Republic of the Philippines

FY 2021 Ex-Post Evaluation Report of Technical Cooperation Project (SATREPS[1])

Enhancement of Earthquake and Volcano Monitoring and Effective Utilization of Disaster Mitigation Information in the Philippines

External Evaluator: Keisuke Nishikawa, Masako Miura, QUNIE CORPORATION

0. Summary

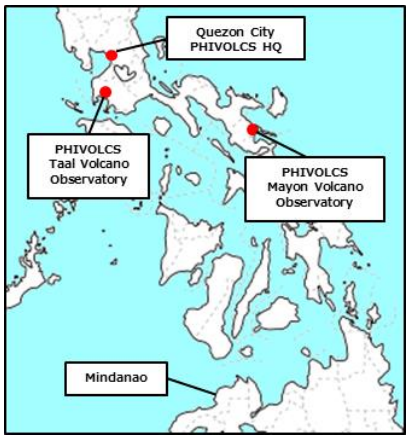
In this project, while maximizing the outcomes of past Japanese disaster management assistance to the Philippines, this project newly introduced up-to-date observation and analysis systems, and provided training for their operation. The project also aimed to improve the capacity of disaster management organization and related organizations in the government of the Philippine to cope with earthquake and volcanic disasters through the identification and rapid and systematic dissemination of information pertaining to earthquakes, tsunamis and volcanoes.

The project is highly relevant and consistent with the development policies of the government of the Philippines and the development needs at the time of planning and project completion. It is also aligned with the Japanese ODA policies at the time of planning. As for the effectiveness, it was confirmed that all the outputs 1 to 4 and the project objectives were achieved. The overall goal of the project was also achieved, as the disaster management government organizations and related organizations have been able to respond quickly based on the disaster management information provided by PHIVOLCS in several earthquakes, volcanic eruptions, and other disasters since the project completion. Therefore, the effectiveness and impact of the project is high. In addition, the project cost and project period were within the plan, thus the efficiency of the project is high. Regarding the sustainability, there is a problem in the technical aspects of the project, but there are no major problems in the policy, institutional, and financial aspects of the project. Therefore, the sustainability of the project effects is high.

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

[1] Science and Technology Research Partnership for Sustainable Development

1. Project Description



Project Locations

Broadband Seismic Station installed in the project

1.1 Background

The Republic of the Philippines (hereafter referred to as "the Philippines") is located in the plate subduction zone of the western Pacific Ocean and, like Japan, has the most active seismic and volcanic activity in the world, resulting in significant damage from disasters. In order to mitigate the damage caused by such disasters, it is necessary to predict earthquakes and volcanic eruptions that may occur in the future in advance through research and surveys, to prepare adequately for disasters, and to provide real-time monitoring information to local residents and authorities when an earthquake or volcanic eruption occurs. This can be used for emergency responses such as issuing evacuation warnings and evacuating residents.

Earthquake and volcano monitoring in the Philippines has been carried out by the Philippine Institute of Volcanology and Seismology (hereafter referred to as "PHIVOLCS") under the Department of Science and Technology. Japan has been implementing a technical cooperation project to strengthen the earthquake and volcano monitoring capacity of PHIVOLCS by establishing an earthquake and volcano monitoring network and providing operational guidance for this monitoring network through grant assistance. More than 10 years have passed since the design stage of the above-mentioned grant assistance project, during which time the earthquake and volcano monitoring technology of Japan and other countries has advanced significantly. However, in comparison to other Asian countries, only the Philippines did not have a telemetered observation network using broadband seismometers, resulting in inaccurate emergency earthquake bulletins in the event of an earthquake. In addition, as for volcano observation, only short-period seismometers are installed in the existing telemetered observation network, making it difficult to forecast eruptions with the accuracy required for long-term eruption prediction and accurate warning and evacuation orders. Contradictory, it was considered possible to establish a reliable volcanic eruption forecasting system by strengthening the existing observation system

and using the latest observation technology.

In response to the above situation, the Government of the Philippines requested the government of Japan to support the application of Japanese earthquake and volcano observation and information transmission technology in the Philippines as the Science and Technology Research Partnership for Sustainable Development (hereafter referred to as "SATREPS"), and this technical cooperation project was launched in February 2010.

1.2 Project Outline

Overall Goal		Capabilities of disaster management authorities and related organizations which respond to earthquake and volcanic disasters are enhanced.
Project Purpose		Earthquake, tsunami and volcano monitoring capabilities of PHIVOLCS are enhanced and improved disaster mitigation information is utilized by the disaster management authorities and related organizations.
Outputs	Output 1	Improved earthquake and tsunami information is obtained in real-time
	Output 2	Accuracy of evaluation of earthquake generation potential is improved
	Output 3	Integrated volcano monitoring information is obtained in real time
	Output 4	Improved disaster mitigation information is provided through a portal site as one of the effective means of information dissemination
Total Cost (Japanese Side)		Approximately 388 million yen
Period of Cooperation		February 2010 - February 2015
Target Area		Manila and vicinity, Mindanao, Taal Volcano and Mayon Volcano
Implementing Agency		・ Philippines Institute of Volcanology and Seismology (PHIVOLCS, under the jurisdiction of DOST) ・ Department of Science and Technology (DOST)
Other Relevant Agencies/ Organizations		N/A
Organizations in Japan		National Research Institute for Earth Science and Disaster Resilience (NIED), Kyoto University, Tokai University, Nagoya University, Geospatial Information Authority of Japan (GSI), Japan Meteorological Agency (JMA), etc.
Related Project		【Technical Cooperation】 ・Project for Improvement of Earthquake and Volcano Monitoring System (March, 2004 – March, 2006) 【Grants】 ・The Project for Improvement of Earthquake and Volcano

	Monitoring System (1999) ・The Project for Improvement of Earthquake and Volcano Monitoring System (Phase 2) (2002) ・The Project for Evacuation Shelter Construction in Disaster Vulnerable Areas in Province of Albay (2011) ・The Project for Improvement of Equipment for Disaster Risk Management (2012) 【Other International Organizations or Aid Agencies】 ・The Institute of Earth Science, Academia Sinica (Taiwan): Ground deformation studies along the Philippine Fault using Global Positioning System (1996) ・Asian Disaster Preparedness Center (ADPC, Thailand): Cooperation on early warning arrangement, preparedness and mitigation on natural hazards (2006) ・CSCAND, UNDP, AusAID: Hazards Mapping and Assessment for Effective Community Disaster Risk Management (READY Project) (2006 - 2011) ・National Cheng Kung University and The Institute of Earth Science, Academia Sinica (Taiwan): Seismotectonic, geodynamic, seismological and volcanological study of the Philippines and Taiwan Regions (2007) ・Norway Geotechnical Institute: Tsunami Hazard and Risk Assessment (2008 – 2010) ・Bureau de Recherches Geologiques et Minieres and other scientific organizations (France) : Mitigate and assess risk from volcanic impact on terrain and human activities (MIA-VITA Project) (2008 – 2013) ・CSCAND, AusAID, Geoscience Australia: Strengthening Natural Hazard Risk Assessment Capacity in the Philippines (2009 - 2010)

1.3 Outline of the Terminal Evaluation

The Terminal Evaluation was conducted in September 2014 by a joint evaluation team consisting of members from the Philippine side (the National Economic Development Authority, PHIVOLCS, and the Philippine Council for Industry, Energy, and Emerging Technology Research and Development) and the Japanese side (JICA Global Environment Department, JICA Philippines Office, and external consultants).

1.3.1 Achievement Status of Project Purpose at the Terminal Evaluation

The capability of PHIVOLCS to monitor earthquakes, tsunamis, and volcanoes has been significantly enhanced. On the other hand, the utilization of information on earthquakes, tsunamis, and volcanoes by disaster management authorities will be encouraged through the portal site as

the first step of the project activities, and should be promoted and accelerated during the rest of the project implementation period.

1.3.2 Achievement Status of Overall Goal at the Terminal Evaluation (Including other impacts.)

Although the structure and contents of the portal site needs to be finalized, disaster-related information from PHIVOLCS is already being regularly referenced and shared by several authorities (through means other than the portal site). During the terminal evaluation, it was confirmed that several authorities are using the disaster information provided by PHIVOLCS on a regular basis in their daily operations.

1.3.3 Recommendations from the Terminal Evaluation

The following recommendations were proposed in the terminal evaluation.

1) To complete the remaining activities by the end of the project period in February 2015 in order to achieve the project purpose
2) To continuously improve the portal site "PHIVOLCS Information Portal" to promote the use of disaster information by disaster management authorities
3) To consider strengthening the staff personnel and budgeting of PHIVOLCS, not only for the maintenance of the currently installed observation equipment, but also for the operation of the observation equipment network that is being enhanced through JICA Grants
4) Based on the significant joint research achievements of the Philippine and Japanese institutions, to consider mechanisms to continue the joint research relationship, such as signing Memorandum of Understanding (MOU) with specific Japanese institutions and access to Japanese research funds for disaster risk reduction and management
5) To promote discussions on specific disaster risk reduction and management activities to enable disaster management authorities to respond and act appropriately on disaster-related information provided by PHIVOLCS, while sharing research results

2. Outline of the Evaluation Study

2.1 External Evaluator

Name: Keisuke Nishikawa (QUNIE CORPORATION)
Masako Miura (QUNIE CORPORATION)

2.2 Duration of Evaluation Study

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

Duration of the Study: July, 2021 – June, 2022
Duration of the Field Study: January, 2021 – February, 2022
(The field survey was conducted remotely.)

2.3 Constraints during the Evaluation Study

Due to the spread of COVID-19, it was not possible to conduct a field survey by external evaluators, and information for the evaluation was collected through a questionnaire-based field survey by a local consultant and online interviews. Therefore, some information and data were not sufficiently provided by the implementing and related agencies, which limited the analysis of some of project achievements.

3. Results of the Evaluation (Overall Rating: A[2])

3.1 Relevance (Rating: ③[3])

3.1.1 Consistency with the Development Plan of the Philippines

The topmost national policy for socio-economic development in the Philippines is *the Philippine Medium Term Development Plan*, and at the time of the planning of the project in 2009, *the Philippine Medium Term Development Plan (2004 - 2010)* was under implementation. The plan referred to the importance of disaster risk management and comprehensive disaster mitigation measures. As non-structural countermeasures in the event of a disaster, it identified the mapping of disaster risk areas (e.g., hazard mapping) and the promotion of community disaster prevention, including community pre-warning systems in areas at risk. As for structural countermeasures, it set goals for the development of defensive and observation facilities for the purpose of prevention and mitigation of damage before a disaster occurs. *The Philippine Medium Term Development Plan (2011 - 2016),* which was under implementation at the time of the project completion in 2015, did not change the aforementioned policy and specified the enhancement of adaptive capacity to environmental disasters as one of the goals related to the conservation, protection, and recovery of the environment and natural resources. It included budget allocation for disaster risk reduction management and climate change adaptation, risk assessment capacity enhancement, and early warning issuance.

As for policies other than the Philippine Medium Term Development Plan, Republic Act No. RA 10121, *"Philippine Disaster Risk Reduction and Management Act,"* was passed in May 2010, establishing the National Disaster Risk Reduction and Management Council (NDRRMC) under the Department of National Defence (DND), with the Office of Civil Defence (OCD) as its secretariat, and the disaster risk reduction and management system was strengthened. In 2011, *the National Disaster Risk Reduction and Management Plan (NDRRMP) 2011-2028* was formulated in accordance with Republic Act RA 10121. NDRRMP outlines specific plans in the four areas of 1) Prevention and Mitigation of risk, 2) Disaster Preparedness, 3) Disaster Response, and 4)

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

[3] ③: High, ②: Fair, ①: Low

Rehabilitation and Recovery, with the aim of establishing *"Safer, adaptive and disaster resilient Filipino communities towards sustainable development."*

Therefore, the project was consistent with the development policies of the Philippines both at the time of planning and at the time of project completion[4].

3.1.2 Consistency with the Development Needs of the Philippines

Since the late 1990s, the government of the Philippine has shifted its policy focus from "post-disaster emergency response and subsequent rehabilitation and reconstruction response" to "comprehensive disaster management that reduces disaster risks before disasters occur as part of poverty alleviation". PHIVOLCS, in line with its mandate, announced its commitment to achieve social results in building communities resilient to volcanic eruptions, earthquakes, tsunamis, and other natural disasters in its "Strategic Map" formulated in October 2012, including the following outcomes.

a. Accurate forecasting and simulation of volcanic eruptions and earthquakes and their related geotectonic phenomena;
b. Determine how eruptions and earthquakes shall occur and the areas likely to be affected;
c. Generate sufficient data for forecasting volcanic eruptions and earthquakes;
d. Mitigate hazards of volcanic activities through appropriate detection, forecast and warning system until Barangay[5] level; and,
e. Formulate appropriate disaster preparedness plans

Also, *National Disaster Risk Reduction and Management Framework (NDRRMF)*, which was approved along with the passage of *the NDRRMP 2011-2028* mentioned above, has also changed the approach to more preventive and proactive response to disasters, rather than starting the response after a natural disaster has occurred. All activities conducted by the project, such as the real-time monitoring of earthquake and tsunami information, the improvement of accuracy of earthquake potential assessment, the real-time monitoring of comprehensive volcano information, and the dissemination of more accurate disaster prevention information to disaster management authorities, have contributed to the achievement of the prioritized areas set by PHIVOLCS and the NDRRMF's preventive and proactive disaster response.

Therefore, the project was consistent with the development needs of the Philippines both at the time of planning and at the time of project completion.

[4] Since a project completion report was not prepared by JICA for this project, "information at the time of project completion" in this report refers to the information as of February 2015, which was obtained through the ex-post evaluation during July 2021 to March 2022. "Information at the time of the terminal evaluation" is as of September 2014, when the terminal evaluation was conducted.

[5] Administrative units in the Philippines consist of Province, City, Municipality, and Barangay, with Barangay being the smallest administrative unit in local government.

3.1.3 Consistency with Japan's ODA Policy

At the time of the planning, *the Country Assistance Policy for the Philippines* formulated in June 2008 identified "protection of lives from natural disasters" as a priority area under the key development issue of "supporting the self-reliance of the poor and improving the living environment." While taking into consideration the financial status of the Philippine side, it was clearly stated the importance to support the development and maintenance of flood control and erosion control infrastructure in high priority areas, as well as the strengthening of measures necessary for residents to evacuate from disasters.

Therefore, this project was consistent with Japan's ODA Policy at the time of planning.

3.1.4 Appropriateness of the Project Plan and Approach

A conceptual diagram of the linkage between project outputs, the project purpose, and the overall goal is shown in Figure 1. The Project Design Matrix (PDM) was changed twice during the project period. The first change was in November 2011, when three tsunami-related activities were added to the project activities: "To enhance tsunami warning system", "To enhance real-time sea-level monitoring system", and "To conduct community awareness-raising activities on tsunami disaster prevention", as Great East Japan Earthquake and Tsunami Disaster in March 2011 reminded of the need for tsunami disaster mitigation and preparedness in the Philippines.

The second change was made in September 2013, when indicators measuring the number of pieces of equipment provided and the number of PHIVOLCS staff trained were added to each output, in order to more clearly measure the degree of achievement of each output.

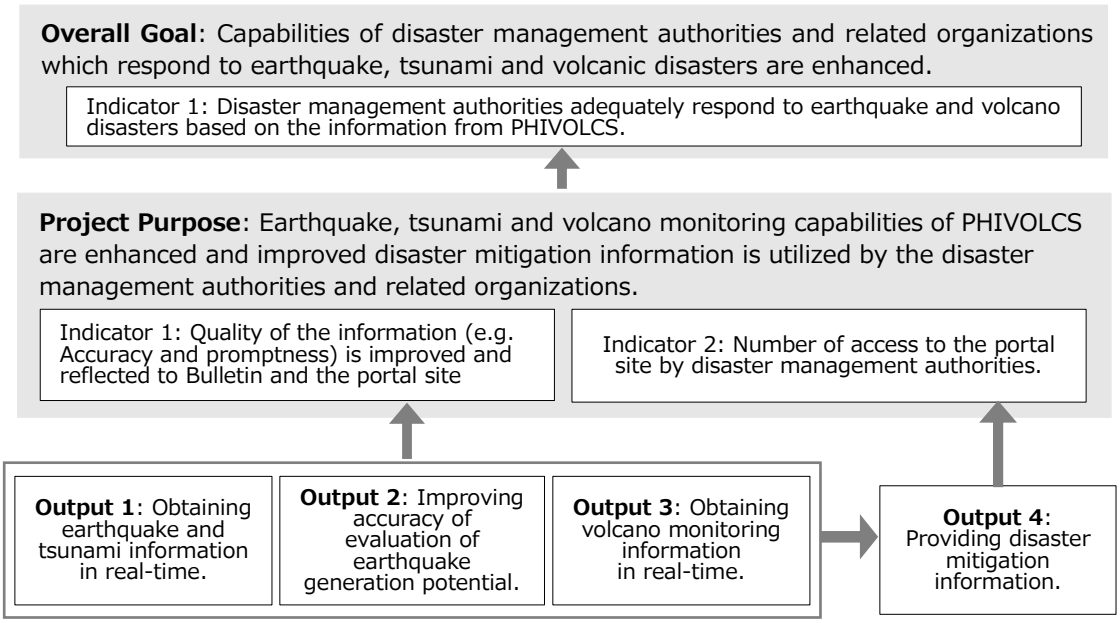


Figure 1: Linkage between Project Outputs, the Project Purpose, and the Overall Goal (Conceptual Diagram)

The first change was made in response to the need to address tsunami damage following the Great East Japan Earthquake, and was appropriate in light of the high likelihood of tsunami damage during earthquakes and volcanic eruptions. The second change was made with the aim of clarifying the degree of results achievement, and is therefore considered to have been a reasonable change.

This project was highly relevant to the country's development plan and development needs both at the time of planning and at the time of project completion, as well as Japan's ODA policy at the time of planning, and it is confirmed that the plan of the project and its approach were appropriate. Therefore, its relevance is high.

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

3.2.1 Effectiveness

3.2.1.1 Project Output

The project set four outputs, the linkage between these outputs and the project purpose is shown in Figure 1. The project aimed to achieve the project purpose by monitoring earthquakes in real time and assessing their potential, monitoring volcanic eruptions in real time, and disseminating information and tools on the portal site for disaster information and disaster risk management and mitigation. At the time of the ex-post evaluation, it was confirmed that the output 1 was mostly achieved, and outputs 2 to 4 were achieved, through the project implementation.

Although only small-scale seismic information has been analysed in the Philippines, through this project, information on large and medium-scale earthquakes (magnitude 4.5 and above), which could not be analysed before, was ascertained, seismic intensity was mapped, tsunami heights and arrival times were measured, and equipment and training were provided for this purpose (Output 1). For tsunami observation, a tsunami database for predicting tsunami height and arrival time was established and used. However, the tidal observation system[7] used to measure the actual tsunami height and arrival time was not sufficiently anchored to the seafloor, resulting in malfunctions and other problems that prevented the system from being fully utilized[8]. Therefore, the National Mapping and Resource Information (NAMRIA) and PHIVOLCS have been using tide observation systems which had been set up by themselves.

In order to understand the risk of earthquake occurrence, the accuracy of earthquake occurrence potential assessment was improved and the analysis of earthquake occurrence potential based on such assessment was implemented. Also, equipment and training for these activities were also

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

[7] The tide observation system was positioned as an experiment to verify the feasibility of introducing and utilizing a system different from those already in use by other organizations in the Philippines.

[8] As for the installation of the tide observation system that was installed in the project but did not work, no new tide observation system has yet been installed at the time of the ex-post evaluation, but discussions are ongoing with the Japanese expert of the project on the installation and the method to be adopted after the completion of the project.

provided (Output 2). In order to understand the possibility of recurrence of earthquakes, an analysis of the recurrence period of past major earthquakes, which is a basic hazard assessment, was conducted, and an earthquake occurrence potential assessment was conducted based on the results of the analysis.

To improve volcano monitoring capabilities, equipment was deployed at Taal and Mayon volcanoes, systems were installed, and various training programs were conducted to automatically determine information related to volcanic earthquakes and microtremors at both volcanoes, monitor volcanic deformation and electromagnetic anomalies in real time, and establish a system to obtain disaster information in real time at the PHIVOLCS headquarters (Output 3). However, Real-time volcano information monitoring at Taal Volcano has been suspended at the time of project completion due to the need to replace and repair the satellite telemetry antenna and other communication infrastructure installed at the Taal Volcano Observatory as a result of Typhoon 9 (Philippine name: Glenda)[9], which made landfall in the Philippines in July 2014. The equipment was restored in December 2015 after the completion of the project, and real-time volcano information monitoring resumed. Although data transmission was temporarily unavailable at the time of project completion, the damage was caused by a natural disaster of a level that cannot normally be assumed, and equipment was in operation before it was damaged by the typhoon. Therefore, Output 3 was concluded to have been achieved.

Regarding information dissemination, information on earthquakes, tsunamis, and volcanoes that has become available or improved in accuracy as a result of this project has been disseminated on a newly constructed portal site. Information on disaster risk management and mitigation and its tools developed through this project are also provided on the portal site (Output 4). The disaster risk management and mitigation tools include an earthquake resistance checklist for general users, a simple and up-to-date diagnosis software for engineers and homeowners, a cartoon based on interviews with Filipino victims of the Great East Japan Earthquake, and a DVD of the same interviews.

Table 1 and Table 2 show the planned and actual numbers of deployed equipment and PHIVOLCS staff who received training provided by the project.

[9] Typhoon 9 in 2014 occurred on July 12, made landfall on Luzon Island on July 15, and hit the capital Manila on July 16, causing extensive damage throughout the Philippines. As of July 20, 97 people were died, 437 were injured, 6 were missing, and 111,372 houses were damaged, including 27,874 completely destroyed (Source: National Disaster Risk Reduction Committee of the Philippines (2014) "NDRRMC Update SitRep No. 18 Typhoon GLENDA). It also caused extensive damage to various infrastructures and crops.

Table 1 Baseline, target, and actual numbers for equipment provided

Output	Equipment	Baseline	Target	Actual number (at the project completion)
1	Broadband Seismometer	9	10	10
	Strong-motion Seismometer	9	10	10
	SWIFT Epicentral Analysis System	0	1	1
	Seismometer	0	100	100 (about 70 are installed)[10]
	Radio Tide Gauge	1	5	5
	Tsunami Scenario Database	0	1	1
2	GPS Campaign Observer	15	15	15 (using PHIVOLCS equipment)
	GPS Continuous Observer	2	3	3 (borrowed from GSI)
3*	Broadband seismometer	0	8	8
	Infrasonoic Meter	0	4	4
	GPS Receiver	7	6	11
	Three-component magnetic force measuring device	0	1	1
	Geomagnetic Observation System	0	2	3
	IP Camera (Networking Camera)	0	-	3
4	Construction of the Portal Site	0	1	1

*The figures for equipment installed for Output 3 are the total number of equipment provided to Taal and Mayon Volcano Observatories.Source: The terminal evaluation report, responses from the implementing agency and a Japanese expert in the project

Table 2 Baseline, target, and actual number of PHIVOLCS staff trained

Output	Training	Baseline	Target	Actual number[11] (at the project completion)
1	Broadband seismometer, Strong-motion seismometer	3	5	5
	SWIFT seismic observation system	0	10	5
	Real-time earthquake intensity mapping	0	5	2
	Real-time tide level monitoring system	0	5	5
2	GPS crustal movement observations	15	15	15
	Geomorphological and geological palaeoseismic survey of inland active faults	2	6	10
	Topographic survey of active submarine faults	0	4	5
3	Broadband seismometer and vibrometer network (seismic observation)	6	6	6
	Site amplification analysis	6	-	1

[10] Although 100 seismometers were provided under this project to determine the seismic intensity at the time of an earthquake, the number of seismometers installed remained at about 70 at the time of project completion. This is because seismometers are often installed in local government buildings and a resolution by the local council is required for installation, which took time to complete the installation. However, as described in 3.2.2, PHIVOLCS has continued to install seismometers after the completion of the project in coordination with local governments.

[11] As a result of a review of the number of staff assigned to the relevant departments and their responsibilities, and a close examination of the staff who needs to take training courses, the actual results for some training courses, such as "SWIFT Seismic Observation System" and "Real-time Earthquake Intensity Mapping," fell below the target values.

Output	Training	Baseline	Target	Actual number[11] (at the project completion)
	Volcano GPS observation	2	-	2
	Volcano electromagnetism observation	0	-	1
4	Construction of the portal site	1	2	1
	Simplified Seismic Assessment Tool	0	2	2

Source: The terminal evaluation report, responses from the implementing agency and a Japanese expert in the project

3.2.1.2 Achievement of Project Purpose

Table 3: Achievement of the Project Purpose

<table>
<tr><th>Project Purpose</th><th>Indicators</th><th>Actual</th></tr>
<tr><td rowspan="2">Earthquake, tsunami and volcano monitoring capabilities of PHIVOLCS are enhanced and improved disaster mitigation information is utilized by the disaster management authorities and related organizations.</td><td>①Quality of the information (e.g. Accuracy and promptness) is improved and reflected to Bulletin and the portal site.</td><td>The technology introduced in this project made it possible for the first time to grasp the correct epicenter mechanism of earthquakes of M4.5 or greater, and to analyze the correct occurrence time and seismic intensity information for large and medium-sized earthquakes, which had not been sufficiently analyzed in the past, thereby the accuracy of the disaster information was improved (prior to the start of this project, there were no seismic intensity meters, and PHIVOLCS staff measured the seismic intensity by bodily sensation).
Also, above mentioned information has been reflected in the periodic report (Bulletin) and on the portal site.</td></tr>
<tr><td>②Number of access to the portal site by disaster management authorities</td><td>The portal site began operation in June 2014. The total number of accesses to the portal site from the start of operation to the completion of the project, as tabulated by the implementing agency, is shown below.
<table>
<tr><th>Month</th><th>Total number of accesses</th></tr>
<tr><td>June, 2014</td><td>216</td></tr>
<tr><td>July, 2014</td><td>50</td></tr>
<tr><td>Augast,2014</td><td>128</td></tr>
<tr><td>September,2014</td><td>580</td></tr>
<tr><td>October, 2014</td><td>447</td></tr>
<tr><td>November,2014</td><td>495</td></tr>
<tr><td>December, 2014</td><td>582</td></tr>
<tr><td>January, 2015</td><td>486</td></tr>
<tr><td>February, 2015</td><td>435</td></tr>
</table>
Although Indicator 2 was "Number of access to the portal site by disaster management authorities," the portal site is open to the public, and the implementing agency does not compile data targeting organizations involved in disaster reduction. Therefore, the above figure is the total number of accesses including general users.
It was confirmed that the number of accesses increased after September 2014 because the first portal seminar was held on September 15, 2014 to inform the public about the details of the portal site and how to use it.</td></tr>
</table>

Project Purpose	Indicators	Actual
		Since the number of accesses by disaster management authorities was not counted, it was hard to measure the degree of achievement of the project purpose "~used by disaster reduction agencies" using this indicator 2. According to the implementing agency, it turned out that disaster management authorities do not access the portal site on a daily basis, but use it when disasters such as earthquakes and volcanic eruptions occur.

Although it was not clear at the time of planning which "disaster management authorities" were to be referred to in the project purpose, it was confirmed by the implementing agency and a Japanese expert during the ex-post evaluation that OCD, which is mainly responsible for disaster management, and the Local Disaster Risk Reduction and Management Office (LDRRMO) in each Local Government Unit (LGU), which is affected by disasters, were assumed as targets.

With regard to the indicator 1, through the achievement of Outputs 1-3, information on earthquakes, tsunamis, and volcanoes was accurately and promptly obtained, and this information was disseminated through bulletin and disaster information on a portal site.

Regarding the indicator 2, two portal seminars were held in September 2014 and February 2015 to promote the use of the portal site, being attended by officials from OCD, the Department of Public Works and Highways, LDRRMO, and others. In line with this, it was observed that the total number of accesses to the portal has increased since September 2014. In addition, at the time of the terminal evaluation, there were confirmed cases of utilization of PHIVOLCS earthquake, tsunami, and volcano information by authorities related to disaster management. However, the “Number of access to the portal site by disaster management authorities,” which is the indicator 2, was not compiled by the implementing agency, and only the total number of accesses, including those by general users, was available. Therefore, the achievement status of the indicator 2 was analyzed after confirming not only the data of accesses but also qualitative information on how OCD and LDRRMO, which are authorities involved in disaster management, are using the portal site. According to the implementing agency, disaster management authorities do not access the PHIVOLCS portal site on a daily basis, but use it when disasters such as earthquakes and volcanic eruptions occur. In addition, LDRRMO in Batangas Province, located in the southern part of Luzon Island, confirmed that they have responded to disasters by referring to the disaster information on the PHIVOLCS portal site. Based on these results, it was confirmed that indicator 2 was mostly achieved.

Therefore, the project purpose was achieved through strengthening earthquake, tsunami and volcano monitoring capability and promoting the use of accurate earthquake and volcano information to disaster management authorities.

3.2.2 Impact

Installation of seismic intensity meters and GPS continuous observation equipment

Although the number of installed seismometers provided by the project was about 70 at the time of completion of the project, PHIVOLCS continued to coordinate with LGUs after the project was completed. In addition to the 100 seismometers provided by the project, PHIVOLCS also proceeded to install seismometers procured by themselves, and as of the ex-post evaluation, 116 seismometers had been installed throughout the country. Also, three sets of GPS continuous observation equipment borrowed from GSI were installed at the time of project completion, but after then, PHIVOLCS proceeded to procure and install its own instruments, and 18 sets of GPS continuous observation equipment have been installed at the time of the ex-post evaluation. All of these units are indispensable for obtaining information on earthquakes and volcanoes, and installation of these units has continued after the completion of the project.

Integration of the portal site and the PHIVOLCS website

The project disseminates earthquake, tsunami, and volcano information on the newly constructed portal site, which operated as an independent site from 2014 to 2019. However, the portal site was integrated into the PHIVOLCS website in the fourth quarter of 2019 with the aim of avoiding confusion when looking for information on each of the volcanoes, earthquakes, and tsunamis. Within the PHIVOLCS website, sub-portals for volcanoes, earthquakes, and tsunamis were established and organized to provide easy access to the respective disaster information and tools.

Utilization of disaster risk management and mitigation tools

The disaster risk management and mitigation tools developed in this project have continued to be utilized even after the completion of the project. Tens of thousands of copies of the "How Safe is My House" bi-fold flyer have been printed several times since the completion of the project and are being used as a disaster awareness tool. In 2021, the "How Safe is My House" web and mobile applications (for Android and iOS) were completed and made available for free download. At the time of the ex-post evaluation, "How Safe is My House" has been integrated into most PHIVOLCS trainings and is also featured in stakeholder trainings and awareness activities facilitated by PHIVOLCS.

3.2.2.1 Achievement of Overall Goal

Table 4: Achievement of the Overall Goal

Overall Goal	Indicator	Actual
Capabilities of disaster management authorities and related organizations which respond to earthquake, tsunami and volcanic disasters are enhanced.	Disaster management authorities adequately respond to earthquake and volcano disasters based on the information from PHIVOLCS.	In several disasters after the completion of the project and up to the time of the ex-post evaluation, information from PHIVOLCS was utilized in disaster response by LDRRMOs and other relevant stakeholders. It is confirmed some cases which prompt disaster responses have been done including issuing evacuation warnings based on disaster information provided by PHIVOLCS.

The "Disaster management authorities and related organizations" in the overall goal was also assumed to primarily target OCD and LDRRMOs, as well as the project purpose. It was also assumed that the indicator "adequately respond" means that appropriate disaster response and evacuation measures would be implemented.

The following examples were shared by the implementing agency and LDRRMOs as information for measuring the achievement of the indicator of the overall goal (Names in parentheses indicate the authorities providing the information).

- In the case of the eruption of Taal volcano in January 2020[12], PHIVOLCS identified signs of an eruption through real-time monitoring by webcams installed near the crater as part of this project, and local authorities were notified, which led to prompt evacuation activities. When a disaster occurs, disaster information is transmitted from PHIVOLCS to OCD, which in turn transmits the information to the targeted Regions and LGUs. However, in the event of a major disaster, PHIVOLCS also provides information directly to each LGU via telephone or other communication tools in an effort to implement a quicker disaster response (PHIVOLCS).
- In Batangas Province, where the Taal volcano is located, a contingency plan for the eruption of Taal volcano was already in place. When the volcano erupted in January 2020, PHIVOLCS provided information to the LDRRMO, which led to a prompt response in accordance with the contingency plan such as calling all residents in three municipalities to prepare for evacuation, strengthening the alert system, arranging vehicles for evacuation and transporting relief supplies, and sending staff to the affected areas (LDRRMO, Batangas Province).

[12] Taal Volcano erupted on January 12, 2020 for the first time in 43 years, reportedly affecting 584,000 people and displacing 194,000 as of February 17, 2020 (Source: Philippine National Disaster Risk Reduction Commission (2020), NDRRMC Update: Situational Report No. 78 Taal Volcano Eruption, 17 February 2020, 6:00 PM). Since then, Taal Volcano has become more active and small eruptions have been observed intermittently, and PHIVOLCS has raised the alert level (5 levels) of Taal Volcano from 2 to 3 in March 2022, reporting a continued threat of a major eruption (Source: PHIVOLCS (2022), TAAL VOLCANO BULLETIN (UPDATE) 26 March 2022 8:00 AM).

- For the M6.6 earthquake that occurred on July 24, 2021 near Calatagan City, Batangas Province, the LDRRMO set up an emergency response system based on information from PHIVOLCS, and regularly monitored earthquake information through the PHIVOLCS website, and the earthquake information was disseminated through social networking services. In addition, disaster response was carried out in cooperation with PHIVOLCS, including requesting PHIVOLCS to assess suspected cracks caused by earthquakes (LDRRMO, Batangas Province).

These cases confirm that the targeted LGUs have been responding promptly and appropriately based on information provided directly by PHIVOLCS or published on its website before or immediately after a disaster. Therefore, the overall goal has mostly been achieved.

3.2.2.2 Other Positive and Negative Impacts

No negative impacts on the natural environment were identified in the project at the time of the ex-post evaluation. Resettlement and land acquisition were also not implemented.

The following other impacts were identified in the ex-post evaluation.

1) Strengthening structures within PHIVOLCS

The Seismological Observation and Earthquake Prediction Division (SOEPD) within PHIVOLCS has been restructured and a tsunami monitoring structure has been established.

2) Conducting similar studies with PHIVOLCS

PHIVOLCS has initiated similar studies, including its own monitoring of the Mount Bulusan.

3) Spillover of results to other projects

Based on the results of this project, a program to strengthen the earthquake and tsunami observation network through JICA grant assistance was initiated with PHIVOLCS in February 2014.

In addition, the earthquake early warning system developed in the project continues to be used as a joint research project between NIED, PHIVOLCS and the Department of Geology and Mines of Bhutan. In Bhutan, the JICA SATREPS project “The Project for Evaluation and Mitigation of Seismic Risk for Composite Masonry Buildings in Bhutan” (2017-2022) has been implemented and cost reduction of the earthquake early warning system has led to its introduction across the county.

Research results on the evaluation of the potential of active faults have been utilized in the JICA SATREPS project “The Project for Integrated Research on Great Earthquakes and Disaster Mitigation in Nepal Himalaya” (2016-2021).

4) Publication of research results at international conferences and journals

The research results of the project were widely published through papers by PHIVOLCS

researchers, presentations at international conferences such as the American Geophysical Union, and publication in its journals. By the time of the ex-post evaluation, four papers and four conference presentations had been made[13].

5) Ongoing human resources development

One staff member from PHIVOLCS received training in seismology in Japan in 2017 and another one in 2019. In addition, one staff member during the project period and six staff members after the completion of the project studied at the National Graduate Institute for Policy Studies (GRIPS) under the Project for Human Resource Development Scholarship (JDS) by JICA and conducted research in fields related to the project.

All the outputs 1-4 have been achieved, and while previously only small earthquakes were monitored, the project has enabled the analysis of information on large- and medium- scale of earthquakes of M4.5 and above, as well as volcanic eruption forecasts through real-time monitoring of volcanoes. This confirmed improving the earthquake, tsunami and volcano monitoring capacity of PHIVOLCS and the accuracy of the disaster information transmitted, those were set as a project purpose. The results of the project have been continuously maintained at the time of the ex-post evaluation, and when the disasters occur, disaster management authorities and related organisations have responded to the disasters based on the information provided by PHIVOLCS. Many other positive impacts were also identified, such as international dissemination of research results, utilization in other projects and continuous human resource development. Thus this project has mostly achieved the overall goal in terms of disaster management and risk reduction.

Therefore, effectiveness and impact of the project are high.

3.3 Efficiency (Rating:③)

3.3.1 Inputs

The main actual and planned inputs for the project are shown in Table 5.

[13] Details of the four conference presentations are as follows.

1. 10th General Assembly, Asian Seismological Commission, November 17-20, 2014, Makati City. Oral Presentation- "Filipinos in Japan: Experiences and Lessons Learned from the 11 March 2011 Earthquake and Tsunami" and "Development of Comics/Manga as a Tool for Public Awareness".
2. International Symposium on Earthquake and Tsunami Disaster Reduction- Sendai International Center, Japan, March 14-15, 2012-JICA Project. Oral presentation- "Video Interviews with Filipino Victims of the 11 March 2011 Great East Japan Earthquake".
3. 6th ASIA Conference on Earthquake Engineering (6ACEE) September 22-24, 2016, Cebu City. Oral Presentation – "Philippines. Strategies for the Development and Dissemination of Tools for Earthquake Safety of Houses: A Collaborative Effort among Experts and Stakeholders".

Table 5: Planed and Actual Inputs

Inputs	Plan	Actual (at the project completion)
(1) Experts	Short-Term: 27 persons	Short-Term: 46 persons Project coordinator: 2
(2) Trainees received	10 persons	34 persons
(3) Equipment	Broadband seismometers and other observation equipment	Provision of equipment for advanced instantaneous seismic source analysis and seismic intensity alerts, real-time comprehensive volcano monitoring and earthquake potential assessment.
(4) Total Project Cost of Japanese side	Approximately, 426 million yen	Approximately, 388 million yen
(5) The Philippines Side	・ Counterpart staffing: 16 ・ Facilities and equipment: office space and equipment for researchers' offices in PHIVOLCS, various costs associated with the research of participating researchers (research budget, travel expenses, etc.)	・ Counterpart staffing: 33 ・ 54 million pesos in total from the start of the project to the point of project completion.
(6) Project Period	February, 2010 – February, 2015	February, 2010 – February, 2015

3.3.1.1 Elements of Inputs

The number of short-term experts deployed under the project increased to 48 compared to the originally planned 27. This is partly because the total number of short-term experts deployed by JMA, GSI and other Japanese government agencies increased due to frequent personnel changes. In addition, as mentioned in 3.1.4, tsunami observation activities were added to the earthquake and volcano monitoring, which necessitated the travel of tsunami observation experts. The interview with the Japanese expert confirmed that while there were changes in the number of personnel, there were no changes in the planned duration of the experts' deployment. Table 1 and Table 2 show the planned and actual equipment provided and training programs undertaken.

3.3.1.2 Project Cost

Despite the addition of tsunami-related activities and an increase in the total number of short-term experts deployed, project costs were 91% of the plan and remained within the plan.

3.3.1.3 Project Period

The project period was five years, from February 2010 to February 2015, as originally planned, and all activities were implemented within the project period.

Both the project cost and project period were within the plan. Therefore, efficiency of the project is high.

3.4 Sustainability (Rating: ③)

3.4.1 Policy and Political Commitment for the Sustainability of Project Effects

The Philippine Development Plan 2017-2022 has been in place since 2017 as the successor to t*he Philippine Medium Term Development Plan 2011-2016*. The Plan identifies key issues such as encouraging individual proactive disaster preparedness through the use of tools provided by DOST, including PHIVOLCS, and ensuring the safety of disaster victims; and continuous capacity building of disaster risk reduction and management stakeholders. All of the results achieved under the project contribute to these issues, and the policy and political commitment for the sustainability of project effects has been maintained.

3.4.2 Institutional/Organizational Aspect for the Sustainability of Project Effects

At the time of the ex-post evaluation, the staffing of the earthquake, tsunami and volcano related departments of PHIVOLCS was as follows (as at January 14, 2022).

- Volcano Monitoring and Eruption Prediction Division (VMEPD): 70 persons (55 permanent employees and 15 contract of service (COS) staff)
- Seismological Observation and Earthquake Prediction Division (SOPED): 112 persons (73 permanent employees and 39 COS staff)
- Geology and Geophysics Research and Development Division (GGRDD): 135persons (34 permanent employees and 101 COS staff)
- Geologic Disaster Awareness and Preparedness Division (GDAPD): 21 (17 permanent employees and 4 COS staff)

The Japanese expert and the implementing agency has confirmed that there were no issues with the above staffing structure in the normal implementation of PHIVOLCS operations, including the new tasks introduced under the project. At the time of the terminal evaluation, concerns were raised about the shortage of staff for the deployment of equipment provided to PHIVOLCS under JICA grant assistance “The Project for Improvement of Equipment for Disaster Risk Management”, which was being implemented at the same time . The Japanese expert confirmed that although it may be necessary to temporarily increase the number of staff or outsource installation work in order to deploy equipment, they were of the opinion that there would be no problem with the current workforce when carrying out normal operations, including the use of the system introduced under the project.

Therefore, it is confirmed that institutional/organizational aspect for the sustainability of project effects is ensured.

3.4.3 Technical Aspect for the Sustainability of Project Effects

The project has provided technical training to many PHIVOLCS staff, and the technologies introduced under the project have been continuously used, mainly by staff who have acquired such expertise. In addition, a staff member who studied at Tokai University under the project and obtained a PhD is still working for PHIVOLCS as a senior scientific researcher in VMEPD. A Science & Technology Forum is regularly held within PHIVOLCS to present and discuss research results. The technologies introduced in the project and the results of analyses based on them are disseminated, for example, volcano monitoring parameters, analyses on records of earthquakes and tsunamis, and various studies are presented weekly in study groups attended by all PHIVOLCS staff. In addition, as mentioned in 3.2.2.2, continuous human resource development is being carried out, with several staff members studying in Japan to learn about the field of earthquake, tsunami and volcano monitoring, even after the completion of the project.

The equipment provided under the project is managed on an ongoing basis by the respective departments in charge. Earthquake-related equipment is managed by SOPED and volcano-related equipment by VMEPD, which repairs or replaces the equipment when it malfunctions or fails.

On the other hand, two PHIVOLCS staff members who received training from JMA on the use of the tsunami database under the project are not currently working in the department concerned, and no replacement staff was assigned. The implementation of normal operations based on the technology introduced under the project has not been affected, but the high-speed tsunami calculator provided under the JICA grant assistance “The Project for the Improvement of Equipment for Disaster Risk Management” has not been utilized yet. The tsunami database for tsunami observation established in the project is still being used at the time of the ex-post evaluation, but it is necessary to utilize the high-speed tsunami calculator provided by the grant assistance in order to further improve the accuracy of the database.

Therefore, there is a challenge in maintaining the technology for the sustainability of project effects.

3.4.4 Financial Aspect for the Sustainability of Project Effects

Each year, PHIVOLCS receives a budget allocation for the maintenance and operation of its equipment under the General Appropriations Act (GAA). After the completion of the project, PHIVOLCS continues to receive budget allocations under the GAA, and the budget and the cost for the maintenance and operation of the equipment for 2015-2022 is as follows.

Table 6: Budget and expenditure on maintenance of equipment in PHIVOLCS

Unit: 1,000 Philippine Peso (PHP)

Year	2015	2016	2017	2018	2019	2020	2021	2022
Budget	9,140	7,502	7,485	7,000	7,684	11,713	14,707	15,040
Expenditure	9,135	7,017	7,472	6,816	5,922	8,006	10,667	—

Source: the implementing agency

The budget is allocated every year and has been increasing since 2018. According to the implementing agency, there are no particular shortfalls in the budget for equipment maintenance and management, indicating that the work is being carried out adequately.

Though there is a challenge in the technical aspect, no major problems have been observed in the policy background, the institutional/organizational and financial aspects. Therefore, sustainability of the project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

In this project, while maximizing the outcomes of past Japanese disaster management assistance to the Philippines, this project newly introduced up-to-date observation and analysis systems, and provided training for their operation. The project also aimed to improve the capacity of disaster management organization and related organizations in the government of the Philippine to cope with earthquake and volcanic disasters through the identification and rapid and systematic dissemination of information pertaining to earthquakes, tsunamis and volcanoes.

The project is highly relevant and consistent with the development policies of the government of the Philippines and the development needs at the time of planning and project completion. It is also aligned with the Japanese ODA policies at the time of planning. As for the effectiveness, it was confirmed that all the outputs 1 to 4 and the project objectives were achieved. The overall goal of the project was also achieved, as the disaster management government organizations and related organizations have been able to respond quickly based on the disaster management information provided by PHIVOLCS in several earthquakes, volcanic eruptions, and other disasters since the project completion. Therefore, the effectiveness and impact of the project is high. In addition, the project cost and project period were within the plan, thus the efficiency of the project is high. Regarding the sustainability, there is a problem in the technical aspects of the project, but there are no major problems in the policy, institutional, and financial aspects of the project. 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

With regard to the improvement of PHIVOLCS's capacity for monitoring earthquake, tsunami and volcano, which was aimed for in the project, staff members with expertise in tsunami data analysis, who have been trained in the project, have already left from the department concerned. Due to this, the task of further improving the accuracy of the tsunami database established in the project by utilizing the high-speed tsunami calculator has not been carried out. It is highly likely that tsunamis will also cause damage in the event of earthquakes and volcanic eruptions, and it is clear that tsunami response will be needed continuously in the future, such as the tsunami damage caused by the eruption of an undersea volcano in Tonga in January 2022. Therefore, it is considered important for PHIVOLCS not only to utilize the tsunami-related technologies and systems introduced in the project, but also to assign appropriate personnel to further improve their accuracy earlier.

4.2.2 Recommendations to JICA

Through implementation of this project, the capacity for earthquake, tsunami and volcano monitoring in the Philippines has been strengthened. Also, the accuracy of the disaster information transmitted from PHIVOLCS has been improved; and now, based on the disaster information identified and disseminated by these technologies, local governments and individuals will be required to implement appropriate disaster response.

"Disaster Risk Reduction and Management Capacity Enhancement Project Phase 2" (September, 2019 – May, 2025)[14], which is currently being implemented, PHIVOLCS, as a relevant agency, will provide disaster information to the implementing agency, which is OCD. The Guidebook for LGUs for the implementation of disaster risk assessment to be developed under "Disaster Risk Reduction and Management Capacity Enhancement Project Phase 2" aims to enable each stakeholder to implement effective disaster risk reduction and management practices while utilizing existing hazard analysis results. One of the pilot activities is also planned to be implemented in Batangas to support the development of local disaster management plans using the online platform for disaster risk being created by PHIVOLCS. Steady implementation of these pilot activities is desirable.

[14] "The Disaster Risk Reduction and Management Capacity Enhancement Project Phase 2" has been developing, monitoring and evaluating disaster risk-based planning in local jurisdictions and municipalities and its dissemination nationwide through strengthening the implementation and coordination capacity of OCD and promoting local disaster risk reduction and management activities.

4.3 Lessons Learned

Setting specific and measurable targets and indicators

Since this project was in a SATREPS scheme, it was envisaged at the time of the planning that the outputs aimed for would mainly be achieved in terms of research. Therefore, more qualitative than quantitative indicators were set to measure the achievement of the outputs. Therefore, as mentioned in 3.1.4, the PDM was changed during the project period and quantitative indicators were added to each output. The project was not able to set clear target values for some of the indicators of the project purpose and the indicator of the overall goal, nor did it assume a specific achievement status. Due to that, in this ex-post evaluation, the achievement level is measured not only by the indicators, but also by other qualitative information, which is considered complementary and comprehensive. While the emphasis is on research results as a SATREPS project, it is important to set more specific and measurable targets and indicators at the time of planning and during implementation in order to clearly indicate the degree of achievement of the project purpose and the overall goal as a JICA technical cooperation project.

Planning of the project to improve research and coping capacities

SATREPS is a scheme aimed at improving the level of research respond to global-scale issues and strengthening the capacity to deal with them comprehensively at research institutions in the country, and it is expected to contribute to society in addition to improving the research capacity of the target institutions. Through this project, the research capacity of PHIVOLCS in earthquake, tsunami and volcano monitoring has been greatly enhanced and various international transmissions have been made through papers and conference presentations. At the same time, the capacity to monitor earthquakes and volcanoes that occur frequently in the Philippines has also been improved and has contributed to enhancing the safety of the people through the use of information for evacuation of local residents and awareness-raising tools for disaster education. The project has confirmed the improvement of both research and response capabilities to the challenge of improving the capacity to respond to natural disasters, and the use of the SATREPS scheme in the project is considered to have been beneficial.

When implementing projects under the SATREPS scheme, it is critical to draw up a project plan based on areas and approaches where it is envisaged that both research capacity and coping capacity can be improved simultaneously, as in this project, rather than one or the other. It is necessary to clarify in project planning and implementation initiatives aimed at improving overall coping capacities, including but not limited to the improvement of research capacities, but also the incorporation in project plans of specific assumptions about how the technologies obtained through research will be used to improve coping capacities, and to incorporate activities envisaging cooperation with projects in the same field that are being implemented in parallel. It

is also desirable to continuously formulate projects in areas where the advantages of Japanese research and technology can be utilised and joint research can be continued.