Republic of the Philippines

FY 2016 Ex-Post Evaluation of Japanese Grant Aid Project

"The Project for Improvement of the Meteorological Radar System"

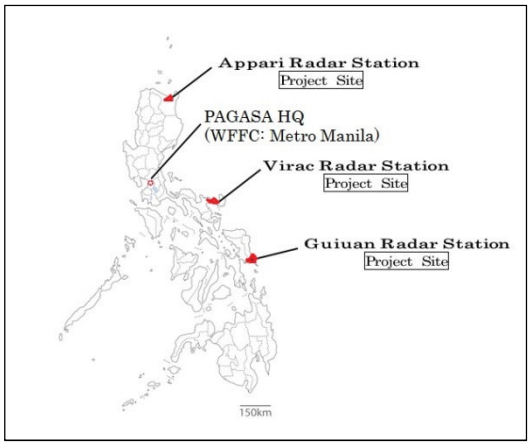
External Evaluator: Kenichi Inazawa, Octavia Japan Co., Ltd.

0. Summary

By developing the existing meteorological radar systems at Virac, Aparri and Guiuan, this project aimed to improve tropical cyclone observation capabilities and upgrade accuracy of weather forecasts of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (hereinafter referred to as "PAGASA"); thereby contributing to reduce risk in disaster caused by tropical cyclones and other severe weather phenomena. The implementation of this project is judged to be consistent with the development policy and needs of the Philippines both at the time of planning and ex-post evaluation. This project also has consistency with Japan's ODA policy. Therefore, its relevance is high. While the project cost was within the initial planned budget, the project period was longer than initially planned. Thus, the efficiency of the project is judged to be fair. Quantitative effects have almost been achieved at the Virac, Guiuan and Aparri stations. In addition, PAGASA headquarters (Weather and Flood Forecasting Center (hereafter referred to as "WFFC")) receive real time rain and wind information generated by the meteorological radar systems, based on which they can continuously monitor for 24 hours and issue typhoon information every hour. Furthermore, it was confirmed through interviews that local governments have been able to secure enough lead time before evacuating local residents based on the typhoon forecast announced by PAGASA. In short, there is possibility that this project has been indirectly contributing to reduce casualties and damages due to natural disasters. Thus, effectiveness and impact of this project are high. In terms of sustainability, no major problems have been observed in the institutional, technical, financial aspects and current status of the operation and maintenance. However operation of the meteorological radar station at Virac that was damaged by Typhoon Nock-Ten (local name: Nina) in December 2016 is suspended at the time of ex-post evaluation. Therefore sustainability of the project effects is fair.

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

1. Project Description



Project Location

Metrological Radar Tower at Virac

1.1 Background

Due to the aging of the meteorological radar systems at Virac, Aparri and Guiuan which were originally developed in 1994, it was difficult to conduct radar monitoring for PAGASA. Since these existing radar systems had no Doppler radar function[1], monitoring stormy wind generated by tropical cyclone on a real time basis, including direction of rainfall motion, and detection of local severe storm associated with tornados in the Pacific Ocean and the coastal areas was not possible. Therefore, PAGASA was unable to accurately locate cyclone centers or intensities of the numerous tropical cyclones and detect heavy rainfall area due to unavailability of wind convergence area data. Based on this situation, the Government of the Philippines requested from the Japanese Government a grant aid project for developing the meteorological radar system of PAGASA.

1.2 Project Outline

The objective of this project is to improve tropical cyclone observation capabilities and upgrade accuracy of weather forecasts of PAGASA, by replacing the existing Virac, Aparri and Guiuan meteorological radar system; thereby contributing to reduce risk in disaster caused by tropical cyclones and other severe weather phenomena.

[1] Doppler function is able to monitor wind velocities up to a maximum of 75 m/s and to detect the directions of rainfall motion within a 200-km radius. It is possible to accurately monitor the direction of strong winds and rainfalls caused by typhoons, as well as storms including tornados, which develop very quickly and cause real time damage. Additionally, it is also possible to identify areas with heavy rainfall from the wind convergence area data.

Grant Limit / Actual Grant Amount	23 million yen (Detailed design) & 3,350 million yen (Main work) / 23 million yen (Detailed design) & 3,169 million yen (Main work)
Exchange of Notes Date / Grant Agreement Date	March, 2009 (Detailed design) & October, 2009 (Main work) / May, 2009 (Detailed design) & November, 2009 (Main work)
Executing Agency	Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)
Project Completion Date	September, 2013
Main Contractor	Marubeni Corporation / Shimizu Corporation (JV)
Main Consultant	Japan Weather Association (JWA)
Basic Design	June 2008 to February 2009
Related Projects	【Grant Aid Project】 "The Project for the Improvement of Capabilities to cope with Natural Disasters Caused by Climate Change" (2010) "The Programme for Rehabilitation and Recovery from Typhoon Yolanda" (2014) 【ODA Loan Project】 "Meteorological Telecommunication System Development Project" (1990) 【Technical Cooperation】 "Project for Enhancing Capacity on Weather Observation, Forecasting and Warning" (2014-2017) "Project for Strengthening Capacity of Integrated Data Management of Flood Forecasting and Warning" (2016-2019) 【Other Donors' Cooperation】 "Establishment of Early Warning System in the Philippines" (Korea International Cooperation Agency (KOICA), 2007) "Strengthening the Disaster Preparedness Capabilities for Meteorological and Hydrological Hazards" (Taipei Economic and Cultural Office, National Science Commission, 2008) "Hazard Mapping and Assessment for Effective Community based

	Disaster Risk Management" (United Nations Development Programme (UNDP), 2006) "Feasibility Study Grant for the PAGASA Met Hydro Telecom System Upgrading Project" (U.S. Trade and Development Agency (USTDA), 2008)

2. Outline of the Evaluation Study

2.1 External Evaluator

Kenichi Inazawa, Octavia Japan Co., Ltd.

2.2 Duration of Evaluation Study

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

Duration of the Study: August 2016 - November 2017

Duration of the Field Study: January 11 - 28, 2017

April 19 - 26, 2017

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

3.1 Relevance (Rating: ③[3])

3.1.1 Consistency with the Development Plan of the Philippines

At the time of planning, the government of the Philippines formulated *The Medium-Term Philippine Development Plan for 2004 to 2010* (MTPDP) in 2004. The plan embodied the 10-point agenda. Its number five thrust was to mitigate the occurrence of natural disasters to prevent the loss of lives and properties The government also formulated *The Four-Point Action Plan* after the series of tragedies in 2004 that hit Aurora and Quezon Provinces and some neighboring areas. The components of the action plan were to strengthen 1) PAGASA's forecasting capability, 2) public information campaign on disaster preparedness, 3) capacity building for local government units in identified vulnerable areas, and 4) mechanisms for government private sector partnership in relief and rehabilitation. In addition, the government also formulated *The National Science and Technology Plan for 2002-2020* (NSTP 2020), which was a long-term plan that defined the direction of Science and Technology (S&T) development in the Philippines until year 2020. Among the priority sectors identified for the

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

[3] ③: High, ②: Fair, ①: Low.

S&T development included natural disaster mitigation, which pointed toward the urgent implementation of this project to minimize damage caused by natural disasters.

At the time of ex-post evaluation, the *Philippine Development Plan (2011-2016)* recognizes that climate change and related natural disasters would lead to more poverty and the deterioration of environmental quality. In acknowledgement of this, the Philippine government formulated the *Disaster Risk Reduction and Management Act (Republic Act 10121)* in 2010 and placed importance on the *Formulation of the National Disaster Risk Reduction Framework*, using an integrated method to manage a variety of disasters, including natural and human-induced disasters. In consideration of these, PAGASA formulated the *PAGASA Strategies and Programs 2016* in 2016, which stresses the importance of improving their systems for forecasting natural and human-induced disasters. Furthermore, the central government also enacted *Republic Act 10692* or *An Act Providing for the Modernization of PAGASA*, in 2015. The act covers PAGASA's modernization of its physical resources and operational techniques, which shall entail the acquisition and/or upgrading of state-of-the-art instruments, equipment, facilities and systems, with emphasis on weather and flood monitoring and warning system and agro-meteorological observation system to strengthen services for agriculture and food security.

Therefore, this project is, and continues to be consistent with the development policy of the Philippines at the time of planning, as well as at the time of ex-post evaluation.

3.1.2 Consistency with the Development Needs of the Philippines

At the time of planning, the existing meteorological radar systems at Virac, Aparri and Guiuan located at the most strategic places for monitoring tropical cyclones hitting/crossing the country were constructed in 1994, financed by Japanese ODA loan "Meteorological Telecommunication System Development Project", and were more than 15 years old. Due to the aging of the existing radar systems, it became difficult to conduct radar monitoring. In addition, since the existing radar systems had no Doppler radar function, PAGASA was unable to monitor stormy wind generated by tropical cyclone on a real time basis, including direction of rainfall motion, and detection of local severe storm associated with tornados in the Pacific Ocean and the coastal areas; it was not possible for PAGASA to accurately locate cyclone centers or intensities of the numerous tropical cyclones and detect heavy rainfall area due to no wind convergence area data in the radar observed data. Furthermore, there was no data communication system to transmit the meteorological radar data such as rainfall intensity, wind

speed/direction inside PAGASA. Thus, considering adequate protection of life and property from tropical cyclone, it was imperative to improve the situation as soon as possible in order to provide continuous and timely dissemination of the storm signal warning and tropical cyclone information to the public.

At the time of ex-post evaluation, typhoon attacks on different areas and routes are increasing in the Philippines, in addition to expansion of its scales. For this reason, PAGASA plans to have 20 meteorological radar systems in total established by 2020 (there are 14, including the radar systems at Virac, Guiuan and Aparri at the time of ex-post evaluation), with the aim of improving their systems for monitoring typhoon routes and movements as well as heavy rainfall. In addition, PAGASA aims to improve the accuracy of weather forecasts and strengthen its institutional systems with the goal to reduce catastrophic effects of natural and human disasters through enhanced meteorological research using latest scientific technologies, human resource development and strengthened organizational development.

Therefore, the project is consistent with the development needs brought to light at the time of planning and ex-post evaluation.

3.1.3 Consistency with Japan's ODA Policy

The *Country Assistance Plan for the Philippines*, which was developed by the Ministry of Foreign Affairs of Japan in 2000, identified the following priority areas and sector assistance policy: (1) "strengthening the economy and overcoming growth constraints toward sustained economic growth"; (2) "rectification of disparities (alleviating poverty and redressing regional disparities)"; (3) "environmental protection and anti-disaster measures"; and (4) "human resources development and institution building". With regard to (3), it is stipulated that "because frequent large-scale natural disasters constrain development, and also tend to impact more heavily on the poor, we will continue to provide aid for flood and sand control and earthquake-related measures, while also assisting in developing the necessary systems and capacity in related government institutions from a medium- to long-term perspective."

This project aimed to strengthen the disaster monitoring function of the Philippines and is in line with the above priority and sector assistance policy ((3) environmental protection and anti-disaster measure). Therefore, it is consistent with the assistance policy of Japan.

In light of the above, this project has been highly relevant to the Philippine's development plan and development needs, as well as Japan's ODA policy. Therefore its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

Table 1 shows the plan and actual outputs of this project.

Table 1: Outputs of the Project (Plan/Actual)

Plan (Before Project's Commencement)		Actual (At the Time of Ex-Post Evaluation)
【Japanese Side】		
[Equipment Procurement and Installation]		
1	Meteorological Radar System: Three units (Virac, Aparri, Guiuan)	Implemented as planned.
2	Meteorological Radar Data Display System: Four units (WFFC, Virac, Aparri, Guiuan)	
3	Meteorological Data Satellite Communication System (Very Small Aperture Terminal; hereinafter "VSAT[4]"): Four units (WFFC, Virac, Aparri, Guiuan)	
[Facility Construction]		
1	Radar Tower Building (including furniture for equipment): Three sites (Virac, Aparri, Guiuan)	Implemented as planned.
【Philippine Side】		
1	Demolition of the existing facilities and building	Implemented as planned.
2	Renovation of the existing building for the Staff Quarter	
3	Removal of the existing radar system, Installation of step-down transformer(s) for 150kVA power supply for the Radar Tower Building	
4	Construction of an access road	

Source: Document provided by Japan International Cooperation Agency (JICA), Answers to the questionnaires by PAGASA

Although there were minor design changes[5], the outputs of the Japanese side were mostly implemented as planned.

Meanwhile, the meteorological radar tower at Guiuan was completely damaged by Typhoon Haiyan (local name: Yolanda) in November 2013[6]. The tower was then rehabilitated through a new grant aid project, the "Program for Rehabilitation and Recovery from Typhoon Yolanda". The construction and the procurement of equipment was implemented as per the design and

[4] It is a high speed data transmitting system utilized by satellites.

[5] Cf. There were minor changes from Basic Design (BD) to Detailed Design (DD). The main changes are explained as follows:
-Virac: Pile No. 2 moved 1,600 mm to north and pile No. 5 moved 1,600 mm to south. As drilling of well which was supposed to be potable water supplier was cancelled, agglomerations of spring water was activated instead. Then, a cubage unit of accumulation expanded and a function of filtration was added.
-Aparri: Direction of radar tower building changed.
-Guiuan: Location of radar tower building moved 2 m to north

[6] Although this system/facility was completed in September 2013 by this project, it was damaged two months later.

scale set out in this project; it was completed in December 2015[7]. Since then, there has been no typhoon damage, and the operation status remains good at the time of ex-post evaluation.

Subsequently, the structure of the meteorological radar tower at Virac was partially damaged by Typhoon Nock-Ten (local name: Nina), which occurred in December 2016. Photo 1 and 2 show the actual condition of damages caused by the typhoon. The electricity supply has been shut off since early January 2017, in order to avoid further damage due to many leakages inside the station which were caused by the typhoon. Since there is no electricity supply, the station is not operational at the time of ex-post evaluation. Meanwhile, PAGASA is considering to conduct the rehabilitation work using its own budgets for the radar tower at Virac, as of April 2017. According to PAGASA, the radar tower will be operational shortly.

Photo 1: Some solar panels were damaged by typhoon Nock-Ten

Photo 2: Water leakage sometimes occur from cracks in the ceiling caused by typhoon Nock-Ten

3.2.2 Project Inputs

3.2.2.1 Project Cost

The initially planned project cost was approximately 3,961 million yen. In reality, the project cost was approximately 3,333 million yen; thus, the project cost was lower than planned (approximately 84% of the plan). Table 2 shows the difference between the initially planned and actual cost of the project.

[7] The Grant Agreement was signed in May 2014.

Table 2: The Initially Planned Project Cost and Actual Cost

	Planned Cost	Actual Cost
Japanese side	3,406 million yen	3,169 million yen
Philippine side	Approx. 555 million yen (=Approx. 214 million PHP[8])	Approx. 164 million yen (=Approx. 71.74 million PHP[9])
Total	Approx. 3,961 million yen	Approx. 3,333 million yen

Source: JICA's document (Planned, Actual), answers to questionnaire (Actual)

The cost was kept within the planned budget because: 1) the construction costs for the Japanese side were minimized through competitive tendering, and 2) the costs for the Philippine side were greatly reduced because, while the initial budget included consumption and import taxes for the procurement of equipment, these were largely exempted by the Philippine government after the project commenced.

3.2.2.2 Project Period

This project was planned to last for 51 months, starting from May 2009 to July 2013. The actual project period was 55 months from May 2009 to November 2013, which was longer than planed (approximately 108% of the plan). The main reason for the delay was that the construction of a road connecting to the meteorological radar tower at Guiuan (to be borne by the Philippine side) took more time than planned, including the procedure until work commencement and the work itself (approx. four months delay)[10]. With regard to completion date of the development of each metrological radar station, which includes the work to be borne by the Philippine side, it was in December 2011 at Virac, in May 2013 at Aparri, and in November 2013 at Guiuan.

While the project cost was within the initial planned budget, the project period was longer than initially planned. On the other hand, the outputs were implemented as per plan. Thus, the efficiency is judged to be fair.

[8] Exchange rate: PHP 1.00=Approx. JPY 2.60, as of August 2008

[9] Exchange rate: PHP 1.00=Approx. JPY 2.29 (Note: The exchange rate was calculated by taking the average rate for the period of the Philippine side's project period, November 2011 – November 2015, based on rates issued by the IMF's International Financial Statistics (IFS).)

[10] According to PAGASA, it took some time for negotiation on land acquisition with the owner of one of the lots for access road.

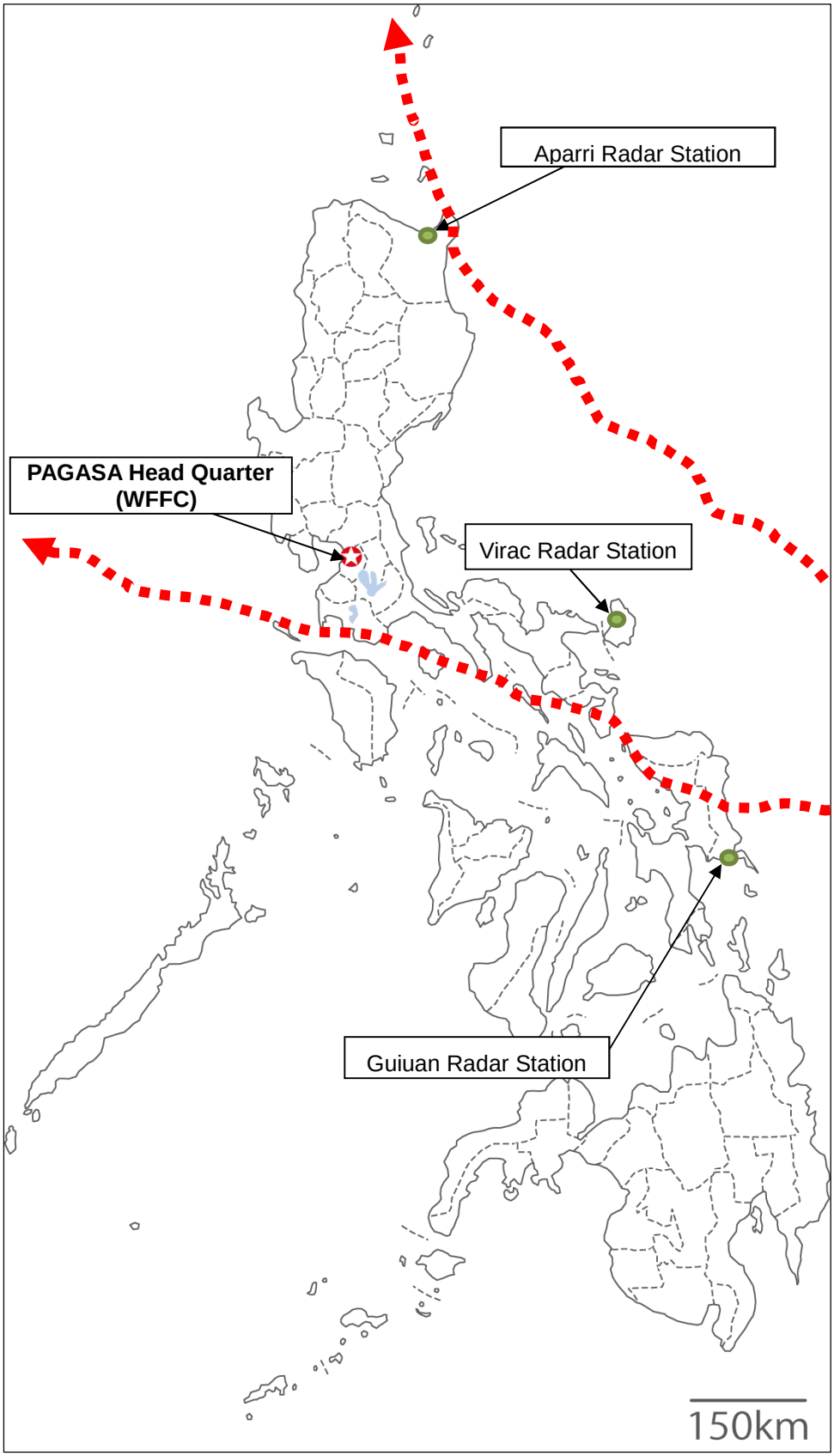


Figure 1: Location of Radar Stations Developed under this Project
(Red dotted lines indicate the two most frequent routes for the typhoons in the Philippines, in recent times.)

3.3 Effectiveness[11] (Rating: ③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

(1) Operation Indicator of the Project: Enhancement of Cyclone Monitoring Capability of PAGASA

This project aimed to improve cyclone monitoring capabilities through the development of systems for the meteorological radar stations at Virac, Aparri and Guiuan. Table 3 shows the operation indicator of the project: Enhancement of Cyclone Monitoring Capability of PAGASA (baseline, target and actual).

Table 3: Operation Indicator of the Project:
Enhancement of Cyclone Monitoring Capability of PAGASA (baseline, target and actual)

<table>
<tr><th rowspan="2">Baseline (2008)</th><th rowspan="2">Target (2014)
(One year after the completion of the project)</th><th colspan="5">Actual</th></tr>
<tr><th>2012</th><th>2013
(Completion year)</th><th>2014
(One year after the completion)</th><th>2015
(Two years after the completion)</th><th>2016
(Three years after the completion)</th></tr>
<tr><td rowspan="6">The range for detecting a precipitation intensity of 1 mm/h or more: a radius of 300km</td><td rowspan="6">The range for detecting a precipitation intensity of 1 mm/h or more: a radius of 450km[12]</td><td colspan="5">[Virac]</td></tr>
<tr><td colspan="5">Target has been achieved since May 2012.
(However since the end of December 2016, Virac station has suspended its function due to damages brought about by Typhoon Nina.)</td></tr>
<tr><td colspan="5">[Aparri]</td></tr>
<tr><td>N/A
(Not yet completed.)</td><td colspan="4">Target has been achieved since August 2013.</td></tr>
<tr><td colspan="5">[Guiuan]</td></tr>
<tr><td>N/A
(Not yet completed.)</td><td colspan="4">In November 2013, super-typhoon Yolanda completely damaged the Guiuan station The radar system operated only for two months, from September to November 2013, thus this evaluation based its judgment on the performance of this period. Target was achieved during then. The station was rehabilitated by a new JICA grant aid project by December 2015. Since then, the function has been working well and target has been achieved.</td></tr>
<tr><td rowspan="4">No capability to monitor tropical cyclonic wind velocity</td><td rowspan="4">The tropical cyclonic wind velocity maximum of 75 m/s within a</td><td colspan="5">[Virac]</td></tr>
<tr><td colspan="5">Same as above description.</td></tr>
<tr><td colspan="5">[Aparri]</td></tr>
<tr><td>N/A
(Not yet completed</td><td colspan="4">Same as above description.</td></tr>
</table>

[11] The sub-rating for Effectiveness is to be considered collectively with Impact.

[12] According to PAGASA, "detection range of precipitation intensity 1 mm/h or more" can sometimes go up to 550 km radius when Doppler function works to its maximum effect.

	200-km radius[13] becomes measurable.	.)	
		[Guiuan]	
		N/A (Not yet completed .)	Same as above description.
No capability to detect the direction of rainfall motion	The direction of rainfall motion within a 200-km radius becomes detectable.	**[Virac]**	
		Same as above description.	
		[Aparri]	
		N/A (Not yet completed .)	Same as above description.
		[Guiuan]	
		N/A (Not yet completed .)	Same as above description.

Source: Document provided by JICA (baseline, target); answers to the questionnaire (actual)

As shown in Table 3, "the range for detecting a precipitation intensity of 1 mm/h or more becomes a radius of 450 km", "the tropical cyclonic wind velocity maximum of 75 m/s within a 200-km radius becomes measurable" and "the direction of rainfall motion within a 200-km radius becomes detectable" have been achieved at Virac following its completion in May 2012. As stated in 3.2.1 Project Outputs section under Efficiency, the radar station at Virac was partially damaged by Typhoon Nock-Ten (local name: Nina), which occurred at the end of December 2016; it is currently not operational at the time of site visit for the ex-post evaluation (end of April 2017). Swift restoration would be preferable in order to maintain the capability of monitoring rainfall, wind velocity and typhoons. At Aparri, target for operation indicators has been achieved following its completion in August 2013. At Guiuan, as described in 3.2.1 Project Outputs section under Efficiency, the station was damaged by Typhoon Haiyan (local name: Yolanda) in November 2013, and was rehabilitated by a new grant aid project to the same design and scale in December 2015. The station is operational without problems at the time of ex-post evaluation; target for operation indicators has all been achieved. However, the original station was only operational from September to November 2013, and thus the two month period is used as the point for the evaluation judgement. As a result, this project contributed to strengthen PAGASA's disaster monitoring functions during the period.

One of the significant reasons for which target for operation indicators has been achieved was that the Doppler function was introduced into the meteorological radar systems in this

[13] According to PAGASA, "monitoring capability of tropical cyclonic wind velocity maximum 75m/s" can go up to 250km radius when Doppler function works to the maximum effect.

project. The function can monitor wind velocities up to a maximum of 75 m/s and detecting the directions of rainfall motion within a 200-km radius, etc. are possible. Before this project began, there was not a single radar station with the Doppler function in the Pacific Ocean area surrounding the Philippines, except Baler radar station located in the eastern part of Luzon Island.

(2) Effect Indicator: Enhancement of Capability of PAGASA for the issuance of public storm signal warning (Detection of tropical cyclone expected to come to the Philippines within the next 36 hrs.)

With regard to the effective indicator shown in Table 4, with the introduction of Doppler meteorological radar systems at Virac, Appari and Guiuan, 24 hour continuous surveillance during typhoons became possible after 2013. More concretely, PAGASA headquarters (WFFC) gained the ability to receive real time information on rainfall and wind levels from the meteorological radar systems at Virac, Aparri and Guiuan; they were able to swiftly issue typhoon warning signals and information (mainly, position and strength of tropical cyclone) on an hourly basis to the organizations such as shown in Figure 2. (It used to be at best every six hours (four times per day) before the project began.)

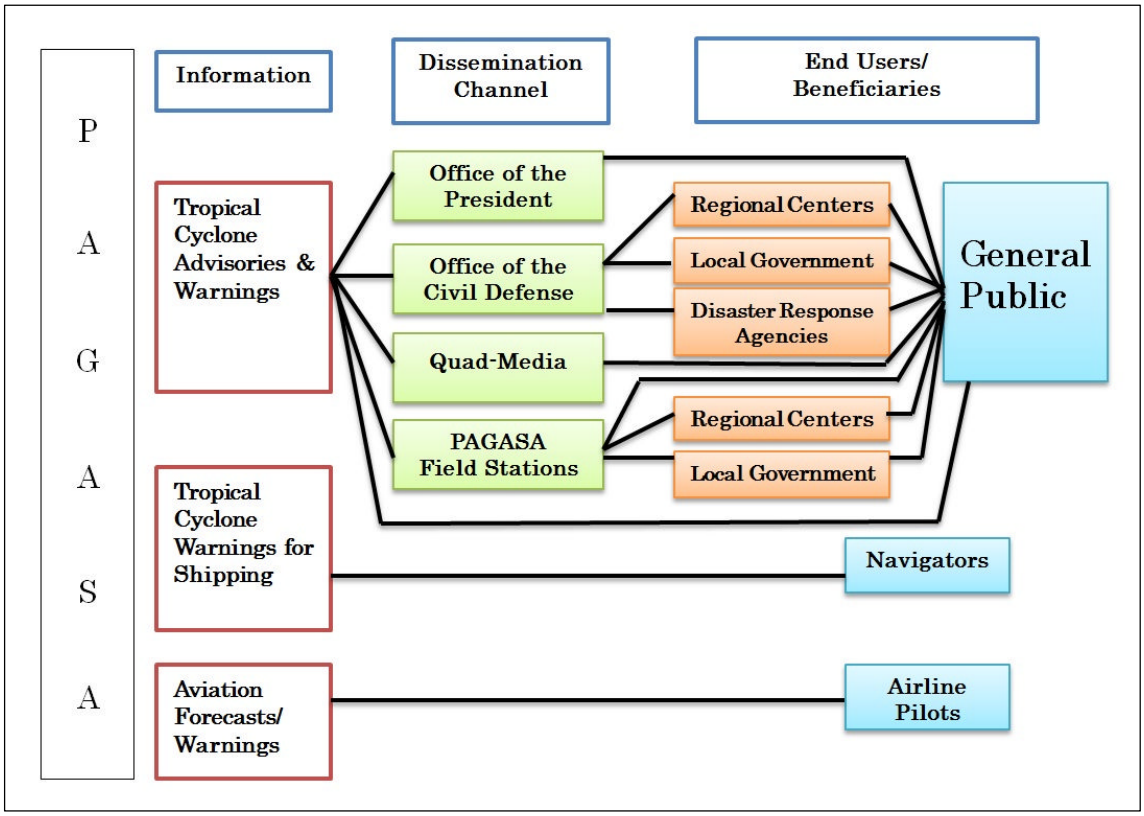
Table 4: Effect Indicator of the Project:
Enhancement of Capability of PAGASA for the issuance of public storm signal warning
(Detection of tropical cyclone expected to come to the Philippines within the next 36 hrs.)
(baseline, target and actual)

Baseline (2008)	Target (2014) (One year after the completion of the project)	Actual				
		2012	2013 (Completion year)	2014 (One year after the completion)	2015 (Two years after the completion)	2016 (Three years after the completion)
4 times a day (every 6 hrs)	Hourly issuance (Position and strength of tropical cyclone)	N/A	Target has achieved since 2013: Hourly issuance (Position and strength of tropical cyclone)			

Source: Document provided by JICA (baseline, target); answers to the questionnaire (actual)

The typhoons, storms and direction forecasts monitored at each of the project's meteorological radar stations are first transmitted to PAGASA headquarters (WFFC). Then, as explained in Figure 2 (Warning Dissemination Chart), the typhoon forecasts announced by PAGASA headquarters are transmitted to local governments, other related ministries and general citizens through the Office of the President, the Office of Civil Defense, the media and

PAGASA's field stations. The general public can get typhoon forecast information through radio, television, newspapers, social media and smartphone application software.



Source: PAGASA

Figure 2: Warning Dissemination Chart

3.3.2 Qualitative Effects (Improvement of the staff's operation skills)

This project became a trigger for improving the capabilities of PAGASA's technical staff engaged in meteorological forecasting and radar systems. In addition, it is contributing to the improved accuracy of weather forecasting. Weather forecasters at PAGASA headquarters (WFFC) and the employees of the meteorological radar stations at Virac and Aparri were interviewed about whether or not their technical skills had improved over the course of implementing this project. The following comments were received: (1) From WFFC: "Through this project, we believe that the capabilities and accuracy of monitoring cyclones and issuing typhoon warning signals have improved and that citizens are increasingly trusting PAGASA's weather forecasts. On the other hand, it is becoming more difficult to predict the scale and nature of typhoons year by year, and more accuracy in weather forecasting is increasingly required. It is therefore necessary to be constantly equipped with a broad range of technical skills such as renewal of equipment, improvement of technical operation, etc. In addition, we

also think that we need to improve our operational capabilities as an organization." (2) From Virac: "We see a change from before the project commenced in that our staff is more motivated to carry out their daily tasks because they can now deal with the latest systems, such as the Doppler function." (3) From Aparri: "With the introduction of the latest systems, such as the Doppler function, we always feel the need to upgrade our IT and analytical skills."

Based on the comments above, it can be presumed that this project is playing a role in boosting staff motivation in the workplace, while also improving the accuracy of weather forecasting through improvements of technical capabilities.

3.4 Impacts

3.4.1 Intended Impacts

3.4.1.1 Contribution to the reduction of risks in disaster caused by tropical cyclones and other severe weather phenomena

It was expected that this project would reduce risk in disaster caused by tropical cyclones and other severe weather phenomena. For a reason nowadays thought to be caused by climate change, the characteristics of natural disasters are changing; typhoons are increasingly accompanied by spontaneous storms and thunder, and some typhoons take routes that have never been seen before. However, the following comments were given about the impact of this project by the project related people:

The management team of the Provincial Disaster Risk Reduction Management Office (PDRRMO) of Cagayan and that of its subordinate office, the Municipal Disaster Risk Reduction Management Office (MDRRMO) of Aparri commented in interviews: "Before this project began (before 2009), one must admit that the accuracy of the weather information PAGASA was providing to the general public and local governments was very low. It was not rare for weather forecasts to turn out to be wrong, and there was not a great deal of trust in them. However, with the new radar stations, the accuracy of PAGASA's weather forecasts and warnings has become high, and subsequently the public's trust on PAGASA has become high. Based on the information provided by PAGASA, we have promptly instructed residents to evacuate during typhoons. One of the most significant factors is thought to be the existence of the radar station at Aparri, which has a Doppler radar. For example, when Typhoon Haima (local name: Lawin, a super typhoon occurred in October 2016) hit the area, residents were constantly in touch to ask for the predicted direction of the typhoon; based on PAGASA's typhoon route forecast information, we think that we were able to provide prompt and relevant information to

the people. If PAGASA's information had not been trustworthy, the casualties (6) enumerated in Table 6 would have been more. In addition to being able to predict expected typhoon courses and future rainfall based on PAGASA's weather forecasts and warnings, we think it is also useful for preparing evacuation sites and giving instructions to residents." Based on such comments, it can be said that through the project, PAGASA is able to provide accurate weather warnings from the radar stations that enable local governments to secure sufficient lead time to evacuate residents during typhoons. As a result, it can be judged that the project significantly contributes to minimizing casualties and damages to assets. Therefore, it can be assumed that there is possibility that damages occurred by natural disasters have been alleviated.

(Reference) Related to above comments, Table 6 shows the numbers of deaths, injured, missing and affected persons due to typhoons in recent years for the province of Cagayan, where the Aparri radar station is located.

(Reference) Table 6: Casualties and affected persons in the Province of Cagayan (2013-2016)

(Unit: person)

Natural disaster &Year	Casualties			Affected Persons
	Death	Injuries	Missing	
Typhoon Odette (2013)	0	0	0	12,785
Typhoon Vinta (2013)	2	11	0	287,826
Typhoon Luis (2014)	1	1	0	47,310
Typhoon Dodong (2015)	0	0	0	6,825
Typhoon Ineng (2015)	0	3	0	75,891
Typhoon Lando (2015)	1	2	0	157,362
Convergence of Monsoon and Easterlies (2015)	0	1	0	88,071
Typhoon Lawin (2016)	6	111	0	856,243

Source: Provincial Climate Change & Disaster Risk Reduction Management Office, Province of Cagayan

Photo 3: Metrological Radar Tower at Aparri

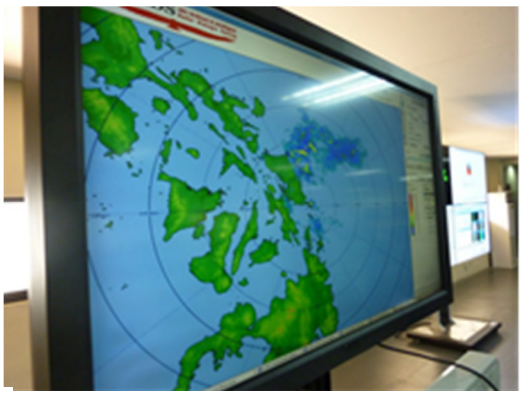


Photo 4: Typhoon Observation at WFFC

3.4.2 Other Impacts

3.4.2.1 Impacts on the Natural Environment

Through the questionnaires, interviews and field inspections, it was confirmed that the meteorological radar stations at Virac, Aparri and Guiuan have not caused any negative impact (Noise, vibration, air pollution, occurrence of dust due to vehicle passage, etc.) on the environment during the implementation of the project, as well as after its completion.

Since the completion of the project, environmental monitoring has not been conducted concerning the facilities and equipment developed by this project. Neither PAGASA nor its supervising body, the Department of Science and Technology (DOST), has established any monitoring system. According to PAGASA, if negative issues concerning the environment were to arise, the Department of Environment and Natural Resources (DENR) would look into the matter first and try to address the issue in collaboration with local governments. However, since there have been no problems throughout till the ex-post evaluation, there is no actual case to verify this point.

3.4.2.2 Land Acquisition and Resettlement

Under this project, no resettlement occurred as a result of this project[14]. While a site for the construction of an access road at Virac was subject to land acquisition, land owned by local government (some hundred square meters[15]) was provided to PAGASA for free. In the case of the site at Aparri, an area of land (about 5,000 m^2), including an access road, was given by the local government for free[16]. Similarly at Guiuan, it was not subject to land acquisition. (A site for constructing an access road (about 975 m^2) was originally owned by PAGASA.)

＜Summary of Effectiveness and Impacts＞

With regard to the quantitative effects, “the range for detecting a precipitation intensity of 1 mm/h or more becomes a radius of 450 km”, “the tropical cyclonic wind velocity maximum of 75 m/s within a 200-km radius becomes measurable” and “the direction of rainfall motion within a 200-km radius becomes detectable” have almost been achieved at the Virac, Guiuan and Aparri stations[17]. In addition, PAGASA headquarters (WFFC) receive real time rain and

[14] The project sites at Virac, Aparri and Guiuan were on hills or coastal areas and far from residential areas; no resettlement was thus necessary.
[15] It was not possible to identify accurate area figures.
[16] There was no particular need to pay compensation to the local governments. Things were processed smoothly.
[17] Although the meteorological radar station at Virac is not operation at the time of ex-post evaluation, it can be judged that these actual indicators for all stations have almost achieved.

wind information generated by the meteorological radar systems, based on which they can continuously monitor for 24 hours and issue typhoon information every hour. Furthermore, it was confirmed through interviews that local governments have been able to secure enough lead time until local residents evacuate based on the typhoon course forecasting announced by PAGASA. In short, there is possibility that this project has been indirectly contributing to reduce casualties and damages due to disasters. Based on these factors, this project has achieved its objectives, and therefore effectiveness and impact of the project are high.

3.5 Sustainability (Rating: ②)

3.5.1 Institutional Aspects of Operation and Maintenance

The executing agency of this project is PAGASA[18]. PAGASA mainly works on meteorological monitoring, communication, analysis, flood forecasting and warnings, as well as related studies and promotions.

Concerning operations at the meteorological radar stations, two observation systems exist: normal observation and special observation. Normal observation is conducted once a day. Special observation commences when typhoon, heavy rain and/or storms are detected by the meteorological radar, and are then conducted every hour (24 times a day). Information is reported to PAGASA headquarters (WFFC) in real time using telephones, email, radios, meteorological data satellite communication system (VSAT), etc. The special observation ends when the typhoon moves outside of the range of the meteorological radar or outside of the Philippine Area of Responsibility (PAR).

The main maintenance works taking place at the meteorological radar stations are daily cleaning, inspection and repairs of the structures inside the compound, as well as surveillance to prevent thefts inside the premises. In addition, the maintenance of the radar systems includes equipment inspection (including data output analysis), the renewal and management of IT software and the changing of parts.

PAGASA has a total of 855 employees (as of December 2016). The number of staff at the meteorological radar stations at Virac, Aparri and Guiuan, constructed by this project, and at PAGASA headquarters (WFFC), are shown in Table 7, 8, and 9:

[18] PAGASA is under the Department of Science and Technology (DOST) and plays a key role in providing meteorological information to national disaster prevention and management efforts. PAGASA is supervised by DOST.

Table 7: Staff at Each Meteorological Radar Station

(Unit: No. of Staff)

Position	Meteorological Radar Station[19]		
	Virac	Aparri	Guiuan
Chief Meteorological Officer	1	1	1
Assistant Meteorological Officer	1	0	1
Observer/Radar Operator	4	4	3
Electronic Engineer/Technician	(4)	(4)	(3)
Mechanical Technician	(4)	(4)	(3)

Source: Answers to questionnaire

Note*: Figures in brackets represent Observer/Radar Operators who also work as Electronic Engineers /Technicians and Mechanical Technicians. This means that they work in teams to play multiple roles.

Table 8: Staff of "Quick Response Team[20]" of Radar System at WFFC

(Unit: No. of Staff)

Position	PAGASA Headquarters (WFFC)
Chief of Meteorological Equipment and Maintenance Section	1
Officer-in-charge of Radar Maintenance Unit	1
Meteorological Radar Engineer	2
Meteorological Radar Technician	4

Source: Answers to questionnaire

Table 9: Staff of "Quick Response Team" of Communication/ICT at WFFC

(Unit: No. of Staff)

Position	PAGASA Headquarters (WFFC)
Electronic Engineer (Communication, VSAT, GPRS[21]/EDGE[22] Equipment)	1
Electronic Technician (Communication, VSAT, GPRS/EDGE Equipment)	4
ICT/Software Engineer (Network & Computer Equipment + Software Maintenance)	1
ICT/Software Technician (Network & Computer Equipment + Software Maintenance)	9

Source: Answers to questionnaire

With regard to the number of staff, staff at PAGASA headquarters (WFFC) and the Virac and Aparri meteorological radar stations commented in interviews: "The necessary numbers of

[19] Each meteorological radar station is under the respective PAGASA Regional Services Division (PRSD). Virac is under the Southern Luzon-PRSD, Aparri is under the Northern Luzon-PRSD and Guiuan is under the Visayas-PRSD. Each Division allocates operation and maintenance budgets to each station, in order to carry out the activities.

[20] At PAGASA headquarters (WFFC), a quick response team has been formed with a view to providing assistance to meteorological radar stations and to quickly respond to any malfunctions of the meteorological radar systems and VSAT.

[21] It is abbreviation of "General Packet Radio Service". It is a packet oriented mobile data service on the 2G and 3G cellular communication system's GSM (Global System for Mobile Communications).

[22] It is abbreviation of "Enhanced Data GSM Environment". It is a digital mobile phone technology that allows improved data transmission rates as a backward-compatible extension of GSM.

staff have been allocated to carry out operation and maintenance works. We would not say that there is any shortage." In fact, there is an increasing focus on meteorological forecasting and flood forecasting and warnings at PAGASA recently, as will be discussed in 3.5.3 Financial Aspects of Operation and Maintenance. Moreover, the budget allocated by the central government to PAGASA is on the increasing trend. As a result, the demanded workload has also increased, and the number of staff, especially at headquarters, is on the increase.

Based on the above, it can be judged that there are no particular problems concerning the institutional aspects of the operation and maintenance of this project.

3.5.2 Technical Aspects of Operation and Maintenance

Since the completion of this project, training sessions have been given to staff at PAGASA headquarters (WFFC), and at each radar station, on a regular basis. For example, practical training sessions, such as the following, have been conducted: "Rainfall Warning System (RWS) Training/Workshop for Forecasters (2013)"; "Training Seminar on Radar Observation and Data Interpretation (2013)"; "Training Course on Probabilistic Quantitative Precipitation Forecasting (PQPF) (2014)"; "Meteorological Technicians Training Course (2015)"; "Disaster Risk Reduction and Management Training for PAGASA Employees (2016)." In addition, On the Job Training (OJT) is also given to newly recruited staff. Particularly, in order to become a weather forecaster, one must have an engineering certificate upon graduating from university, and upon joining PAGASA one must go through a year-long weather forecasting training course as well as a month-long practical, hands-on training course.

Interviews with staff at PAGASA headquarters (WFFC), and at each radar station, confirmed that they understood the importance of their operation and maintenance duties and the specifications of the equipment procured through this project. In addition, the interviews confirmed that the staff responsible for the operation and maintenance of equipment have ample work experience and are equipped with the technical skills to promptly address any problems associated with the functionality and operations of the equipment.

During the project implementation, there were technical supports and advices from the Japanese consultant regarding the operation of the radar station. Support in terms of trainings were organized and conducted both at WFFC and radar stations to enhance the capacity of personnel in data interpretations and usage, operations and maintenance of the radar system.

A maintenance manual was provided by the consultant from this project, and each member of staff at the meteorological radar stations refers to the manual as needed in order to carry out

their day-to-day duties.

In light of the above, it can be judged that there are no particular problems with the technical aspects of the operation and maintenance of this project.

3.5.3 Financial Aspects of Operation and Maintenance

Table 10 shows PAGASA's total budgets for the last three years. The amount has significantly increased since the commencement of the project. This is because PAGASA's duties, in terms of meteorological forecasting, communications, analyses, forecasting and warning (including for floods), along with related research and advocacy works, have increased recently and thus the budgets have also increased. The amount almost tripled from 2014 to 2015 as a result of the central government recognizing the importance of PAGASA's roles and duties. According to PAGASA, they have been allocated the same level of budget since 2016.

Table 10: PAGASA's Total Budgets

(Unit: 1,000 PHP)

2013	2014	2015
1,452,205	1,256,104	3,464,214

Source: PAGASA

Table 11 shows the operation and maintenance budgets of WFFC and those allocated to PAGASA's Regional Services Divisions (PRSDs) that administer the radar stations at Virac, Aparri and Guiuan for the last three years. The operation and maintenance budgets of WFFC, as well as those of PRSDs that administer the radar stations at Virac, Aparri and Guiuan, are also on the increase[23]. Executive staff at WFFC and chief officer at the Virac and Aparri radar stations commented in interviews: "The necessary budgets have been allocated in recent years and financial matters do not interrupt our duties. Also, the budgets in the near future will be estimated as same level as the current status."

[23] It was not possible to identify the O&M budget of each individual radar station.

Table 11: O&M Budgets of WFFC and Regional Services Division (PRSD)

(Unit: 1,000PHP)

	2013	2014	2015
WFFC	22,853	59,131	56,808
Southern Luzon-PRSD (Virac radar station is under their jurisdiction)	8,240	11,675	11,675
Northern Luzon-PRSD (Aparri radar station is under their jurisdiction)	16,481	23,350	23,350
Visayas PRSD (Guiuan radar station is under their jurisdiction)	15,794	22,377	22,377

Source: PAGASA

Note: It was not possible to obtain the O&M amount of each metrological station and proportion which each PRSD provides.

In light of the above, it can be judged that there are no particular problems with the financial aspects of the operation and maintenance of this project.

3.5.4 Current Status of Operation and Maintenance

Concerning systems for maintaining the facilities and equipment at the meteorological radar stations established by this project, the staff at each radar station clean and repair daily, weekly or monthly[24] in accordance with the category of the maintenance work. In the case of the meteorological radar system requiring a major repair beyond the capacity of PAGASA to deal with, local suppliers (local representations of Japanese companies) will be called upon to address the matter.

Spare parts are managed by PAGASA headquarters. According to PAGASA, there have been no problems in terms of shortages or delayed delivery related to the procurement of spare parts at the time of ex-post evaluation.

In terms of the metrological radar station at Virac, the electricity supply has been shut off since early January 2017, in order to avoid further damage due to many leakages inside the station which were caused by Typhoon Nock-Ten (local name: Nina). Since there is no electricity supply, the station is not operational at all, as of late January 2017. Meanwhile, PAGASA headquarters (WFFC) is considering to conduct the rehabilitation work about the radar tower at Virac, as of April 2017. According to PAGASA, the radar tower will be operational shortly.

[24] The different categories of the maintenance works are as follows: daily maintenance tasks at each meteorological radar station, including cleaning inside the facility and a simple check of equipment functionality; weekly tasks are equipment inspections, including data output analyses; and monthly tasks are inspections of the radar antenna and frequency data.

＜Summary of Sustainability＞

With regard to PAGASA's operation and maintenance systems at the time of ex-post evaluation, the necessary numbers of staff are secured to carry out operation and maintenance works. Concerning the technical aspects, training has been held regularly, and staff members are well-experienced. Regarding the financial aspects, through observation and interviews with the staff at WFFC as well as at Virac and Aparri meteorological radar stations, it can be judged that budgets of operation and maintenance regarding the meteorological radar systems developed by this project are sufficient. However, the meteorological radar tower at Virac that was partially damaged by Typhoon Nock-Ten (local name: Nina) in December 2016 is suspending at the time of ex-post evaluation. It should be rehabilitated as early as possible. Based on the above, the sustainability of this project can be fair.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

By developing the existing meteorological radar systems at Virac, Aparri and Guiuan, this project aimed to improve tropical cyclone observation capabilities and upgrade accuracy of weather forecasts of PAGASA; thereby contributing to reduce risk in disaster caused by tropical cyclones and other severe weather phenomena. The implementation of this project is judged to be consistent with the development policy and needs of the Philippines both at the time of planning and ex-post evaluation. This project also has consistency with Japan's ODA policy. Therefore, its relevance is high. While the project cost was within the initial planned budget, the project period was longer than initially planned. Thus, the efficiency of the project is judged to be fair. Quantitative effects have almost been achieved at the Virac, Guiuan and Aparri stations. In addition, PAGASA headquarters (WFFC) receive real time rain and wind information generated by the meteorological radar systems, based on which they can continuously monitor for 24 hours and issue typhoon information every hour. Furthermore, it was confirmed through interviews that local governments have been able to secure enough lead time before evacuating local residents based on the typhoon forecast announced by PAGASA. In short, there is possibility that this project has been indirectly contributing to reduce casualties and damages due to natural disasters. Thus, effectiveness and impact of this project are high. In terms of sustainability, no major problems have been observed in the institutional, technical, financial aspects and current status of the operation and maintenance. However operation of the meteorological radar station at Virac that was damaged by Typhoon Nock-Ten (local name:

Nina) in December 2016 is suspended at the time of ex-post evaluation. Therefore sustainability of the project effects is fair.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

It is recommended that PAGASA rehabilitate the meteorological radar station at Virac, which was partially damaged by Typhoon Nock-Ten (local name: Nina) in 2016, as early as possible in order to maintain its capabilities of monitoring rainfall, wind velocity and typhoons.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

Importance of site selection and swift development regarding metrological radar station

In this project, Virac, Appari, Guiuan were selected for development of metrological radar stations. As shown in Figure 1, typhoons in the Philippines are passing over these stations very frequently. It was significant and urgent to develop the stations in these areas. Meanwhile, the typhoon's size and route in the Philippines are changing and forecast is becoming complicated year by year (according to PAGASA, it is because of influence of climate changes), it is necessary for PAGASA to respond by constantly improving typhoon monitoring. In order to carry out accurate typhoon monitoring, it is said that the appropriate selection of project site and the swift development of the stations are always necessary.