Summary of Terminal Evaluation

1. Outline of the Project	
Country: Republic of Ecuador	Project title: Project for Enhancement of the Volcano Monitoring Capacity in Ecuador
Issue/Sector: Disaster management	Cooperation scheme: Technical Cooperation Project
Division in charge: Disaster Management Team, Group III (Water and Disaster Management), Global Environment Department	Total cost (As of November, 2006): 217,296 thousand yen
Period of Cooperation : May 1, 2004 - April 30, 2007	Partner Country's Implementing Organization: Geophysical Institute/Department of Geophysics, National Polytechnic University (Instituto Geofísico- Depto. de Geofísica, Escuela Politécnica Nacional)
	Supporting Organization in Japan: National Research Institute for Earth Science and Disaster Prevention

1-1 Background of the Project

The Republic of Ecuador is located across Andes Mountains, and has many active volcanoes such as Tungurahua and Cotopaxi. Many people live surrounding these active volcanoes and, therefore, the mitigation of volcanic disasters is one of priority issues of the country.

Monitoring of active volcanoes is undertaken by Geophysical Institute (IG) of National Polytechnic University. The monitoring is carried out by networks of seismometers of IG. The networks observe seismic waves that are closely associated with precursors of volcanic eruptions, and IG prepares volcanic activity reports for disaster mitigation based on the data obtained by the networks. The reports are sent periodically to the civil defense institute and related local governments.

Formerly, the seismometers of IG could detect short-period seismic waves but not low-frequency vibrations which are often observed in the beginning of the volcanic activities and, therefore, IG was not able to grasp the precursor signals of eruptions adequately. Consequently, IG could not prepare volcanic activity report that sufficiently took account of internal activities of volcanoes, and IG realized the necessity of improving the report so that organizations related to volcanic disaster management could take appropriate actions against volcanic disasters. Under these circumstances, there was an urgent need for introducing (1) a new network of seismometers capable of observing long-period seismic waves, (2) air vibration meters, (3) a real time data collection system, and (4) quantitative data analysis techniques.

The Government of the Republic of Ecuador submitted an official request to the Government of Japan in July 2002, for cooperation in observation and analysis of volcanic earthquakes. In response to this request, Japan International Cooperation Agency (JICA) in cooperation with IG commenced the "Project for Enhancement of the Volcano Monitoring Capacity in Ecuador" (hereinafter referred to as "the Project").

JICA dispatched an evaluation study team to Ecuador during the period form November 5 to 25, 2006 in order to confirm the achievements of the Project that would end on April 30, 2007.

1-2 Project Overview

(1) Overall goal: To enhance the capacity of mitigating volcanic disasters in Ecuador.

(2) Project purpose: To enhance the capacity of volcano monitoring at Mt. Cotopaxi and Mt. Tungurahua

(3) Outputs:

Output 1

The Geophysical Institute improves its capacity to monitor the volcanic activity including long-period and very-long-period events on a real time basis at Mt. Cotopaxi and Mt. Tungurahua.

Output 2

The Geophysical Institute improves its capacity to process and store volcanic activity data properly including long-period and very-long-period events at Mt. Cotopaxi and Mt. Tungurahua.

Output 3

The Geophysical Institute enhances its capacity to analyze precursory signals of eruptions.

Output 4

The results of the analyses are described properly in the volcanic activity reports.

Output 5

The volcanic activity information from the Geophysical Institute is understood and effectively used by the disaster prevention authorities concerned.

1-3 Inputs (as of November, 2006)

＜Japanese side＞

1) Short-term experts

8 Japanese experts were dispatched in the fields of seismic analysis, seismic observation, and leader of installation of seismic observation system.

2) Training in Japan

Two persons of IG were accepted in Japan for training in the field of volcanic observation and data analysis.

3) Provision of equipment

Observation equipments and a vehicle equivalent to 181,985 thousand yen were provided. Technicians for installation of equipments were also dispatched.

4) Other expenses

Costs entailed by the activities of Japanese experts were covered.

The total amount provided to cover all the expenses for inputs listed above was 217,296 thousand yen.

＜Ecuadorian side＞

1) Counterpart personnel

25 researchers and technicians were assigned as counterparts of the Japanese experts, apart from the Project Director. Among them, 10 counterparts were in charge of volcanology and seismology, and the other 15 were in charge of equipment.

2) Local costs

IG covered the cost for remodeling a part of its building for project activities. IG also prepared lands for installing equipments in observation sites and repeaters, and provided labor costs for installation of equipments as well as costs of transport of equipments. The total costs covered by IG were 138,605.94 US Dollars.

2. Outline of the evaluation study team

Members of Evaluation Team (Japanese side)	1. Satoru Mimura (Leader) Team Director, Disaster Management Team, Global Environment Department, Japan International Cooperation Agency 2. Shingo Fujiwara (Cooperation Planning) Disaster Management Team, Global Environment Department, Japan International Cooperation Agency 3. Erika Tanaka (Evaluation Analysis) Global Link Management Inc. 4. Atsuko Yoshikawa (Interpreter) Japan International Cooperation Center	
Period of Evaluation	November 5, 2006 - November 25, 2006	Type of Evaluation : Terminal

3. Outline of the results of the evaluation

3-1 Results of Evaluation

Project purpose

As to the project purpose to enhance the capacity of volcano monitoring at Mt. Cotopaxi and Mt. Tungurahua, the Project is making a progress toward it but more time is required to attain the originally expected level of achievement because there was a delay of activities due to the eruption of Tungurahua Volcano and subsequent impediment of installation of equipment.

As a result of the fact that the volcanic monitoring network installed by the Project is functioning and monitoring data are obtained and analyzed on the real time basis, volcanic activity reports of IG have become more accurate than those produced in the time when the Project commenced, and delivered timely to the related organizations. In particular, on the occasion of eruptions of Tungurahua in July and August 2006, the equipment installed by the Project obtained accurate data on the real-time basis, and appropriate analyses were undertaken. Then, IG provided precise information on the volcanic activities to disaster prevention authorities and mass media in a timely manner.

However, there are still some issues to be addressed toward the enhancement of volcano monitoring capacities to a sufficient level. Due to the continuous volcanic activities, one of the five monitoring

stations to be established in Mt. Tungurahua has not been established yet. Furthermore, the equipments of two monitoring stations were destroyed by the volcanic eruption. Therefore, the monitoring of Mt. Tungurahua is undertaken by only two monitoring stations. In addition, there have been troubles of data transmission, and this hinders the monitoring in real time by IG. The lack of the number of monitoring stations and the data transmission problem make it impossible to obtain quality data, which was expected in the beginning. Even at the monitoring stations functioning normally, the start of acquiring data was delayed due to a delay of equipment installation. Therefore, IG has not been sufficiently experienced in the monitoring using the new equipment introduced by the Project, which led to a delay of improvement and application of data analysis systems. In addition, the data obtained by the monitoring network of the Project have not led to the improvement of the volcanic activity information for related organizations.

Outputs

Output 1: The Geophysical Institute improves its capacity to monitor the volcanic activity including long-period and very-long-period events on a real time basis at Mt. Cotopaxi and Mt. Tungurahua.

Indicator 1 : The data of volcanic activities including long-period and very-long-period events are acquired on a real time basis at the Institute.

The Ecuadorian counterparts have become capable of installing equipments at monitoring stations on their own. They have learned how to operate the real-time monitoring system, and have become capable of dealing swiftly with troubles of the monitoring network. Four out of five monitoring stations of Mt. Cotopaxi produce monitoring data in real time without errors. The other one station has a problem of data transmission during daytime on weekdays due to the saturation of 2.4GHz band that are used by the network. As to the signals coming from Mt. Tungurahua where only two monitoring stations are functioning because of the destruction of equipments by the eruption on August 17, 2006, there is the same data transmission problem during daytime on weekdays.

Output 2 : The Geophysical Institute improves its capacity to process and store volcanic activity data properly including long-period and very-long-period events at Mt. Cotopaxi and Mt. Tungurahua.

Indicator 2-1 : Continuous volcanic activity data are systematically monitored and locations of the events are determined.

Wave form monitoring is carried out for Mt. Cotopaxi and Tungurahua using the available data through data reception server and automatic wave form generating program. For Mt. Cotopaxi, seismic sources are automatically located by automatic analysis program. For Mt. Tungurahua, a lack of some monitoring stations makes it impossible to determine seismic sources using the data obtained only by the monitoring network of the Project but the sources are located with complementary data obtained by existing short-period seismometers. The accuracy of locating seismic sources by IG has been significantly improved for both Mt. Cotopaxi and Mt. Tungurahua.

Indicator 2-2 : Continuous data are stored and wave form are systematically cataloged.

Continuous volcanic activity data obtained by the network are systematically monitored for both Mt. Cotopaxi and Mt. Tungurahua. A computer program to make a database of event data are about to be developed.

Output 3: The Geophysical Institute enhances its capacity to analyze precursory signals of eruptions.

Indicator 3-1 : Two investigators are capable of more advanced quantitative analysis of long-period and very-long-period events and associated signals. Two other investigators can conduct same analysis under the guidance of the two investigators.

Two investigators of IG developed their capacity of data analysis but they left IG. However, another two investigators who were trained by them, and one more investigator who received training from the latter two can carry out basic analysis of volcanic activities without any difficulties.

Indicator 3-2 : Capacity of analyzing other data is enhanced.

The understanding of the magmatic systems of Mt. Cotopaxi and Mt. Tungurahua was enhanced because of the enhancement of quantitative wave-form analysis methods. The introduction of the computer program that applies these analysis methods to the data obtained by the monitoring network of

the Project has not been fully completed.

Output 4: The results of the analyses are described properly in the volcanic activity reports.
Indicator 4 : Results of the analyzed data including long-period and very-long-period events are written in the volcanic activity reports.

The volcanic activity reports basically describe results of analyses using data obtained by short-period seismometers. Furthermore, the results of analysis using data obtained by the monitoring network of the Project are gradually reflected on the volcanic activity reports

Output 5: The volcanic activity information from the Geophysical Institute is understood and effectively used by the disaster prevention authorities concerned.
Indicator 5 : Improved volcanic activity reports are comprehended by the disaster prevention authorities.

The volcanic activity reports are periodically delivered to related organizations such as Civil Defense and local authorities, and these organizations highly appreciate them as being timely and precise information. On the occasion of the eruption of Mt. Tungurahua from July to August 2006, the data obtained by the broad-band seismometers and air vibration meters newly introduced by the Project significantly contributed to the monitoring of the volcanic activities, and they were utilized for the provision of information to mass media and disaster management authorities. However, owing to the delay of the activities, the results of analyses including those using long-period seismic waves have not been fully reflected on the volcanic activity reports. Therefore, such information has not fully been utilized by the disaster prevention authorities.

3-2 Process of implementation

The Project is about to attain the expected achievements but overall progress is rather behind the schedule.

The main cause of the delay was that the installation of necessary equipments for project activities required more time than expected. For one reason, the preparation for the installation of equipment required significant time, and installation was delayed due to the blockade of traffic by strikes and bad weather. For another reason, the eruption of Mt. Tungurahua from July to August 2006 destroyed equipments of two monitoring stations, and there was one planned monitoring station where equipments could not be installed because it was not accessible due to the eruption. This planned monitoring station is under consideration for relocation. Moreover, there have been cases of discontinuation of data acquisition due to the data transmission problem. All these factors mentioned above led to the delay of data acquisition and analysis compared to the original schedule but significant achievements have been made by corrective measures such as using data from existing equipments of IG.

Project activities have generally been carried out orderly in reference to the Project Design Matrix (PDM). Modifications to PDM have not been made. It is necessary to establish a system to confirm and share information on the progresses and achievements of the Project between both Japanese and Ecuadorian sides.

Both Japanese and Ecuadorian personnel implemented the project activities with high motivations. Communication between Japanese experts and Ecuadorian counterparts has been effective. Some engineers who were dispatched from Japan for installation of equipments were not very proficient in English and had some difficulties with communication with Ecuadorian counterparts but satisfactory transfer of technology was undertaken.

3-3 Summary of Evaluation Results

(1) Relevance

The relevance of the Project is high in reference to the needs and policies of Ecuador as well as Japanese Official Development Assistance (ODA) policy for Ecuador.

In Ecuador, volcanic disaster is one of the most significant threats of natural disasters together with meteorological disasters resulting from El Niño phenomenon, earthquakes, floods, and landslides. In order to cope with volcanic disasters, it is important to strengthen risk management that enables to take necessary actions before disasters occur. This project aims at enhancement of volcano monitoring capacities that is a vital key to the adequate risk management. Therefore, the relevance of the Project is high. Furthermore, Mt. Cotopaxi and Mt. Tungurahua currently have the highest risks

of volcanic disasters among all volcanoes in Ecuador.

The national development plan of Ecuador from 2003 to 2007 indicates that one of the six basic policies is “civil protection, security, assurance of justice, food security, and environmental conservation”. This basic policy deals with management of natural disasters including threats of volcanoes. The “line of action 3” that was set in accordance with this basic policy defines “prevention of various disasters (i.e. natural, man-made, and technical disasters)” as a policy that contributes to environmental conservation.

Priority areas of Japanese ODA for Ecuador consist of “poverty reduction”, “environmental conservation”, and “disaster management” according to the political dialogue held in July 2005. Within “disaster management”, the priority is given to the “reduction of vulnerability to natural disasters”.

(2) Effectiveness

Sufficient outputs are attained through the activities implemented by the Project, and enhancement of capacities of volcano monitoring at Mt. Cotopaxi and Mt. Tungurahua is confirmed. However, the degree of enhancement of the capacity is not sufficient due to the effects of the delay of activities.

By the introduction of the new monitoring equipment, it is now possible to acquire a kind of data which could not be obtained by existing equipments, in real time at Mt. Cotopaxi and Mt. Tungurahua. IG can now deliver adequate volcanic activity information including those data to related organizations 24 hours a day. There is a reputation among the related organizations that there have been improvements in the reliability of the information from IG. However, currently available data are not sufficient to undertake scientific analyses for accurate understanding of the movements of magma because the installation of equipment at one more monitoring station at Mt. Tungurahua has not been undertaken, and two monitoring stations are not functioning due to the damages caused by the eruption. Furthermore, counterparts of IG have not been fully trained in data analysis using the analysis equipment provided by JICA because of the delay of installation of monitoring equipment. Therefore, it is a coming task to develop a capacity to synthetically interpret the volcanic activities using the data obtained by the monitoring network of the Project.

As to the efficient utilization of the results of analyses of volcanic activities, IG and related organizations efficiently used the results of the analysis to take appropriate actions when Mt. Tungurahua erupted in 2006. However, trainings have not been undertaken yet for relate organization using the results of analyses of the data obtained by the monitoring network of the Project, due to the delay of establishing monitoring stations at Mt. Tungurahua. In order to develop a comprehensive volcano monitoring capacity, capable of appropriately responding to emergency situations, it is necessary to improve the volcanic activity reports reflecting the results of analyses using the data of the new monitoring network, and carry out activities to give support to the related organizations.

The 5 Outputs of the Project are all necessary for volcano monitoring, and they contribute to the attainment of the Project Purpose to enhance the capacity of volcano monitoring at Mt. Cotopaxi and Mt. Tungurahua.

Regarding the Important Assumptions of the Project, there were uncontrollable external factors, i.e. the delay of installation of equipments and destruction of equipments due to the eruption of Mt. Tungurahua. In addition, two counterparts who received transfer of technology at the beginning stage of the Project left IG but the remaining staff members of IG trained by those two are attaining the expected Outputs of the Project.

(3) Efficiency

Because of the delay of inputs and destruction of installed equipment by the eruption, there was some room for improvements in terms of efficiency at the time of this evaluation but inputs already introduced were generally utilized effectively.

The dispatched Japanese experts for the Project were highly qualified having high-level expertise, and undertook technical transfer activities as expected. The engineers who were dispatched for the installation of equipment could have carried out more effective activities if they had been able to adjust the time of their activities striking a balance with the regular operations of IG.

There was a loss of efficiency because two counterparts left IG after receiving training in Japan, and could not participate in the project activities after the installation of equipment. However they had transferred the acquired technology through the training to other staff of IG before they left and, therefore, it is considered that the outcomes of the counterpart training in Japan remain in IG.

The equipment provided for the Project was indispensable for the enhancement of volcano monitoring capacity and greatly contributed to the establishment of technically more sophisticated monitoring stations and repeater sites, and to the acquisition of high-quality information and the implementation of advanced analyses which had not been possible previously. The seismic waves and the air vibration, which were precursory signals of the eruption of Mt. Tungurahua, were precisely recorded by the project equipment, and analyzed by IG counterparts and Japanese experts. This led to the timely prediction of the large-scale eruption. Although some equipments were destroyed by the eruption, other equipments have generally been utilized effectively and have contributed significantly to the volcano monitoring. The maintenance of the equipment has been adequate.

The delay of the installation of the equipments affected the overall efficiency of the Project. Moreover, there is still a problem of data transmission in some sites where there is heavy traffic of communication with the same frequency band as that being used by the monitoring network because of the interference of electric waves. To solve this problem, the Project will undertake a detailed survey of the state of the use of different frequency bands and will modify the data transmission system to avoid the data transmission failures.

Some equipments were destroyed by the eruption of Mt. Tungurahua at two monitoring stations and they are out of service at the moment although this was brought by an uncontrollable factor. The Project will re-install equipments after a reconsideration of the location of the monitoring stations to avoid the effects of pyroclastic flows and lahars, and this will restore the function of the monitoring stations.

As to the inputs form Ecuadorian side, the allocation of a sufficient number of qualified counterparts contributed to the attainment of the project outputs. In addition, administrative and operational staff also appropriately supported the Project. The technical staff and laborers provided by Ecuadorian side were very effective for quick and proper installation of equipments at repeater sites and monitoring stations.

(4) Impact

The possibility of attaining the Overall Goal of the Project is high, considering the fact that IG and related organization minimized the victims at the occasion of the eruption of Mt. Tungurahua in 2006.

Although the Project established the monitoring networks for only two volcanoes, namely Mt. Cotopaxi and Mt. Tungurahua, the volcano monitoring capacities of IG have been enhanced through the activities at these two volcanoes, which can be applied to other volcanoes. For this reason, it can be expected that the monitoring capacities will be improved at all volcanoes in Ecuador.

Mitigation of volcanic disasters can not be achieved only by the improvement of monitoring capacities but IG has been developing good relationships with related organizations for many year, and also there is exchange of information and experience among related local authorities and local civil defense units, which will make it possible to disseminate the project outcomes to areas outside the project target areas and use them to mitigate volcanic disasters there. The keys to producing the impact of the Project in the future are to improve the understanding of information from IG by disaster preventions authorities, and also to strengthen the countermeasures for disaster mitigation by them.

Unexpected positive impacts of the Project are that the improvement of the quality of volcanic activity information of IG led to the enhancement of institutional credibility of IG, and that the delivery of volcanic activity information at the time of the eruption of Mt. Tungurahua resulted in greater interests in and better understanding of volcanoes among various stakeholders. In addition, the cooperation between Japan and Ecuador has become widely known by general public in Ecuador.

Unexpected negative impacts of the Project were not observed.

(5) Sustainability

It is considered that the sustainability of the Project is generally high but further actions will be effective to enhance the sustainability to a sufficient level because there has been the delay of the project activities.

As to the technical sustainability, IG is considered, at the time of this evaluation, to have a certain level of capacity to sustain the Project technically. However it is necessary to further enhance the overall capacities of data analysis of IG personnel as there has been a lack of time to analyze the data obtained by the monitoring network of the Project due to the delay of the installation of the equipment. In addition, computer programs to continuously enhance the technical sustainability

have not been developed. For example, if a computer program is developed to automatically store and analyze data for undertaking routine works, it will strengthen the technical sustainability. Important factors for the technical sustainability are that the staff members of IG remain in their respective positions, and that spare parts of the equipment are stably provided.

Organizational sustainability is generally high. The Government of Ecuador considers disaster management as an important issue. In addition, the status of IG in the administration of volcanic disaster management defined by the Presidential Order 3593 will not change. Potential threats to the institutional sustainability in the future include a change in the current framework of disaster management, and weak commitments to disaster management from some responsible persons in disaster prevention authorities at both central and local levels.

Financial sustainability is also generally high. Currently, IG has not been allocated sufficient budget from the central government but IG has been developing a mechanism to raise funding on their own, which will ensure financial sustainability. The possibility of budget cut in the future due to the change of government administration and organizational reform of the University is not zero but not seems to be significant.

3-4 Factors that promoted or hindered the realization of project effects

One of the factors that promoted the realization of the project effects was strong motivation of Japanese experts and Ecuadorian counterparts. Another factor was the improved capacity of IG as well as a close relationship between IG and organizations related to disaster management, which led to realize an effect of the Project at the occasion of the eruption of Mt. Tungurahua. On the other hand, a factor that hindered the realization of the project effect was the delay of the installation of the equipment. The eruption of Mt. Tungurahua destroyed some equipments making two monitoring stations out of service, and prevented the installation of equipment at the remaining one monitoring station. At the same time, however, the eruption provided a valuable opportunity to deliver necessary information to related organizations that they required to make appropriate decisions.

3-5 Conclusions

The Project is making a steady progress toward the fulfillment of the Project Purpose although some delay in its progress is observed. As to the process of implementation, a part of planned activities has not been implemented yet due to the delay of installation of the equipment as well as the destruction of equipments by the eruption. Outputs are being attained but the delay of the process of implementation has left a task to further enhance the monitoring capacities through analyzing the data obtained by the monitoring network of the Project. Therefore, it requires some more time to fully attain the Project Purpose. The highly appreciated actions of IG at the eruption of Mt. Tungurahua indicate that the possibility of attaining the Overall Goal of the Project is high if the remaining task is undertaken.

3-6 Recommendations

1. Extension of the cooperation period of the Project

The cooperation period of the Project should be extended for two years in order to fully attain the Project Purpose, which would not be possible by the end of the present cooperation period.

2. Project operation policy in the future

(1) Restoration of the monitoring stations that were affected by the eruption

1) The Project should study adequate locations of the monitoring stations including the possibility of relocating the existing stations.

2) The Project should repair or replace the damaged equipments.

(2) Solving the problem of data transmission

1) The Project should confirm the data transmission and relaying routes (including the locations of repeater sites).

2) The Project should identify frequency bands that would not cause data transmission failures caused by the saturation of the frequency band currently used.

3) The Project should make an equipment procurement plan to solve the data transmission problem and undertake the following tasks.

a) To summit an application to a competent authority for the use of the frequency band that has been identified as suitable.

b) To procure and install the equipment after the acquisition of a permit to use the frequency band.

(3) Implementation of the transfer of technology

While improving the situations of equipment as described above, the Project should also implement the transfer of technology regarding data analysis.

(4) Strengthening the collaboration with disaster prevention authorities

The Project should undertake dissemination activities to enhance the understanding of Civil Defense and local authorities responsible for disaster management about how to use the volcanic activity information (including the interpretation of the results of quantitative analyses of the volcano monitoring data) provided by IG.

3. Administration and progress management of the Project

The Project should consider the introduction of a joint mechanism with participation of both Japanese and Ecuadorian sides for coordination among related organizations of the Project as well as the management of the progress. IG, JICA, and Japanese experts should be involved in the mechanism, and National Institute of International Cooperation (INECI) and Embassy of Japan may also participate as observers when necessities arise.

4. Revision of PDM

It is desirable to revise the PDM including its indicators, taking the opportunity of signing the Record of Discussions for extension of the cooperation period or dispatch of JICA study team if the cooperation period of the Project is actually extended.

3-7 Lessons learned

- For those projects in which the provision of equipment plays an important role, the preparation of the procurement of the equipment should be undertaken with much caution and time. It is an idea to dispatch a study team or experts for making the specifications of the equipment, prior to the commencement of the project if it is possible. Furthermore, procedures for installation of equipment, such as acquisition of land or a permit to use a certain frequency band, are vital factors for smooth installation of the equipment, and they can vary among different countries. Therefore, such procedures need to be closely studied in advance and surely undertaken.
- For those projects that deal with natural phenomena, there may be situations when urgent procurement of equipment is necessary. Therefore, it is desirable to establish a special mechanism to simplify and hasten the process of the procurement from a tender to delivery and installation of equipment.
- For projects related to disaster management, provision of spare parts for equipment should be flexible, considering the possibility of the equipment being damaged by natural disasters during the cooperation period.