*" (SATREPS) (June 2016- June 2021)

1.3 Outline of the Terminal Evaluation

1.3.1 Achievement Status of Project Purpose at the Terminal Evaluation

At the time of the terminal evaluation, the Project Purpose had been achieved. Software development for the hydrological cycle integrated information system, an online system for the compilation of the comprehensive research outputs of the project had been completed by the time of the terminal evaluation. In January, 2014, the hydrological cycle integrated information system was completed as CCDC in KU and the data and research outputs were uploaded and made available to the public on the CCDC website.

1.3.2 Achievement Status of Overall Goal at the Terminal Evaluation

In the terminal evaluation, there was no clear mention of the prospects of achievement of the Overall Goal. However, the terminal evaluation assessed efforts for utilization of research outcomes based on the following: i) the current and future utilization of the integrated information system by the major government authorities participating in the project; and ii) the current cooperation and collaboration for the utilization of the research outputs. Regarding i), at the time of the terminal evaluation, it was mentioned that RID and TMD were going to use the system. As a noteworthy example, at the time of a flood occurring in 2011, it was also pointed out that the outputs of the project had provided knowledge for a revision of the Master Plan for the Chao Phraya River Basin Management and the establishment of the flood warning system by RID.

1.3.3 Recommendations from the Terminal Evaluation

In the terminal evaluation, recommendations for the project implementation period and the post project period were proposed.

(Recommendations to be implemented within the project implementation period)

1. Preparation of a framework to manage the integrated information system
2. Dissemination of project outputs/outcomes
3. Preparation of equipment lists by each of the implementation agencies
4. Identification of future research topics
5. Summary of feedback on the integrated information system
6. Management of the flux towers

(Recommendations on actions to be taken for the post project period)

1. For KU, RID and TMD: Finalizing the drafted policy in the framework to manage the integrated information system and sharing this with the members participating in the project by March 2015
2. For researchers on the Thai side: Making efforts to realize research identified in the project as “future research topics”
3. For KU: Compiling feedback from the users and improving the integrated information system based on this feedback

2. Outline of the Evaluation Study

2.1 External Evaluator

Hisami Nakamura, OPMAC Corporation

2.2 Duration of Evaluation Study

The ex-post evaluation study was conducted with the following schedule:

Duration of the Study: September 2016 – January 2018

Duration of the Field Study: December 11, 2016 – December 23, 2016, June 18, 2017 – June 24, 2017

3. Results of the Evaluation (Overall Rating: A[3])

3.1 Relevance (Rating: ③[4])

3.1.1 Consistency with the Development Plan of Thailand

At the time of ex-ante evaluation, the "*National Water Vision*" of the Office of the National Water Resources Committee, aimed at ensuring sufficient quality and volume of water for all users through efficient management and the organization and legal systems to enable equitable and sustainable water resource utilization for the improvement of life quality and participation of all stakeholders by 2025. Also, in the "*National Strategy on Climate Change Management*" (2008-2012), which was prepared based on the 4th Assessment Report (AR4) of the Inter-governmental Panel on Climate Change (IPCC), proposals were made for improvements in weather forecast capacity, development of databases and models for assessment of the impact of climate change on water resources, and for risk assessment of floods and droughts and identification of hazard areas.

At the time of the terminal evaluation of the project, in the "*Climate Change Master Plan*" (2013-2050)[5], which was under preparation by the Office of Natural Resources and Environmental Policy and Planning (ONEP) of the Ministry of Natural Resources and Environment (MONRE), water resource management was prioritized as the most important measure for adaptation to climate change. In addition, the "*National Economic and Social Development Plan*" (2014-2016), which was under implementation at the time of project completion, focused on actions to cope with climate change.

As mentioned above, in Thailand, the importance of water resource management was highlighted in the national development plan and the national strategy for climate change management from the time of the ex-ante evaluation to the time of project completion. Therefore, this project, which aimed at the establishment of a hydrological cycle integrated information system equipped with necessary data and models for assessment of the impact of climate change, was consistent with the development policies of the government of Thailand.

[3] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

[4] ③: High, ②: Fair, ①: Low

[5] It has been under process of the cabinet approval as of June, 2017 at the time of ex-post evaluation.

3.1.2 Consistency with the Development Needs of Thailand

In Thailand, there is a great need for adequate water resource management information due to issues including increasing flood damage, ground subsidence caused by overuse of groundwater, long term downward trends in annual discharges and droughts in the Chao Phraya River, necessity for the adequate operation of large scale reservoirs (including dams) in the years when floods occur, and issues of dam developments in the affluent of the Mekong River.

On the other hand, at the time of ex-ante evaluation, although the relevant government authorities, including MONRE, TMD and RID, had been making efforts towards hydro-meteorological observation and weather forecasts, including flood warnings, they did not have a sufficient level of capacity in water-related disaster management and water resource management to cope with climate change. In "*the National Strategy on Climate Change Management*" (2008-2012), the government of Thailand recognized that there was insufficient information and knowledge about climate change for policy decisions.

In December, 2010, at the 16th Conference of Parties (COP 16) of the United Nations Framework Convention on Climate Change (UNFCCC) ("*the Cancun Agreements*") held in Cancun, Mexico, the implementation of research aiming at data collection, storage, analysis and modeling of climate data and more systematized observations, together with the provision of more precise climate-related data for policy decision makers at national and regional level were recommended. While the international framework on climate change requires to provide more precise climate-related data, the government of Thailand had a great need for information and knowledge necessary for policy decisions. Therefore, the project, which aimed at establishment of a hydrological cycle integrated information system that would enable to provide this necessary data, was consistent with the development needs of Thailand.

3.1.3 Consistency with Japan's ODA Policy

"Support for environment management systems" was highlighted as one of the components of "countermeasures to issues associated with the maturation of society" which was one of the four priority areas in the *Economic Cooperation Plan for Thailand*, revised by the Ministry of Foreign Affairs (MOFA) of Japan in May, 2006. The plan focused on cooperation for improvement of the urban environment and environment and disaster management as, because it was a newly industrializing economy, Thailand needed efforts for more proactive environment management. In addition, in the MOFA *"Country Operation Plan for Thailand"*, enhancement of disaster management and disaster response capacity was a priority area, as proactive efforts by Thailand on regional and global issues through the enhancement of its capacity for response to global issues would benefit and be important for the sustainable growth and stabilization of Southeast Asia. Under those policies, JICA implemented a broad

range of support for capacity development in the areas of water resource and disaster management, including adaptation and mitigation measures against climate change. In light of above, the project objective to establish the hydrological cycle integrated information system for adaptation to climate change was consistent with the Japan's ODA policy for Thailand.

The project was sufficiently consistent with the development policies and the development needs of Thailand as well as with Japan's ODA policy. Therefore, the relevance of this project is high.

3.2 Effectiveness and Impact[6] (Rating:③)

3.2.1 Effectiveness

3.2.1.1 Project Output

At the time of project completion, the level of achievement of the outputs of the project was as follows.

Output 1: Monitoring capacity in the field of hydro-meteorology for climate change impact is enhanced.

(Indicators)
1-1. The role of Thai research group (TRG) in the promotion of the continuous monitoring for climate change impact are defined.
1-2. Tutorials/academic papers for the continuous monitoring system are prepared/submitted.
1-3. More than 20 TRG members are trained and obtain necessary knowledge and skills in developing, implementing, and managing the continuous monitoring of climate change impact.
1-4. The quasi-real-time hydro-meteorological data transfer systems are installed at observation stations by Thai Meteorological Department and Royal Irrigation Department in Chao Phraya River Basin.

Output 1 was achieved since all the indicators were achieved.

Nineteen research groups to promote research under the project were formulated and the definition of each group was completed by May 2011. Manuals for flux observation and telemetry observation were developed by the observation team in February 2011. By the time of the terminal evaluation, 25 academic papers had been published in academic journals.

Technology for the estimation of rain volume was transferred to 56 participants in total

[6] Sub-rating for Effectiveness is to be put with consideration of Impact.

through training in Thailand, training in Japan, workshops and site visits. As for flux observation, methodologies for the collection of observation data and analytical skills required for the assessment of the impacts of climate change and changes in land use on the hydrological cycle were transferred to members of the group 8 (5 members) by using the flux observation system constructed by the project.

The quasi-real-time hydro-meteorological data transmission system (telemetry system) was installed in 32 sites in total, including 24 sites at RID observation stations, 4 sites at TMD observation stations and 4 sites for the flux observation towers managed by the three project participant organizations.

Output 2: An integrated model in consisting with natural hydrological cycle and anthropogenic activities is developed.

(Indicators)
2-1. The hydrological models for Chao Phraya River Basin are established.
2-2. The models of anthropogenic activities are established and incorporated in hydrological models.
2-3. Tutorial/academic papers for the integrated modeling system are prepared/submitted.
2-4. Precision of discharge estimation (annual discharge, peak discharge on monthly basis) by the integrated model is no more than ±20% difference than measured volume.

Output 2 was achieved since all the indicators were achieved.

The 5 resolution hydrological cycle model targeting the Chao Phraya River Basin (H08)[7] was developed by group 11 and the revised model for the Chao Phraya River Basin based on the land surface process model developed by the Kyoto University (Simple Biosphere including Urban Canopy: SiBUC)[8] was developed by group 13.

Furthermore, the model adding anthropogenic activities (operation of the two dams on the Chao Phraya River, the Bhumibol Dam and Sirikit Dam) to the H08 hydrological cycle model was developed and the "H08 Manual User's Edition" was compiled as a practical guide to the integrated hydrological cycle and water resource model and this was made available to the public via the website. Six academic papers were submitted to academic journals by the model groups.

[7] The model was modified based on the open source global water resource model "H08" which was developed by the National Institute of Environmental Studies, Japan.

[8] SiBUC is a model developed for improving the accuracy of the land surface process model by adding the effects of urban and water bodies to the biosphere model (Sib). In meteorology, the urban canopy means the sphere covered by buildings.

As a result of simulation to reproduce past discharges in the Chao Phraya River Basin for the period from 1981 to 2004 using the H08 model, the difference between the actual value and the simulated value was around ±20%. In average simulation results using the SiBUC model, the differences in annual discharges and monthly peak discharge were 17.5% and 20.8%, respectively. Therefore, the differences between the actual values and the simulated values found by using the models were almost within the target value of ±20%.

Output 3: Methodology of water-related risk assessment incorporating climate change impact with anthropogenic activities are developed.

(Indicators)
3-1. Hydro-meteorological data and simulation outputs are integrated to incorporate in impact assessment.
3-2. Disaster potential in present and future are estimated and risk indices are identified.
3-3. Tutorials/academic papers for risk and impact assessment are prepared/submitted.
3-4. The quasi-real-time risk indices are developed as for an adaptation measures to water-related disasters under climate change, and utilized for early warning system.

Output 3 was achieved since all the indicators were achieved.

Various types of impact assessments were conducted using the hydro-meteorological data and simulation results prepared through the activities of Outputs 1 and 2.

In terms of landslide risk assessment, group 16 checked the disaster risks in the northern mountainous area, the central western mountainous area and the western and central Malay Peninsula area and developed landslide disaster hazard maps. The hazard maps were distributed in areas that could be seriously damaged (the provinces of Chiang Mai, Uttaradit and Phetchabun). As for the risk assessment of coastal erosion, areas with potential coastal erosion and areas with serious damages by coastal erosion were confirmed throughout the whole of Thailand by group 20. The results were presented in a project workshop held in Sendai in November, 2013. In terms of the risk assessment of floods through tropical heavy rain and droughts, group 3 selected risk indices for use in impact assessment and identified flood and drought risks in all 22 provinces of Thailand.

Fourteen academic papers on the risk assessments mentioned above were submitted to academic journals.

The project developed quasi-real-time risk indices and these indices were utilized for disaster warning. In particular, the results of running water analysis by the project were

utilized for the flood early warning system developed by the Foundation of River and Water Basin Integrated Communications of Japan (FRICS) at RID as a part of *the Project on Comprehensive Flood Management Plan for the Chao Phraya River Basin*. In addition, the hydro-meteorological status of the Chao Phraya River Basin was published on the website in quasi-real time. Furthermore, landslide disaster emergency transmission systems were established in areas with a high frequency of landslides in Krabi Province by group 16.

Output 4: The methodologies and outputs are promoted in order to be applied or incorporated into coping strategy to the climate change impact in Thailand.

(Indicators)
4-1. Recognition of IMPAC-T among water related policy makers is enhanced.
4-2. Cooperation arrangement will be signed.

Output 4 was mostly achieved since indicator 1 was achieved and indicator 2 was partially achieved. It was confirmed that recognition of IMPAC-T among policy makers in the water sector of Thailand had been enhanced. Contributions to improvement of recognition were made by: an interim report of the flood survey under implementation by the project, presented by a Japanese expert of the project who had participated in an emergency damage site survey dispatched by the government of Japan through JICA in November, 2011; IMPAC-T workshops held by the project; presentation on the subtopic of "issues of water-related disasters" to the technical sessions of the 2nd Asia Pacific Water Summit (APWS). In particular, discussions about the possible contribution of scientific technology to flood control, made in the presence of the Prime Minister of Thailand, enhanced the understanding of the contribution of IMPAC-T on the part of government authorities. Participation of the top management of RID and TMD in the IMPAC-T activities also brought about an improvement in the recognition of IMPAC-T. Furthermore, other contributions of the project to the consideration of flood control after the flood of 2011, such as recommendations made by the Japanese expert of this project concerning the operation of dams and reservoirs for flood prevention for flood control plan under preparation by the government of Thailand lead to further enhancement of recognition.

Meanwhile, according to the terminal evaluation report, it was envisaged that agreements and signing on the arrangements for cooperation on the dissemination or application of the research outputs of the project would provide frameworks enabling the individuals participating in the project activities to continue to participate in the research activities in the future. Thus, it can be considered that indicator 2 was aiming at cooperation arrangements composed of a larger number of the project participating agencies. There are some cases of cooperation arrangements between the research institutions participating in the project for

some specific objectives. However, these have been limited to memoranda or partial agreements, such as a memorandum between KU and PU for joint research on flux observation and cooperation for the construction of flux towers and an agreement on data sharing between KU and RID.

3.2.1.2 Achievement of Project Purpose

The Project Purpose of "the development of a prototype Integrated System to help decision-making on the adaptation to water-related risks under the impact of climate change" refers to the online "Integrated Information System" which comprehensively compiles the research outputs of the project. This enables the storage and processing of hydro-meteorological data transmitted from the observation stations of RID and TMD as well as from the flux observation towers installed by the project, also downloading of the models developed by the project, the running of simulations using data collected by the project and the models, and the uploading of the outputs by the research groups. The planned outputs of: i) improvement of hydro-meteorological observation capacity by the establishment of systems for assessment and the observation of climate change impact, ii) the development of the hydrological cycle and water resource model, iii) the development of water-related risk assessment, iv) recognition of the methodologies and models developed by the project on the part of the stakeholders and agreements on cooperation

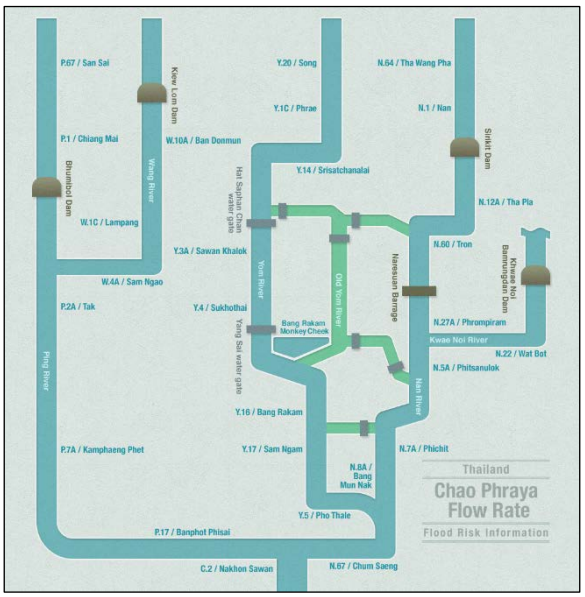

Figure 1: Flow Rate of Chao Phraya River updated on the CCDC website

arrangements made, were mostly achieved as planned. The software for the online hydrological cycle integrated information system, the aim of the project, was developed to compile the project outputs comprehensively. The Integrated Information System was completed as CCDC in KU and information and research outputs useful in mitigating water-related risks were made available on the website

Table 1: Achievement of Project Purpose

Project Purpose	Indicator	Actual
A prototype of the integrated system to help decision-making on the adaptation for water-related risks under climate change impact is established.	(Indicator) Recommendations and integrated information from the system are published on the web pages.	Achieved. Development of the software for the online hydrological cycle integrated information system comprehensively compiling the research outputs by the project had been completed by the time of the terminal evaluation. The hydrological cycle integrated information system was completely established as CDCC in KU in January 2014. The data and research outputs were publicly opened on the CDCC website.

In the light of above, the Project Purpose was achieved.

3.2.2 Impact

3.2.2.1 Achievement of Overall Goal

As mentioned above, although PDM was prepared for the project and the Overall Goal was set, the verifiable indicator for the Overall Goal was not set. Therefore, in this ex-post evaluation, the Overall Goal of this project was considered as “actions for the utilization of research outcomes by using the research outputs of the project are expected to be taken”. This ex-post evaluation attempted to verify the achievement of the Overall Goal as “an expected positive impact”. For reference, the achievement level of the Overall Goal was experimentally assessed by the status of “efforts for utilization of research outcomes”, which are considered to be the utilization and application of the system and the research outputs developed by the project and the incorporation of those outputs as scientific evidence into policies and programs by the relevant agencies, including the implementing agencies of the project.

The flood of the Chao Phraya River in 2011 became a trigger, making the stakeholders understand the importance of efforts for utilization of research outcomes and to start concrete actions for utilization of research outcomes. Since the activities to analyze hydro-meteorological data and to develop a hydrological cycle model for the forecastability/ predictability of floods in the Chao Phraya River have been under implementation by the project, suggesting that timely prediction of floods through the project activities was difficult in 2011 In addition, the counterparts from TMD and RID were kept extremely busy with emergency flood countermeasures which caused a stagnation of project activities. However, this was taken as an opportunity and, because the importance to improve the analytical capacity of hydro-meteorological data was recognized by government authorities of Thailand, the research outputs of the project, including the H08 model, the analysis results of hydro-meteorological data and various kinds of simulation results, were utilized for policy and program planning by the government authorities.

The specific actions for utilization of research outcomes by the implementing agency after project completion, as confirmed at the time of ex-post evaluation, are as follows:

(1) KU

KU has published and updated Geographic Information System (GIS) maps on their website, using the skills and methodologies for analyzing and using satellite image data obtained through the project. These maps are utilized by government authorities. In addition, KU has participated in the on-going SATREPS project of ADAP-T as one of the implementing agencies and researchers who had participated in the project activities of IMPAC-T as counterparts also have been engaged in the activities of ADAP-T. In the project activities of ADAP-T, activities for "Co-Design" have been implemented to reflect the simulation results of models such as H08 and the research outputs have been incorporated into policy planning for soil management, disaster management and groundwater development through co-work with the Land Development Department (LDD), the Department of Disaster Prevention and Mitigation (DDPM) and the Department of Groundwater Resources (DGR). Since the concept of "Co-design" by ADAP-T is an action for utilization of research outcomes, the utilization of the research outputs and utilization of research outcomes have been promoted through co-works between research institutions including KU and government authorities.

(2) RID

At the time of the ex-post evaluation, RID was continuing analysis of data collected by the telemetry system[9] installed by the project and was conducting flood risk management using the H08 model (the hydrological cycle model for the Chao Phraya River Basin). Also, an RID officer, who had participated in IMPAC-T as counterpart, continued research into a model to forecast water use for farmers based on the H08 model (utilization for cropping).

(3) TMD

TMD published weather forecasts utilizing the results of the H08 model and data analysis technology transferred by the project on the TMD website and provided the information to the relevant government authorities. In addition, TMD is providing ONEP with information for the Climate Change Adaption Plan (CCAP) which is under preparation.

[9] A system to observe subjects at remote points and to collect data. Instruments measuring data such as sensors and measures as well as transmitters which convert data to electric pulses and transmit them are installed at observation points. Receivers to receive the data and systems to store and analyze it are installed at the receiving point.

It has been confirmed that government authorities other than the implementing agencies of IMPAC-T have utilized the research outputs of the project. The Department of Water Resources has been implementing drought control using the drought forecast and the support model based on the simulation results of the H08 model as well as satellite images. Also, through the activities of ADAP-T mentioned above, the results of analysis, forecast and simulation of scientific data such as rainfall by the models, including H08 developed by IMPAC-T, have been integrated in the socio-economic data of each area and this integrated data is used in adaption measures in each area. For example, flood/drought vulnerability maps using the integrated data are used for the consideration of measures to improve farming.

As mentioned above, where the verifiable indicator for the Overall Goal is assumed to be "the hydrological cycle integrated information system and the models for analysis and simulation of hydro-meteorological data are utilized as a tool for the consideration of long-term policy based on scientific evidence", the Overall Goal can be considered to have been "achieved" as the research outputs and analytical results using the models developed by the project have been referred to in the policy and programs of several government authorities.

Table 2: Achievement of the Overall Goal

Overall Goal	Indicator	Actual
The developed system by the Project contributes for Thai authorities concerned to make decisions and develop adaptation measures against risks under climate change impact.	No indicator was set in the PDM. This ex-post evaluation assessed the achievement level of the Overall Goal with the following expected impact: • The hydrological cycle integrated information system and the models for analysis and simulation of hydro-meteorological data are utilized as a tool for the consideration of long-term policy based on scientific evidence	• KU: Collection and analysis of hydro-meteorological data has continued in CCDC installed by the project in KU and data has been provided on the website developed by IMPAC-T. • RID: The H08 model has been utilized for flood control. • TMD: The H08 model has been utilized for hydro-meteorological data analysis.

3.2.2.2 Utilization of the Research Outputs related to the Project

This ex-post evaluation verified the utilization of the research outputs related to IMPAC-T as expected positive impacts besides actions for utilization of research outcomes. The utilization of the research outputs related to the project which were observed by the ex-post evaluation is as follows:

(1) Continuation of research on the hydrological cycle and water-related risk, newly started research based on the research outputs of the project, and improvement of research capacity

In KU, many of the researchers who had participated in IMPAC-T have been participating

in ADAP-T, a successor project of IMPAC-T, continuing their research based on the outputs of IMPAC-T (the data and the models) and conducting analysis and simulation for utilization of research outcomes. For example, in the activities of ADAP-T, analysis combining data such as economic and social activities, demographic distribution and so on has been conducted for the development of hazard maps using the H08 model to cope with water-related risks such as floods and droughts in the Upper Chao Phraya River Basin as a part of measures for adaptation to climate change impact. Also, in RID, which is an administrative institution responsible for the management of irrigation water, the counterpart of IMPAC-T, in his Ph.D. dissertation, has modified the H08 model for combining socioeconomic data in areas with irrigation and implemented simulation to improve farming through the recommendation of optimum cropping based on the forecast of water availability. In addition, two lecturers of CU who had participated in the activities of IMPAC-T have continued their research on the application of results from analyzing data of groundwater, discharges of surface water and water resources to irrigation water management by using SiBUC.

(2) Spillover effects from the system and the research outputs established by the project

From the point of view of the development of younger researchers, environment-related research using data collected using the flux observation towers installed by the project has continued in Ratchaburi (KU), Tak (NU) and Payao (PU). In Ratchaburi, a graduate student of KMUTT has been preparing his Ph.D. dissertation using the observation data and a researcher who participated in IMPAC-T has been supervising him. In Nakhon Sawan (KMUTT), the flux observation tower installed by the project was destroyed by fire. It was located in a sugarcane field which was burned off for farming. However, KMUTT reinstalled the flux observation tower using their own budget and thus monitoring activities have continued.

In addition, ex-counterparts who participated in the activities of IMPAC-T have been preparing their Ph.D. dissertations under the supervision of the Japanese researchers engaged in IMPAC-T. As mentioned above, the ex-counterpart from RID has attended Ph.D. courses at the University of Tokyo. The topics of his dissertation is the improvement of farming using the modified H08 model.

Photo 1: Flux observation tower installed in Ratchaburi

3.2.2.3 Other Positive and Negative Impacts

(1) Impact on the Natural Environment

No positive or negative impact on natural environment by the project was confirmed.

(2) Resettlement and Land Acquisition

No resettlement and land acquisition occurred through the project.

(3) Establishment of an Early Warning System in Krabi Province

As a part of activities of the Output 3 aiming at the development of methodologies for water-related risk assessment considering anthropogenic activities and climate change impact, an early warning system to notify local people of the risk of landslides was established in Krabi Province where there is a higher frequency of landslides. This activity was implemented as a pilot activity to establish a system which was responsive to the needs of local people. The system was composed of a rain gauge installed in a slope in the mountain where there was a higher risk of landslides together with equipment to transmit the data of rain water volume using short radio signals as a warning to a village located at the base of the mountain. Although the system had been maintained by the villagers, it was not functioning due to the battery of the sensor being out at the time of the ex-post evaluation.

The effectiveness and impact of this project are high since the expected effects were realized through the implementation of the project as planned. All the planned outputs, including development of the hydrological cycle model and analysis of hydro-meteorological data, were produced as planned and the hydrological cycle integrated information system to publish and provide the results of analysis and the research outputs was completed as planned. As a result, the Project Purpose had been achieved by the time of project completion. In addition, as a way to utilization of research outcomes, the research and analysis activities using the research outputs of the project, the models developed by the project and the analytical technologies and skills transferred through the project have been continued by the implementing agencies of the project. The results of those activities have been utilized as scientific evidence and are reflected in the policy and program planning of the government authorities which are responsible for the consideration and implementation of water resource management, flood and drought control, and adaptation to the impact of climate change. In addition, there were spillover effects contributing to the development of younger researchers through the preparation of Ph.D. dissertations using the research outputs of the project and equipment installed by the project.

3.3 Efficiency (Rating:③)

3.3.1 Inputs

Table 3: Inputs for the Project

Inputs	Plan	Actual
(1) Experts	1 Long-Term (Project Coordinator) 11 Short-Term (Chief Advisor, Research Planning, Hydro-Meteorological Observation, Hydrological and Anthropogenic Activities Modeling, Impact and Risk Assessment)	1 Long-Term (Project Coordinator), 16 Short-Term (Chief Advisor, Training Planning, Global Observation considering Climate Change Impact, Establishment of Hydrological Cycle and Water Use Model considering Anthropogenic Activities, and Impact and Risk Assessment including Climate Change Impact and Anthropogenic Activities)
(2) Trainees received	50 persons (Counterpart trainings in Japan)	64 persons (Training in Japan at the University of Tokyo, Kyoto University, Tohoku University and so on)
(3) Equipment	Hydro-meteorological data integrated system: servers, mass storage devises, etc.), quasi hydro-meteorological observation system (communication system and meteorological and hydrological observation instruments), concentration observation (supersonic velocity thermometer, radio balance measure, water quality sensor and wind profiler)	Weather observation sensors (rain gauges, automatic weather stations, soil moisture meters, etc.) Flux observation systems for 4 sites, Flux observation tower constructed in PU, GPRS modems for telemetry, Spectro radiometers, construction cost for the installation of sensors, equipment for the hydrological cycle integrated information system (servers, projection systems for the KU server, data servers, etc.)
(4) Local Cost Expenditure	No information	35 million yen (Cost for procuring consumables for research equipment provided, including the flux observation systems, payrolls for research assistants, travel expenses in Thailand, etc.)
Japanese Side Total Project Cost	Total 450 million yen	Total 439 million yen
Thai Side Total Project Cost	No information	KU: Cost for purchasing servers and GPS, operation and maintenance cost for the servers (1 million Bahts per annum), construction cost for the server room (1 million Bahts) communication and electricity cost (0.45 million Bahts per annum), cost for the storage and transport of equipment provided by the project, cost for posting academic papers, cost for purchasing materials and equipment used by group 16 (0.02 million Bahts) RID: Communication cost and maintenance cost for servers, Cost for transport, installation and works of the telemetry equipment TMD: Communication cost and maintenance cost for servers

Source: Ex-ante evaluation sheet, Terminal evaluation report

3.3.1.1 Elements of Inputs

(1) Japanese Side

For the dispatch of experts, while one long-term expert was dispatched as planned, the number of short-term experts dispatched increased to 16 from the original plan of 11 but there was no change in the areas of expertise. As for the trainees received, the number of trainees increased to 64 from the original plan of 50 but no details, including the specific numbers of trainees for which training courses were held, was mentioned in the plan. The training by JICA and the training and workshops held by the University of Tokyo, the Kyoto University, the Tohoku University, the Hokkaido University and the National Institute of Environmental Studies aimed at necessary technical transfer for activities to produce the outputs of the project. These resulted in the definite achievement of the outputs. As for the provision of equipment, observation equipment including rain gauges, flux observation systems, and telemetry systems which were necessary for the production of the planned outputs were installed. At the same time, the equipment for the project purpose of the establishment of the Integrated Information System, including data servers, was installed.

(2) Thai Side

On the Thai side, 51 persons in total, including the officers and researchers of the implementing agencies of KU, RID and TMD as well as researchers of KMUTT, NU, UP and CU, participated in the project activities as counterparts of this project. The project office was set in KU and KU provided the necessary office appliances. Besides this, each implementing agency provided the necessary data for the activities and the production of the planned outputs. In addition, each implementing agency bore the cost of purchasing necessary equipment, the costs for installation and utilization of the equipment installed by the project (including maintenance cost).

3.3.1.2 Project Cost

The actual project cost was 439 million JPY against the planned project cost of 450 million JPY which was within the plan (ratio against the plan: 98%). Although the actual numbers of experts dispatched and trainees received exceeded the plan, comparison between the actual and the plan was not possible due to a lack of data for the time of planning. However, the increases in both numbers were due to necessary additional inputs to cover the research areas for the production of the planned outputs and the project cost was within the plan. Therefore, it can be judged that these additional inputs contributed to the efficient production of the research outputs.

3.3.1.3 Project Period

The project was implemented for the period from May, 2009 to March, 2014. The project period was 4 years and 11 months as planned (ratio against the plan: 100%).

The project cost was within the plan and the project period was as planned. Therefore, the efficiency of the project is high.

3.4 Sustainability (Rating: ③)

3.4.1 Related Policy and Institutional Aspects for the Sustainability of Project Effects

In *the National Climate Change Master Plan* (2015-2050), "development of useful knowledge, databases and technology for adaptation to climate change impact and low carbon development" is included as one of the 4 missions. Also, "water resources" is included in the 6 adaption strategies in the Master Plan. Based on the Master Plan, research activities such as the provision of hydrological cycle data and hydro-meteorological data by the Integrated Information System and analysis by the models have been promoted. Since this, CCAP has been prepared by ONEP through consideration of the results of analysis of the hydro-meteorological data. Thus, the implementing agencies of the project have been required to provide results of analysis and simulation using the models developed by the project.

By the above mentioned polices of the government of Thailand for adaptation to climate change impact, the sustainability of the project effects has been ensured from the policy and institutional aspect.

3.4.2 Organizational Aspects for the Sustainability of Project Effects

Considering the effects of the project, this ex-post evaluation assessed the organizational arrangements necessary to sustain the project effects from the following three aspects: i) operation and maintenance of the Integrated Information System established by the project, ii) research activities related to the research outputs of the project, and iii) cooperation and collaboration between the government authorities and researchers for the utilization of the research outputs of the project.

(1) Organizational arrangements for Operation and Maintenance of the Integrated Information System established by the project

The Integrated Information System (the servers) for storage and analysis of the data transmitted from each observation station was installed and sustained at CDCC in KU. In addition, data has been updated on the CDCC website since project completion. Thus, the organizational arrangements for the collection and analysis of hydro-meteorological data has been maintained.

(2) Organizational arrangements for research activities related to the research outputs of the project

Since the many of the ex-counterparts of IMPAC-T, including the researchers of KU and the officers of RID and TMD, have been engaged in the activities of ADAP-T as counterparts, the activities for research and the analysis of hydro-meteorological data and the hydrological cycle have been continued. Furthermore, the organizational arrangements to promote actions for utilization of research outcomes have been under preparation. While KU and RID concluded an agreement for cooperation on hydro-meteorological research, TMD concluded a memorandum of understanding (MOU) on research cooperation with NU.

Photo 2: RID officers engaged in the activities of ADAP-T

(3) Cooperation and collaboration between government authorities and researchers

As mentioned above, the research outputs of the project not only contributed to collaboration among KU, TMD and RID, who had participated in IMPAC-T, but they also promoted the reflection of scientific evidence based on the research outputs and analytical results using the models developed by the project in policies and programs of other related government authorities, such as ONEP, including water resource use, disaster management and flood and drought control. Also, through ADAP-T, the organizational arrangements for utilization of research outcomes have been established and enhanced at the local level.

3.4.3 Technical Aspects for the Sustainability of Project Effects

In this ex-post evaluation, the technical capacity necessary to sustain the project effects was assessed from the following aspects: i) the necessary skills and knowledge to utilize the research outputs of the project, ii) research capacity related to the research outputs of the project, and iii) scientific literacy necessary to reflect the research outputs of the project in policies.

(1) Necessary skills and knowledge to utilize the research outputs of the project

The ex-counterparts of KU, TMD and RID who had participated in IMPAC-T have sustained the skills and knowledge necessary to use the Integrated Information System and the models developed by the project such as H08 and SiBUC. KU has maintained CCDC and provided the results of analysis and simulation of the data stored in the Integrated Information System for the government authorities. RID has continued monitoring based on the telemetry

system installed by the project and has taken measures for flood and drought control in irrigation water management. TMD has applied H08 and the technology for the utilization of satellite images transferred by the project to weather forecasting, thus improving the accuracy of their routine works.

(2) Research capacity related to the research outputs of the project

The research capacity of the implementing agencies and other agencies related to the research outputs of the project has been sustained and improved. As mentioned above, the researchers of KU, KMUTT, NU and PU who had participated in IMPAC-T have been continuing their research activities using the equipment provided by the project. Also, they have been engaged in the development of younger researchers through the supervision of graduate students who have been conducting their research and preparing their Ph.D. dissertations using the equipment provided by the project. In addition, after the project completion, the counterparts of RID who had participated in IMPAC-T have also been improving their individual research capacity through the preparation of Ph.D. dissertations based on the research outputs of the project.

(3) Scientific literacy necessary to reflect the research outputs of the project in policies

As mentioned above, the scientific literacy of government authorities in Thailand has improved. Not only TMD and RID, but also other government authorities concerned with adaptation to climate change impact, including ONEP, have been promoting the utilization of the results of data analysis and simulation by using the research outputs and the models developed by the project as scientific evidence for the consideration of policies and programs on water resource development, disaster management, and flood and drought control for the agriculture sector. Furthermore, the scientific literacy of local governments has been enhanced through ADAP-T.

3.4.4 Financial Aspects for the Sustainability of Project Effects

The financial sources for the sustainment of the project effects were assessed from the aspects of: i) maintenance of the equipment and facilities installed by the project and ii) activities related to the research outputs of the project.

(1) Maintenance of the equipment and facilities installed by the project

For the maintenance of CCDC (in particular, data servers) equipped by the project, the necessary payroll and maintenance costs (around 0.1 million Bahts per month to cover the electricity cost for cooling the data server room) have been covered by KU where the systems were installed. The telemetry system, servers and PCs provided for RID were registered as

assets of RID and their maintenance costs were budgeted and ensured by RID. The annual budget for one observation station with a telemetry system is 0.012 million Bahts and the total annual budget for the 20 observation stations with telemetry systems installed by the project amounts 0.24 million Bahts. As for the telemetry systems provided for TMD (4 sites), TMD has been utilizing them since project completion, but has not registered them as assets and has not ensured a budget for their maintenance. Although TMD recognized the necessity of registering the equipment provided by the project in the asset list of TMD in order to ensure the maintenance budget, the sufficient instruction for the registration of the equipment was not handed over to the newly assigned manager at the time of personnel rotation and the procedures for registration was not taken. However, it was confirmed that the procedures for registration of the equipment had been started at the time of the ex-post evaluation. On the other hand, the equipment, including PCs, has not already been used due it having exceeded its expected lifetime and no maintenance cost was necessary. Among the four flux observation towers, all except one have been maintained and utilized and KU, KMUTT and UP to which the flux towers were transferred have ensured the maintenance budgets. KMUTT reinstalled the flux tower which was destroyed by fire using their own budget and has been continuing observation activities.

(2) Activities related to the research outputs of the project

All the implementing agencies of KU, RID and TMD which participated in IMPAC-T have been utilizing and applying the research outputs of the project to their works and most of the ex-counterparts who participated in IMPAC-T have also been continuing activities related to the project. Each of the implementing agencies has ensured a budget to cover the necessary costs for the activities related to the project, including payroll. Further research activities have been supported by the project budget of ADAP-T, which has been under implementation with the cooperation of JICA, for utilization of research outcomes, including the utilization of the research outputs of IMPAC-T.

For the improvement of research capacity at an individual level, a part of the budget for researches on the Ph.D. courses by the counterparts of RID participating in the project has been supported by the Agricultural Research Development Agency (ARDA), a Thai research institute.

In the light of above, no problem was observed in any aspects of policy or in the institutional, organizational, technical and financial aspects. Therefore, the sustainability of the project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project aimed at establishing a system to provide broadly useful information based on the development of simulation models and technology for river flow predictions together with the proof of their usability as scientific evidence. It aimed at use for plans of water control and utilization as well as the consideration of countermeasures against floods and droughts in the agriculture sector and disaster control against floods and landslides in the disaster management sector. The project was consistent with the development policies of Thailand for improvement of weather forecast capacity and the development of databases and models for the assessment of the impact of climate change on water resources. It was also consistent with Japan's ODA policy prioritizing support for environmental management. Also, the project was consistent with the development needs of Thailand in policy planning for adaptation to climate change and for decision making based on appropriate information about water source management. Thus, its relevance is high. By the time of project completion, the project had developed hydrological and meteorological data observation systems and produced research outputs such as hydrological cycle models and water-related risk assessment methodologies. A "Climate Change Data Center", an integrated system for hydrological cycle information was also established in order to support preparation of adaptation measures to mitigate water-related risks. In addition, as a part of actions for "utilization of research outcomes", the implementing agencies of the project have continued research work using the research outputs and models developed by the project and analytical techniques were transferred by Japanese researchers for work including hydrological and meteorological data analysis. These research and analytical outputs have been utilized and reflected in the policy and program planning of the relevant government agencies responsible for considering and implementing water resource management, flood and drought control, and adaptation to climate change. In addition, the research outputs produced by the project and the research equipment provided by the project have been utilized by young researchers for writing their Ph.D. dissertations Furthermore, there have been some spillover effects on the improvement of research capacity and the scientific and technological literacy of government officers as well as on the promotion of actions for utilization of research outcomes policy planning by government agencies based on scientific evidence. For example, even after project completion, government officers on the Thai side who had participated in the project activities were writing Ph.D. dissertations on improvement of the models developed by the project in order to consider more appropriate water use for more effective farming. All this indicates a high level of effectiveness and impact of the project. Efficiency of the project is high as the project cost was within the plan and the project period was as planned. The implementing agencies of this project, KU, RID and TMD have sustained and strengthened their research system and their organizational arrangements for the utilization of the models and data analytical techniques. Researchers and

officers engaged in these activities have also sustained their research capacity and skills in data analysis. Each of the implementing agencies has ensured a budget to cover the maintenance costs for the systems and the equipment installed by the project and for the personnel necessary for research work and related data analysis. Therefore, the sustainability of the project effects is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Implementing Agency

None.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

Involvement of the related institutions for actions to be taken for utilization of research outcomes

The project involved not only a university as a research institution (KU) but also government authorities using the research outputs including the analysis and results of simulation of hydro-meteorological data and the hydrological cycle models developed by the project in their routine work (TMD and RID) as implementing agencies. As a result, this implementation arrangement enabled consideration of how to utilize the research outputs during the project implementation period. Furthermore, it contributed to the institutional arrangements for reflecting the data as scientific evidence in policies and programs through the provision of the data to the government authorities responsible for adaptation to climate change impact (ONEP) as well as to other relevant government authorities in areas related to the hydrological cycle including water resource development, disaster management, and flood and drought control (in the agriculture sector). In addition, ADAP-T, which has been successively implemented after IMPAC-T, incorporates project activities aiming at utilization of research outcomes (consideration and planning of policies and programs using the research outputs in cooperation with local governments) in its project design, which reflects the project effects of IMPAC-T. For the project design of SATREPS, it is desirable that the implementation arrangement should be clarified based on the research contents to be implemented by the project for the project period, as well as institutional arrangements for the utilization of the expected research outputs of the SATREPS project for the post project period, in order that consideration may be made of the actions to be taken for utilization of research outcomes. At the same time, from the project planning stage, JICA needs to facilitate the stakeholders of the project including Japanese researchers, research institutions and the relevant organizations of the target country, to help in their understanding of the

importance of the actions for utilization of research outcomes and to coordinate them as a donor agency.

End