

Republic of Honduras

FY 2016 External Ex-Post Evaluation of Japanese Grant Aid Project

“The Project for Landslide Prevention in the Tegucigalpa Metropolitan Area”

External Evaluator¹: Hajime Sonoda, Global Group 21 Japan, Inc.

0. Summary

The Project for Landslide Prevention in the Tegucigalpa Metropolitan Area, a grant aid cooperation project, (hereinafter referred to as “the Project”) was implemented to mitigate the risk of landslide disaster in El Berrinche and El Reparto of Tegucigalpa by means of constructing landslide prevention facilities and developing a landslide monitoring system and an early warning and evacuation system, thereby contributing to promotion of landslide prevention in the Tegucigalpa metropolitan area. The Government of Honduras has consistently made conscious efforts regarding disaster management and there is a strong necessity in Tegucigalpa for disaster prevention targeting landslides and floods. The Project was relevant to Japan’s ODA policy at the time of its planning and, therefore, the relevance of the Project is high. As the project cost was within the planned amount but the project period exceeded the planned period, efficiency of the Project is fair. Landslide prevention facilities introduced by the Project have been functioning properly and the targeted landslide blocks have been stabilized. Although the information dissemination to nearby residents has not been sufficient, landslide monitoring continues and an early warning system operated by the Tegucigalpa Municipal Emergency Committee (*Comité de Emergencia Municipal*: hereinafter referred to as “CODEM”) and community disaster management organizations is functioning in the two targeted sites. Technical capability of the Municipality of Tegucigalpa to handle landslide prevention measures is being strengthened but the application of these measures in the metropolitan area is limited. While the concrete achievement of the new facilities to mitigate disaster damages cannot be verified because there has been no heavy rain since the completion of the Project, the Project has provided many residents with peace of mind. To summarize, effectiveness and impact of the Project are high. There are no major issues in regard to the institutional, technical and financial aspects of the Project in terms of its sustainability. Taking the good operation and maintenance conditions of the landslide monitoring system and the landslide prevention facilities into consideration,

¹ In order to undertake detailed technical and professional analysis in addition to an evaluation analysis by the external evaluator, an expert analysis by Professor Hiroshi Fukuoka (Director of the Research Institute for Natural Hazards and Disaster Recovery, Niigata University) was conducted. Professor Fukuoka specializes in landslide studies and has participated extensively in international research and technology dissemination activities related to landslide, for example landslide survey in Machu Picchu, Peru, technical cooperation in Central America and Central Asia (as an expert dispatched by JICA), among others. Professor Fukuoka participated in the initial field survey of this ex-post evaluation and gathered information from field visit as well as from the executing agency, exchanged views with government organizations and academic research institutions related to disaster management in Honduras, and prepared an expert analysis paper. In this ex-post evaluation, evaluation results, recommendations and lessons learned were compiled with Professor Fukuoka’s advices. Summaries of his expert analysis paper are shown as Box1 and 2. It should be noted that the external evaluators (Sonoda) took part in the analysis on “Relationship with JICA’s other cooperation on landslides (Box 2)” of the expert’s analysis.

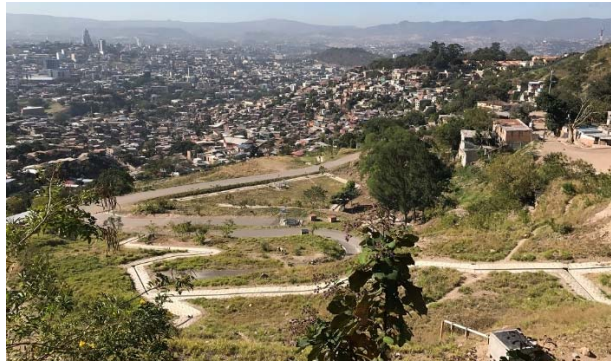
sustainability of the Project is high.

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

1. Project Description



Project Location



Complete view of El Reparto (After the implementation of countermeasures)

1.1 Background

Tegucigalpa, the capital of Honduras, is vulnerable to natural disasters because of the natural conditions which make it prone to flooding and landslides and its disorderly urbanization with a continuous inflow of poor people from rural areas. Total more than 13,000 people have been either killed or missing due to Hurricane Mitch in Honduras, which hit Central America in October, 1998. In Tegucigalpa alone, number of people killed or missing exceeded 1,000. A massive landslide which occurred in El Berrinche of Tegucigalpa not only destroyed residential areas but also blocked Choluteca River which was running through the centre of the city, causing flood damage over a wide area in the centre of the metropolitan area.

As part of the assistance for post-hurricane reconstruction in Honduras, Japan International Cooperation Agency (JICA) implemented the "Study on Flood Control and Landslide Prevention in the Metropolitan Area" from 2001 to 2002 with a view to formulating a disaster management master plan for flood and landslide prevention in Tegucigalpa. In this study, having identified high risk areas for flood and landslide, feasibility studies on urgent and priority projects were conducted. The Project was implemented in response to the request made by the Government of Honduras concerning landslide prevention measures of which feasibility was studied.

1.2 Project Outline

The Project is implemented to reduce the risk of landslide disaster in El Berrinche and El Reparto of Tegucigalpa by constructing landslide prevention facilities, conducting landslide monitoring and developing an early warning and evacuation system, thereby contributing to promote landslide prevention in the metropolitan area.

E/N Grant Limit / Actual Grant Amount	(Detailed Design) 45 million yen; (Main Work) 1,053 million yen (Detailed Design) 45 million yen; (Main Work) 994 million yen
Exchange of Notes Date / Grant Agreement Date	(Detailed Design) February 2011; (Main Work) June 2011 (Detailed Design) February 2011; (Main Work) June 2011
Executing Agency	The Joint Coordination Committee composed of the following members was responsible for project implementation and maintenance: Municipal Administration of Central District (AMDC, Chairman), Ministry of Public Works, Transportation and Housing, Ministry of External Planning and Cooperation, Ministry of Natural Resources and Environment, Permanent Contingency Commission (COPECO)
Project Completion	October 2013
Main Contractors	Hazama Ando Corporation
Main Consultant	Joint Venture of Central Consultant Inc. and Earth System Science Co., Ltd.
Preparatory Study	July – December 2010
Related Projects	Study on Flood Control and Landslide Prevention in the Metropolitan Area (Development Study; 2001 – 2002); Project on Capacity Development for Disaster Risk Management in Central America "BOSAI"(Technical Cooperation; 2007 – 2012); Hazard Geology Focusing on the Landslides in Tegucigalpa (Dispatch of Science and Technology Experts: 2012-2014); Assistance for Strengthening and Capacity Building of Professional techniques for the Control and Mitigation of Landslide in Tegucigalpa Metropolitan Area (Dispatch of Individual Experts; 2015 – 2016); Project on Capacity Development for Disaster Risk Management in Central America, Phase 2 (Technical Cooperation; 2015 – 2020)

2. Outline of the Evaluation Study

2.1 External Evaluator

Hajime Sonoda (Global Group 21 Japan, Inc.)

2.2 Duration of Evaluation Study

This ex-post evaluation study for the Project was conducted over the following period.

Duration of the Study: October 2016 to February 2018

Duration of the Field Survey: February 9 to 24, 2017 and May 29 to June 3, 2017

2.3 Constraints for Evaluation

As both of the sites targeted by the Project are areas with unstable public security, a police escort was required for the field visit by the evaluator. Because of the difficulty of staying for a long time, it was impossible to visually and closely check some of the facilities constructed under the Project. Moreover, as it was risky to enter neighboring

residential areas, interviews with community disaster management organizations were held in the conference room of CODEM. Direct interviews with schools and residents in and around the targeted sites were not possible. A beneficiary survey by a local consultant was conducted with the guidance of community disaster management organizations and being escorted by police,² and it was not possible to conduct random sampling of target households.

3. Results of the Evaluation (Overall Rating:A3)

3.1 Relevance (Rating: ③³)

3.1.1 Consistency with the Development Plan of Honduras

At the time of planning (2010), Honduras, as a country most severely hit by Hurricane Mitch, was keen to introduce measures to prevent natural disasters. *Natural Disaster Management System Act*⁴ was enacted in 2009 and the *National Plan 2010 – 2022* formulated in 2010 lists natural disaster management as one of the seven priority targets. At the same time, the *National Climate Change Strategy* was formulated as a strategic plan for disaster management sector under the *National Plan*.

At the time of ex-post evaluation, Honduras maintains its National Climate Change Strategy. Active promotion of disaster management by Honduras based on the framework of the *Natural Disaster Management System Act* is illustrated by its adoption of the *National Policy for Integrated Risk Management*⁵ in 2013 and the *National Plan for Integrated Risk Management (2014 – 2019)*⁶ in 2014.

As described above, the Project was highly relevant to the development policy of Honduras at the time of both its planning and ex-post evaluation.

² As part of the ex-post evaluation, a beneficiary survey using a questionnaire was conducted through personal interviews, targeting those residents under direct threat of landslide in the two targeted areas. The purpose of this survey was to establish whether or not the early warning and evacuation system at household and community levels had been properly established, and what changes had been made to local lives due to the mitigation of landslide risk. In the light of unstable public security of these areas, the interviewers visiting the districts were guided by a member of a community disaster management organization with a police escort. Interviewees were selected by judgement sampling. Number of households actually interviewed was 51 in El Berrinche and 54 in El Reparto. The ratio of men to women was 28% to 72%.

³ ①: Low; ②: Fair; ③: High

⁴ *National Disaster Management System Act (Ley del Sistema Nacional de Gestión de Riesgos)* covers disasters in general and aims at prevention, mitigation, response and rehabilitation of/to disasters.

⁵ *National Policy for Integrated Risk Management (Política de Estado para la Gestión Integral del Riesgo en Honduras)* aims at strengthening the cooperation between various organizations as a general target. More concrete targets are ① enhanced understanding of the threat and risk of disasters, ② incorporation of the concept of comprehensive risk management in policies, ordinances, strategies, etc., ③ strengthening of disaster prevention budget management, ④ capacity building of organizations and ordinary citizens and ⑤ swift and appropriate response to emergencies and disasters.

⁶ *National Plan for Integrated Risk Management* is a six-year plan formulated by the Permanent Contingency Commission (COPECO) in 2014 for the purpose of effectively implementing the *National Policy for Integrated Risk Management*. It provides more detailed descriptions of the implementation bodies, implementation timing, evaluation indicators and other relevant matters concerning concrete targets, strategic guidelines and policies stipulated by the said policy.

3.1.2 Consistency with the Development Needs of Honduras

Of the target areas of the Project, the landslide occurred at El Berrinche at the time of Hurricane Mitch (1998), in addition to the complete destruction of some 100 houses and seven people recorded missing, brought about extensive flood damage due to a landslide dam formed by the clogging of Choluteca River that is located to the south of El Berrinche. On the other hand, more than 100 houses were completely destroyed in El Reparto. Despite such damages in the past, no adequate landslide prevention measures had been in place in either sites at the time of planning, continuing the situation of a persistence risk of new landslides due to rainfall.

At the time of ex-post evaluation, however, the landslide risk is believed to have been greatly reduced by the Project in both sites (see the section on Effectiveness). Meanwhile, according to the Municipality of Tegucigalpa, there are incidents of landslides or cliff failures almost every year in Tegucigalpa, even from 2014 and onwards, causing damage to houses, etc. *The Action Plan*⁷ formulated by the Municipality of Tegucigalpa in 2016 states that 11% of the municipal population lives in high landslide risk areas, and land areas with medium to high landslide risk account for 80% of the metropolitan area, creating a major obstruction to the development of the metropolitan area. Moreover, 85% of the population of these landslide risk areas are low income people living in newly developed residential areas. The Action Plan proposes four strategic targets: ① integrated water management, ② reduction of the vulnerability to natural disasters, ③ inclusive and orderly growth and ④ safe and prosperous communities. For the purpose of disaster management, the Action Plan proposes appropriate regulations for land use, recognition of the disaster risk (including a detailed study with landslide damage projection), introduction of a natural disaster insurance system, flood control measures targeting Choluteca River, resettlement of residents from landslide risk areas, landslide survey and monitoring, and introduction of an early warning system. The Action Plan also refers to the maintenance of landslide prevention facilities constructed under the Project.

Based on the above, the relevance of the Project to the development needs of Honduras is high at the time of both planning and ex-post evaluation.

3.1.3 Consistency with Japan's ODA Policy

At the time of planning, according to the *Rolling Plan* (2010, Ministry of Foreign Affairs) for Honduras, four priority areas for assistance were “basic education”, “health and water”, “regional development” and “disaster management and measures against climate change”. As “disaster management” is listed as one of the development themes under “disaster management and measures against climate change”, the Project is classified as assistance for the said development theme.

⁷ *The Tegucigalpa and Comayagüela Action Plan (El Plan de Acción para Tegucigalpa y Comayagüela)* assisted by the Inter-American Development Bank.

Based on the above, the Project is highly relevant to Honduras's development plan and development needs as well as Japan's ODA policy. Therefore, its relevance is high.

3.2 Efficiency (Rating: Ⓣ)

3.2.1 Project Outputs

Under the Project, structural measures to prevent landslides⁸ were implemented targeting El Berrinche and El Reparto along with the development of landslide monitoring facilities and technical assistance under the capacity building component (hereinafter referred to as "soft component") of the Project. The planned and actual outputs by the Japanese side are shown in Table 1.

Table 1 Comparison between the Planned and Actual Outputs

	El Berrinche		El Reparto	
	(Planned)	(Actual)	(Planned)	(Actual)
<u>Structural Measures for Landslide Prevention</u>	8	8	2	2
Catchment well	6,500m	6,500m	3,200m	2,910m
Water collecting boring works	250m	250m	none	none
Horizontal boring works	692m	751m	147m	139m
Drainage boring works	3,379m	2,454m	1,951m	1,443m
Open and closed canals	16,199m ³	17,100m ³	3,736m ³	4,710m ³
Soil removal works	16,699m ³	17,600m ³	4,209m ³	3,310m ³
Embankment works				
<u>Monitoring System</u>	(Planned)	(Actual)	(Planned)	(Actual)
Rain gauge	1	1	1	1
Extensometer	4	4	2	2
Borehole inclinometer	1	2	1	1
Automatic groundwater gauge	3	3	1	1
<u>Soft Component</u>	(Actual) In connection with the topics listed in the left column, lectures, field visits, analytical exercise of landslide stability, exercise of preparing a hazard map, etc. were conducted in three sessions along with the construction work, principally targeting those officials involved in disaster management activities in Tegucigalpa. No evacuation drills were conducted.			
Maintenance system of the facility				
Monitoring system				
Early warning and evacuation system				

Source: Materials provided by JICA and Tegucigalpa city

⁸ According to the *Landslide Prevention Act* of Japan, a landslide is defined as "the phenomenon of sliding down of part of the ground caused by groundwater, etc. or the phenomenon of ground movement accompanying the sliding down of the ground". The type of landslide targeted by the Project is the recurrent sliding of soil mass (landslide block) along the sliding surface formed by a landslide in the past. When the groundwater level rises due to heavy rain, the soil mass above this level is subject to buoyant force, and the resistance force (friction force) of the sliding surface becomes smaller than the sliding force (force that the soil mass would slide down along the sliding surface), causing a landslide. Therefore, a landslide can be prevented by controlling a rise of the groundwater during rain through evacuating groundwater by catchment wells and horizontal boring works, and draining of surface water by channel works, etc. Removal of soil in the upper part of a landslide block reduces the sliding force while banking in the lower part of a landslide block increases the resistance force. Works designed to improve the balance between the resistance force and sliding force by removing such causative factors of a landslide are called "control works". In contrast, works designed to stop part or whole of the landslide movement by using the resistance force held by anchors, steel pipe piles, caisson piles, etc. are called "prevention works". Under the Project, landslide prevention was implemented through control works.

The Honduran side was responsible for the relocation of power poles and distribution lines, improvement of the sewer inlets to the target areas, provision of a temporary yard, disposal of waste, deployment of policemen and traffic policemen during the construction work and construction of a gabion revetment at the scouring site on the left bank of Choluteca River. These works were carried out as planned.

The plan for the Project was prepared during the “Preparatory Study for the Project for Landslide Prevention in the Tegucigalpa Metropolitan Area” (July-December, 2010, hereinafter referred to as “the Preparatory Study”). The planning policy of the Preparatory Study to primarily use “control works” in view of economy was appropriate (see Box 1). The findings of interviews with CODEM and the field survey indicate that the scope and construction quality of the structural measures implemented under the Project are appropriate.

During the Preparatory Study, a new movement of one landslide block not previously recognized was confirmed in a peripheral area of El Berrinche. Although this block was outside the planned scope of the control works under the Project, one bore hole to install an inclinometer was added for monitoring purposes at the time of the detailed design. No control works were implemented for this block. As for the structural measures for landslide prevention, changes were made to the locations and quantities of water collecting and drainage boring works, canals and catchment wells to be adjusted to topographical deformation occurred before the commencement of construction, and also to the location of the construction road to avoid unstable sites prone to landslides. These changes were judged to be necessary and appropriate.

As for the data transfer and warning transmission from monitoring equipment, wireless transmission using mobile phone lines was originally assumed. This was changed at the time of the detailed design to cable-based data transfer with the installation of observation stations at the premises of nearby cooperating households. While this change was made in consideration of mitigating the risk of theft and better economy, it became necessary for officials in charge to visit these stations to obtain data. The original plan for groundwater gauges was an automated measurement and transfer of continuous data to observation stations. All the three automatic groundwater gauges installed in El Berrinche broke down, however, due to a lightning strike during the construction. Then, all of them were changed to manual gauges in consideration of the difficulty of repairing such breakdowns in the future (the bore hole for measuring operation were left for the installation of the manual gauges which were procured separately). These changes meant that it would be necessary to visit these bore holes each time to measure the groundwater level in El Berrinche and that continuous data would not be available. In El Reparto, an automatic water gauge was installed as planned for observation of the groundwater level.

The above changes of the monitoring system, etc. were made based on judgements on the actual site conditions. The change of the data transfer method and installation of manual water gauges for observation of the groundwater in El Berrinche adversely affected the convenience of

data acquisition and data continuity. Moreover, even though the scope of monitoring and locations of the monitoring equipment are considered to be generally adequate, they are not necessarily sufficient because of its configuration featuring an equipment quantity and locations commonly employed for small-scale landslides (see Box 1).

Training organized as part of the soft component was attended by members of CODEM and other stakeholder organizations i.e. Ministry of Public Works, Transportation and Housing, Ministry of External Planning and Cooperation, Ministry of Natural Resources and Environment, and Permanent Contingency Commission (hereinafter referred to as “COPECO”). CODEM members underwent training primarily focusing on landslide monitoring and maintenance of the facilities. According to CODEM, contents of the training were adequate. Although some of the theoretical topics requiring specialized knowledge of geology, etc. were difficult, the trainees acquired basic knowledge of landslide and basic skills for the operation and maintenance (including landslide monitoring) of the Project. As all of the training participants from other stakeholder organizations had moved to other organizations by the time of the ex-post evaluation, it was not possible to obtain their opinion on the training. Some senior officials of the community disaster management organization in the two areas also participated in the training, but no evacuation drill with the participation of residents was conducted because CODEM was too busy due to a mudslide caused by the rupture of a water main during the period planned for it.

Box 1

Summary of an Expert Analysis (1) : Appropriateness and effectiveness of the structural measures and landslide monitoring of the Project

Hiroshi Fukuoka (Director of the Research Institute for Natural Hazards & Recovery, Niigata University, Professor)

Landslide prevention facilities were constructed under the Project using such “control works” as catchment wells, open canals, drainage boring works, soil removal and embankment works. In Japan, such “prevention works” as anchors, steel pipe piles and caisson piles may be used to tackle potentially large landslides in socially important areas. However, these require large budget, their maintenance is complicated and the local production of replacement parts is very difficult. Because of this, the restriction of the scope of the Project to “control works” is considered to be a valid decision. The catchment wells installed are appropriate as using the standard design in Japan in terms of the diameter, depth, liner plate, protection net for the opening, maintenance steps and drainage boring. Design of all other facilities does not raise any special concerns.

However, it cannot be said that these new facilities have completely eliminated the possibility of reactivation of large-scale landslide in El Berrinche in future triggered by a direct hit of an earthquake or extremely heavy rain and formation of a landslide dam due to the clogging of Choluteca River and flooding of central Tegucigalpa on the opposite bank. To prepare for such an event, construction of underdrains along the river channel could be useful as well as stockpiling of drainage pump and fabric pipes. As these measures are cheaper than caisson

piles and other “prevention works”, feasibility of their adoption should be examined from now on.

As for landslide monitoring, extensometers and borehole inclinometers, both of which are typical and the most reliable instruments to observe any ground movement, were selected and installed under the Project. Having understood the scope of monitoring and the structure and mechanism of these instruments, CODEM has conducted their maintenance, collection and basic analysis of the data by itself. Therefore, types of monitoring facilities installed is generally appropriate and it appears that minimum necessary technical transfer has been successfully performed. However, the landslide monitoring system introduced under the Project comprises a quantity and deployment of equipment usually employed to monitor small-scale landslides, it gives an impression that the system was half-finished in both sites.

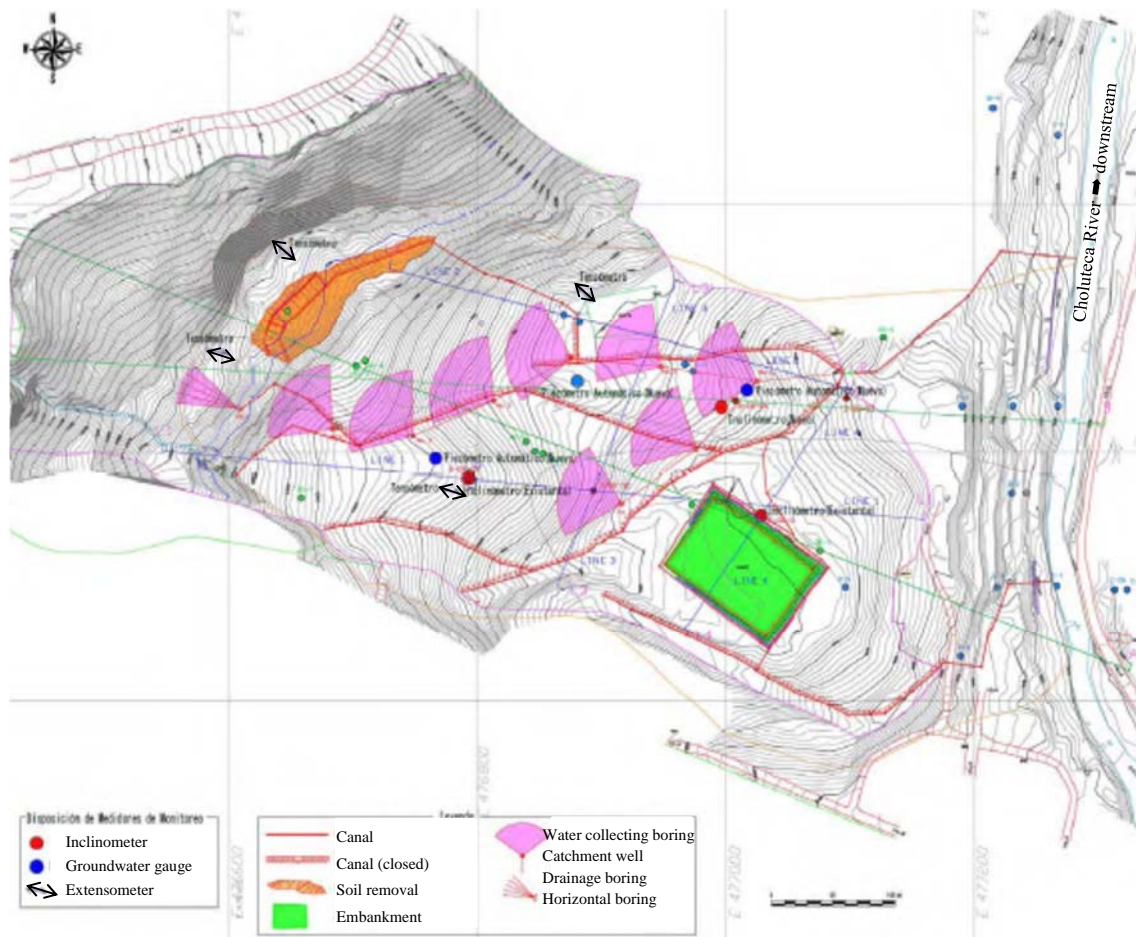
In El Berrinche, a socially important district, a monitoring system for the entire landslide area should be established with total coverage of the landslide blocks from top to bottom by extensometers and periodical monitoring using a total station.⁹ In regard to data analysis, there is still some room for improvement in view of devising data analysis according to the quality of data, for example, removal of noises, extraction of minute displacements, etc.

As far as extensometers are concerned, a unit of short span extensometer of 10m - 20m is installed at several places near the top of the slope. Movement of the main scarp could have been detected with high accuracy if another unit of short-span extensometer had been installed branching out from the long span invar line (up to 100 m). In the case of borehole inclinometers, the most basic analysis method has been transferred. However, there were cases where sliding movement could not be quantified simply by repeating this method when the actual displacement was smaller than the margin of error. Monitoring frequency of the groundwater level is insufficient. Technical transfer was not made on quantitative assessment of the effects of catchment wells based on the groundwater level monitored since the construction of a catchment well in comparison with the monitoring results before construction, for which monitoring should had been started before construction. Observation stations are installed on the premises of individual households and have been properly maintained. However, there has been a lack of training for house dwellers on how to respond when an early warning siren is sounded. There has also been a lack of evacuation drills.

In general, CODEM has conducted maintenance of the facilities installed under the Project in a competent manner. Monitoring results of the two sites, especially the data recorded by the extensometers and borehole inclinometers, do not show any significant movement, indicating that the target landslide blocks have been stable. This means that the Project has generally achieved its objective of stabilizing the landslides. It is acknowledged that, by combining “control works” which are inexpensive and based on a simple structure, the Project has been achieving sufficient effects in terms of the stabilization of landslides. There is, however, no sufficient understanding of what level of heavy rainfall and subsequent rise of groundwater could lead to a reactivation of landslides because of the lack of sufficient data to properly analyse the relationship between the rainfall intensity and movement of landslide blocks. The landslide in El Berrinche has a complex structure where many landslide blocks thrust into one another. At the time of planning, stability analysis was conducted with only two sections and this cannot be described as sufficient. Further trial calculations using more suitable models are desirable in the future.

⁹ A total station is a survey instrument which integrates an electro-optical distance meter, which measures distance by beaming light to the target point and electronically analysing the reflected light reaching the instrument, and an electronic theodolite which measures angles. Both angles (vertical as well as horizontal angles) and distance can be simultaneously measured by a single instrument. When this instrument is applied to a landslide, three-dimensional movement vectors of the survey point can be obtained.

At the time of constructing catchment wells, neither photographs of geological sections, soil samples from the sliding surface were preserved nor observation data on preconstruction groundwater level were preserved. In Japan, 360-degree photographs of a geological section are taken at 1 m intervals of the drilling depth at the time of the drilling and construction of a catchment well. As these photographs show the conditions of geological structure, inclination and conditions of sliding surface much better than drilling cores, they are extremely useful as reference materials for understanding mechanism of the landslide and also for visitors after the completion of the construction work. Soil samples from the sliding surface are essential to determine, through a soil test, the strength parameter which is the most important element of stability analysis and also important for future examination of countermeasures. Meanwhile, data related to the changes of groundwater level before and after the well construction is the most important data used for judging effects of the well after its completion. It is regrettable that the precious opportunity to obtain these materials and data was not seized.



Source: Preparatory Study

Fig. 1 Planned layout of landslide control works (example of El Berrinche)



Complete view of El Berrinche



Open canal (El Berrinche)



Catchment well and its interior in El Berrinche
(water collection boring works deployed in a fan-like fashion can be observed)

3.2.2 Project Inputs

At the time of planning, it was assumed that the Project would be implemented by a Joint Coordination Committee composed of Municipality of Tegucigalpa (Chairman), Ministry of Public Works, Transportation and Housing, Ministry of External Planning and Cooperation, Ministry of Natural Resources and Environment and COPECO. At the beginning, the Joint Coordination Committee met every week and staff members of the participating organizations underwent the training held as part of the soft component. All of the organizations except Municipality of Tegucigalpa gradually lost interest, declining the level of the Joint Coordination Committee activities. This decline, however, did not particularly affect the implementation of the Project, as the principle organization for implementation was Municipality of Tegucigalpa and coordination with other organizations were made separately as necessary. No problems resulting in a major increase of project cost or project period occurred at the project implementation stage.

3.2.2.1 Project Cost

The planned total project cost was 1,101 million yen of which 1,096 million yen and 5 million yen were to be borne by the Japanese and Honduran sides respectively. The actual project cost for the Japanese side was 1,039 million yen (95% of the planned amount) for the detailed design and project implementation (construction of facilities, procurement of equipment, supervision and soft component) and was within the planned amount. No information was obtained regarding the actual project cost of the Honduran side.

3.2.2.2 Project Period

The planned project period was approximately 32 months from January 2011 when the grant agreement was to be signed to August 2013, including the detailed design and procurement periods. In reality, the grant agreement was signed in February 2011 and the construction work commenced in December 2011 after the detailed design and procurement periods. The work was completed in October 2013. The actual project period, therefore, was 33 months from February 2011 to October 2013 (103% of the planned period), exceeding the planned project period.

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

3.3 Effectiveness¹⁰ (Rating: ③)

The purpose of the Project is to “reduce the risk of landslide disaster in the two target areas” which can be achieved by “reducing the probability of landslide occurrence (stabilization of landslide blocks)” and “reducing the risk of damage (when a landslide occurs)”. As described in detail below, the landslide prevention facilities introduced under the Project have so far been functioning properly and it is fair to judge that the targeted landslide blocks have been stabilized. On the other hand, even though the information dissemination to the residents cannot be described as sufficient, landslide monitoring is continuing in the two target areas by the Project, suggesting that the early warning system run by CODEM and the community disaster management organization is duly functioning. Therefore, it can be judged that the purpose of the Project has been generally achieved.

3.3.1 Reduction of the Probability of Landslide Occurrence

In the Project, reduction of the probability of landslide occurrence will be achieved by (i) lowering groundwater level at the time of rain by evacuating groundwater, which is a causal factor

¹⁰ The effectiveness is rated in consideration of not only the effects but also the impacts.

for instability of landslides, through construction of catchment wells and canals, and by (ii) changing the balance of sliding and friction forces of landslide blocks through soil removal and embankment works.

As for the 10 catchment wells, during the field survey, it was observed that they were properly functioning and collecting groundwater. Open canals also appeared to be functioning without any problems. According to the data of the groundwater level gauges installed at four locations in the two sites, the groundwater level in the two sites declined by an average of 3.8m compared to the preconstruction level and the actual decline exceeded the planned 5m at the two locations. Such declines of the groundwater level are believed to have contributed to stabilizing landslide blocks.¹¹ Both the soil removal works and embankment works in the two sites are found to be functioning well with proper maintenance and no topographical deformation affecting the landslide risk is observed.¹² In contrast, in El Reparto, there is a high possibility of inflow of household waste water from a large settlement at the top of the slope into the groundwater, not being caught by the open canals. The incursion of oil into the catchment wells has also been reported. It can be pointed out that there is a possibility that such inflow of household waste water affects the groundwater level, increasing the risk of landslide occurrence.

Monitoring data from the extensometers and borehole inclinometers installed at the two sites indicate that no specific movements have been detected since the completion of the Project at the landslide blocks targeted for landslide prevention by the Project. Therefore, it is safe to judge that the expected effects of the Project regarding reduction of the risk of landslide occurrence has largely been achieved, as the landslide prevention facilities introduced under the Project are adequately functioning in general and believed to have stabilized the targeted landslide blocks.¹³

¹¹ Recalculation of the safety factor (ratio between the sliding force and friction force: a larger value indicates a higher level of the stability of a landslide block) was made in consideration of the actual decline of the groundwater level at El Reparto, for which information on the safety factor calculation process in the Preparatory Study was obtained. The recalculated safety factor was 1.18 which exceeded the planned safety factor of 1.15. No similar recalculation was possible for El Berrinche as the calculation process employed at the time of planning was unknown, while, as the decline of the groundwater level has not reached 5 m in this area, the actual safety factor is inferred to be below the planned level. In the Preparatory Study, safety factor was considered as a quantitative indicator for effectiveness of the Project. However, in this report, only the ground water level was referred in the main text, but not the safety factor, considering that (i) safety factor itself is not measurable on site, (ii) re-calculation based on declined ground water level was possible only for El Reparto, and (iii) decline in ground water level is directly related with an increase of the safety factor.

¹² Since Municipality of Tegucigalpa declared the two areas as non-habitable zone, no illegal settlement has taken place at the landslide sites in the two areas. In El Berrinche, those neighbouring residents who cooperate for maintenance of the landslide prevention facilities cultivate maize, pulses, etc. at the site with a consent of the Municipality. In El Reparto, such neighbouring residents also cultivate crops and graze livestock. No irrigation is conducted in either sites and there is no danger of reactivation of landslide due to cultivation or grazing.

¹³ Scope of the Project was designed to prevent reactivation of landslide with the equivalent level of rainfall by Hurricane Mitch. However, no heavy rainfall comparable to that of Hurricane Mitch has been recorded since the completion of the Project to the time of the ex-post evaluation. Therefore, there is a possibility that landslide may be reactivated due to an earthquake or exceptional rainfall in the future, and it does not mean that the Project has completely nullified the risk of landslide. Moreover, according to CODEM, very slow movement in response to rainfall has been observed at the landslide block which has been newly discovered in El Berrinche and where only monitoring equipment was installed. As the movement observed does not affect the entire landslide, however, this movement is not considered dangerous.

3.3.2 Reduction of the Risk of Damages When a Landslide Occurs

Reduction of the risk of damage when a landslide occurs will be achieved by appropriate evacuation of residents based on early warnings issued according to the results of landslide monitoring.

(1) Landslide Monitoring

A range of monitoring devices (borehole inclinometers, groundwater level gauges, extensometers and rain gauges) installed in the two sites of the Project have been properly functioning and continuous monitoring is carried out.¹⁴ After completion of the Project, during the period from 2015 to 2016, in accordance with the advice of a succeeding technical cooperation (dispatch of experts) entitled “Assistance for Strengthening and Capacity Building of Professional Techniques for the Control and Mitigation of Landslides in the Tegucigalpa Metropolitan Area” (hereinafter referred to as “the succeeding technical cooperation”) based on the monitoring results up to that point and in view of more effective monitoring, location of two extensometers was changed and the span of one of them was extended from 10m to 20m. While extensometers and rain gauges in both sites and one water gauge for observation of groundwater in El Reparto gather continuous hourly data by automated recording, borehole inclinometers in both sites and underground water gauges in El Berrinche do not provide continuous data because of their manual measurement operation by the staff in charge on-site. Based on the guidelines prepared under the Project for landslide monitoring, the manual measurement of the groundwater level by visiting officials is planned twice a month as standard practice, and to be performed as required after each heavy rainfall. The guidelines also plan an acquisition of data at each observation station to take place twice a week. According to CODEM, however, frequency of manual measurement and visits to observation stations has been roughly half of the plan due to constraints imposed by the limited number of vehicles and personnel.¹⁵

The monitoring results are made into graphs using a dedicated software. After a simple analysis, they are compiled into a monitoring report prepared every six months. This report also includes the results of and necessity for maintenance works.

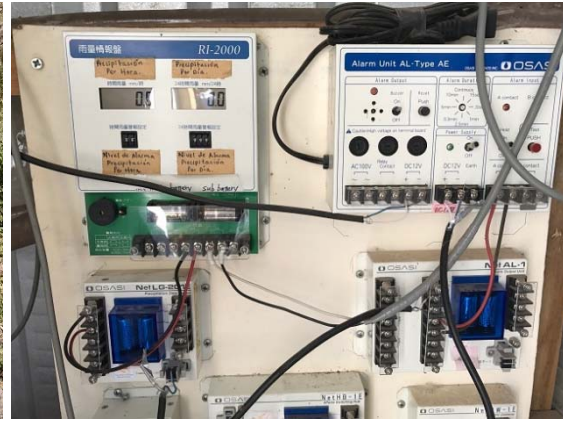
As described above, although the frequency of data acquisition by manual measurement and from observation stations is not often, CODEM has been independently conducting the operation of monitoring equipment and data collection / analysis. It is, therefore, judged that the landslide monitoring envisaged by the Project has been implemented generally in an appropriate manner.

¹⁴ Excludes an inclinometer in one borehole which was rendered unusable because a stone was dropped (see the section on sustainability). As a borehole inclinometer monitors movement inside a landslide block, its inoperability does affect the monitoring but not the risk of the targeted landslide block.

¹⁵ Even if the acquisition of data from the observation stations is less frequent, the data itself is accumulated through the automated recording function and there should be no missing data.



Extensometer (El Reparto)



Inside of the observation station (El Reparto)

(2) Early Warning and Evacuation System

Each observation station established at a cooperating household in the two areas is accompanied by a warning system (siren) which issues warnings based on the observation results of rain gauges and extensometers. An alarm is sounded when the rainfall intensity reaches 10mm/hr or 100mm/day or more, or any extensometer records a movement of 2mm/hr or more. These reference values were suggested by the consultant in charge of the soft component of the Project.¹⁶ So far, erroneous sounding has occurred when an extensometer has been touched by an animal or other but the alarm has not sounded due to rainfall or movement of landslide blocks. Whenever an alarm sounds regardless of there being a genuine or erroneous cause, the cooperating household immediately reports it to CODEM to trigger a visit by staff members to the site in question. As part of the soft component, proposals were made concerning appropriate procedures for (i) judgement of whether an alarm is erroneous or genuine, (ii) conducting on-site monitoring (identification of precursory phenomena) when a landslide risk is confirmed, and (iii) judgement on evacuation and cancellation of an alert. These procedures have been adhered to as proposed.

There is a total of five community disaster management organizations in the two areas, all of which were organized in 2010 after training assisted by GOAL (an international NGO established in 1977) and US Agency for International Development (USAID). Senior members of two of these organizations participated in the training for the soft component of the Project but neither the preparation of a hazard map / an emergency plan nor evacuation drill with resident participation took place within the scope of the Project.¹⁷ There is regular telephone

¹⁶ According to the expert who conducted the detailed analysis, these reference values are set based on international experience, including that of Japan, and the situation of past disaster cases in the two targeted districts, and they are considered to be appropriate as initial reference values. However, more precise and customized reference values for each landslide block is possible in the future by establishing the relationship between rainfall intensity and movement of landslide block for each site based on continuous monitoring. While, it must be noted that these sirens were not installed assuming to directly convey warning messages to nearby residents.

¹⁷ According to the results of interviews with CODEM, after the completion of the Project, the GOAL / USAID conducted a landslide evacuation drill in El Berrinche in 2014 while the GOAL and COPECO jointly conducted an earthquake evacuation drill in El Reparto in the same year. In 2016, the COPECO organized a training session for all the community disaster management organizations in the city, including those in the two areas, and a football

communication regarding disaster prevention between CODEM and the five community disaster management organizations. Given the facts that staff members of CODEM periodically visit the cooperating households with the installed observation station for data gathering and that there is also cooperation between CODEM and resident groups entrusted with security and maintenance works, it is fair to say that there is a firmly established communication and coordination between CODEM and each community disaster management organization.

On the other hand, the beneficiary survey found that 95% of the respondents had no experience of participating in a disaster management seminar, training or drill. Only 16% responded that they would obtain information on disaster management from the community disaster management organization and half of the respondents said that they did not even know of the existence of such an organization. Moreover, only half of the respondents were judged to have adequate knowledge of disaster risk and evacuation.¹⁸ It appears that many residents judge the level of risk and necessity for evacuation at the time of heavy rain based on their past experiences of disaster. 70% of the residents understand the purpose of the Project but only 56% understand its functions (stabilization of landslide through evacuation of groundwater, landslide monitoring, etc.).

Based on the above, while the alarm and evacuation system operated by CODEM and five community disaster management organizations based on the early warning system installed under the Project is judged to be functioning, dissemination of information to residents is not sufficient.

3.4 Impacts

3.4.1 Intended Impacts

Overall goal of the Project is “promotion of landslide prevention measures in the metropolitan area”. The Project was expected to play a pioneering role as a model case for landslide prevention for other landslide risk areas of Tegucigalpa. In this context, the following impacts of the Project can be pointed out.

(1) Promotion of landslide prevention for other landslide risk areas in Tegucigalpa

The Municipality of Tegucigalpa has identified a total of 22 landslide risk areas that require landslide prevention measures. Other than El Berrinche and El Reparto where landslide prevention measures were introduced by the Project, introduction of structural measures has made little progress in other areas except for El Bambú and Ulloa where minor works have been conducted for landslide prevention as described below.

ground on the embankment works constructed by the Project in El Berrinche was used for some of the training activities.

¹⁸ These judgements were made by the surveyors based on the responses to the questionnaire survey.

- El Bambú was originally included in the scope of the Project along with El Berrinche and El Reparto. However, an active movement of one landslide block observed during the Preparatory Study led to the judgement that it would be difficult to realize permanent control works. As a result, El Bambú was excluded from the scope of the Project, and a basic concept for emergency measures consisting of canals and embankment works was presented as part of the Preparatory Study. In subsequent years, the Municipality of Tegucigalpa constructed the canals and embankments (“Landslide Control Works in El Bambú”, 2013) utilizing the assistance of JICA (counterpart fund for non-project grant aid cooperation). According to CODEM, landslide movement in this district has been relatively stable although movement has not completely stopped.
- In Ulloa, there are some 2,500 households in the landslide risk area. In this area, GOAL has installed a monitoring system with USAID funding to observe (manually) the groundwater level and to monitor any damage (cracks) to houses, along with construction of canals, resettlement of some residents and introduction of a warning and evacuation system based on rain gauges run by community disaster management organizations.
- In some other landslide risk areas, retaining walls and construction of evacuation roads were implemented with the assistance of the Central American Bank for Economic Integration (CABEI) and Germany. However, there has been no case in these areas of the construction of catchment wells or large-scale soil removal and embankment works or horizontal boring works like the Project.

Reasons for the slow progress of the implementation of structural measures include (i) the financial restriction which makes such implementation rely on external aid and the fact that (ii) it is difficult to find relocation sites for those households living on a landslide block as there are little well-located land appropriate for living in the metropolitan area. In the case of Ulloa, for example, only some 30 households out of 1,000 households which need relocation have been relocated so far because of the lack of suitable relocation sites. On the other hand, at present, detailed surveys of each area for planning structural measures are being carried out slowly with an assistance of JICA and others. According to the stakeholders in Honduras, the consultant for the Project and the experts worked for the succeeding technical cooperation, there is little prospect of implementing catchment wells, which was employed by the Project, being introduced in other landslide risk areas of Tegucigalpa because of their huge construction cost and high level of technical difficulty. Even if some structural measures are to be introduced in the coming years, it is likely that such measures will be limited to open canals, horizontal boring works, soil removal and embankment works as they are relatively low cost and easily constructed.

As far as non-structural measures (development of a landslide monitoring system and early

warning / evacuation system) are concerned, a monitoring system consisting of two extensometers and two rain gauges was established under the succeeding technical cooperation. In addition, Municipality of Tegucigalpa plans to install such monitoring equipment as rain gauges, inclinometers and others with an assistance of CABEI for the purpose of clarifying the relationship between rainfall and landslides, improving the warning and evacuation system and studying feasible control works, focusing on eight landslide risk areas other than the two areas of the Project and El Bambú. Furthermore, CODEM has distributed 32 simple rain gauges to community disaster management organizations in 16 landslide risk areas and has established a mechanism whereby CODEM maintains contact with these organizations as required at the time of rain with a view to issuing a warning when the rain intensity exceeds a set threshold.

As described above, landslide prevention in Tegucigalpa has been making gradual progress and the Project can be said to have constituted the starting point for the promotion of the implementation of landslide prevention in the city.

(2) Capacity building of organizations related to landslide prevention

Technical capacity to implement landslide prevention measures is being strengthened in Municipality of Tegucigalpa due to the consolidation of municipal units related to disaster management assisted by the succeeding technical cooperation (See Box 2). Apart from CODEM which is responsible for operation and maintenance of the Project, Municipality of Tegucigalpa also has a Risk Assessment Unit which prepares risk maps and conducts risk assessment with site visits, etc. in proceeding building permit applications in order to prevent inappropriate construction in disaster risk areas. In 2014 after the completion of the Project, Municipal Unit for Integrated Risk Management was established under the direct control of the Mayor as an organization to provide technical support for the municipality's disaster management efforts.¹⁹

The Project realized the first full-scale landslide prevention measures in Municipality of Tegucigalpa. Tegucigalpa acquired basic knowledge and practical experience to implement landslide prevention measures in a concrete manner through the Preparatory Study, construction of various structures, installation of a monitoring system and their operation and maintenance under the Project. After completion of the Project, JICA through the succeeding technical cooperation provided (i) advices on the organizational development of the Municipality for landslide prevention, (ii) technology transfer regarding compilation of a landslide ledger, (iii) technology transfer regarding operation and maintenance of the landslide prevention facilities and the monitoring equipment installed under the Project, and (iv) advices on collaboration with the National Autonomous University of Honduras. Even though there are some technical issues that

¹⁹ This Unit has five civil engineers of which four completed the disaster prevention officer training program organized by COPECO. Weekly training took place for one and a half years. There is a total of 80 disaster prevention officers nationwide.

may require assistance by external experts, such as enhancement of technical capacity for analysing monitoring data, improvement and strengthening of monitoring system and improvement of early warning and evacuation system, Municipality of Tegucigalpa is believed to be strengthening its technical capability to deal with landslide prevention. The Project has made a major contribution in this context as it constituted the starting point for the capacity building of the Municipality for landslide prevention.

For the implementation of the Project, the Joint Coordination Committee chaired by Municipality of Tegucigalpa with the participation of other stakeholder organizations (Ministry of Public Works, Transportation and Housing, Ministry of External Planning and Cooperation, Ministry of Natural Resources and Environment and COPECO) was established and staff members of these organizations participated in the training held as a soft component of the Project. In this ex-post evaluation, interviews were conducted at the Ministry of Public Works, Transportation and Housing and the Ministry of Natural Resources and Environment, but it was not possible to verify the direct impact of the Project on capacity building due to the fact that those staff members participating in the Project have since changed positions. In the case of COPECO, the Project is believed to have achieved indirect capacity building as a person who was closely involved in the preparatory and implementation stages of the Project as a staff member of the CODEM subsequently became responsible for the metropolitan area at COPECO.

As the landslide control works introduced under the Project were unprecedented in Central and Latin America, they have been visited by researchers, engineers and students of Honduras and other countries. The football field in El Berrinche which was constructed as part of the project facilities was used as a venue for the training organized by COPECO etc. for community disaster management organizations. Interviews with organizations related to disaster prevention (COPECO and CODEM) and researchers of universities found that opportunities for people to visit concrete landslide control works has greatly contributed to education and enlightenment. As such, the Project has important demonstration as well as educational effects.

Box 2

Summary of an Expert Analysis (2): Relationship with JICA's Other Cooperation Regarding Landslides

Hiroshi Fukuoka (Director of the Research Institute for Natural Hazards & Disaster Recovery, Niigata University, Professor)

The Project was implemented as a priority project which was selected based on the master plan formulated by JICA's "Study to Plan Urgent Flood and Landslide Control Measures in the Tegucigalpa Metropolitan Area" (Development Study; 2001 – 2002). The landslide hazard map compiled under this Study visually presented an entire picture of landslide risk areas in Tegucigalpa for the first time, providing a momentum for institutionalization of land use restrictions. One reason for the selection of the two targeted sites of the Project and El Bambú as targets for the priority project was that the number of households to be resettled was rather

small in comparison with the expected scale of damage. This selection can be considered as valid in view of the fact that resettlement has not made much progress in other landslide risk areas. As for flood control measures and non-structural measures, it has been 15 years since the proposal was made. Such measures have been being gradually implemented or in preparation for implementation by Municipality of Tegucigalpa and COPECO, even though the original plan has not been exactly followed. In the light of the above, it is fair to say that the directions proposed by the master plan was generally appropriate.

JICA implemented the “Project on Capacity Development for Disaster Risk Management in Central America – BOSAI (Phase 1)” from 2007 to 2012 for the purpose of strengthening community disaster management led by local governments and community disaster management organizations, and is currently implementing the Phase 2 of this project for the planned period of 2015 to 2020. The areas targeted by these Phase 1 and 2 projects differ from those of the Project and the counterpart personnel of the Phase 1 have gradually left CODEM. As such, there is only limited collaboration between the BOSAI projects and the Project.

Since the commencement of the Project, JICA has conducted capacity development concerning landslide control measures, including strengthening of linkage between universities / research institutes and the government, through “Hazard geology focusing on the landslides in Tegucigalpa (Dispatch of Science and Technology Researchers; 2012 – 2014)” and “Assistance for Strengthening and Capacity Building of Professional Techniques for the Control and Mitigation of Landslides in Tegucigalpa Metropolitan Area (Dispatch of Experts: 2015 – 2016)”. Even though collaboration between universities/research institutes and the municipal administration has unsolved issues, cooperation with academic community is essential for development and inheritance of landslide prevention technologies in Honduras. It is, therefore, imperative to seek more appropriate forms of cooperation in future.

3.4.2 Other Positive and Negative Impacts

(1) Impacts on natural environment

The Project aimed at stabilizing landslide blocks and reducing the impacts of landslides on natural environment. An environmental permission (building permission) for the Project was issued by the Tegucigalpa city. An environmental mitigation plan was prepared and carried out during construction. According to Municipality of Tegucigalpa, no major environmental impacts were confirmed neither during nor after the construction. In the two targeted areas, cherry trees were planted at the expense of the contractor for the greening along with the implementation of landslide control works. However, hardly any of these cherry trees now survive due to damage caused by the grazing of animals and the lack of watering and other care.

(2) Land acquisition and resettlement

Land for the Project was acquired in El Reparto from absentee landowners prior to the commencement of the construction. No problems were encountered with the acquisition of land. Nine households in El Reparto were resettled. According to CODEM official in charge of this resettlement at the time, it was not socially a simple process as many of the residents did not agree with resettlement. However, the actual resettlement took place without problems with the assistance of GOAL (NGO) which had been involved in the fostering of community disaster

management organizations in the two areas. Because of the change of municipal administration, it was not possible to obtain detailed information on the resettlement process and compensation.

(3) Socioeconomic impacts on the target area

The Project is expected to reduce landslide damages in the two areas but there has been no concrete case to verify the damage reduction effect of the control works, because, to date, there have been no heavy rainfall comparable to that caused damage (Hurricane Mitch, 1998).

According to the senior officials of the community disaster management organizations in the two areas, residents have undergone such psychological changes as “now we can sleep with peace of mind” and “no need to worry about resettlement or evacuation any more”. Other impacts have also been reported, including increased investment in housing, increase of land and house prices and return of some residents who moved to other areas after the landslide caused by Hurricane Mitch. Moreover, it has been pointed out that the frequency of road cracks and spring water incidents at the time of rain in the surrounding area has declined since the implementation of the Project. These phenomena may suggest impacts of the Project but are difficult to verify in a concrete manner.

The beneficiary survey found such opinions as “elimination of the risk has led to peace of mind” (59% of the respondents) and “life is more convenient due to the access road constructed under the Project” (24%). However, it must be noted that the principal interests of daily life of local residents of the two areas are the development of sewerage, improvement of public security, improvement of roads and traffic and increase of income. The priority of disaster prevention generally ranks low.

(4) Regional impact concerning the dissemination of landslide prevention measures

With an assistance of JICA, the first and second Central America and Caribbean Landslide Conference was held in Tegucigalpa in March 2013 and July 2016 respectively. During these conferences, presentations on the Project and site visits were made.²⁰ Moreover, the Project was introduced at the Central American Regional Conference of the Centre of Coordination for the Prevention of Natural Disasters in Central America (CEPREDENAC) held in Tegucigalpa in March 2017. As described above, the Project has been introduced at international conferences held in Tegucigalpa to other Latin American countries, contributing to the dissemination of

²⁰ At the first conference, 20 research presentations were made by 12 countries. The conference which lasted for four days was attended by some 100 people. At the second conference, 43 presentations were made by universities, research institutes and such administrative organizations as the Central American Integration System (SICA: *Sistema de la Integración Centroamericana*) and Centre of Coordination for the Prevention of Natural Disasters in Central America (CEPREENAC: *Centro de Coordinación para la Prevención de los Desastres Naturales en América Central*) in 12 countries (Honduras, Germany, Argentina, Colombia, Mexico, Guatemala, El Salvador, Nicaragua, Costa Rica, Panama, Cuba and Japan). This conference lasted for three days and was attended by some 220 people.

landslide prevention measures.

Through its implementation, the Project has largely achieved its objectives. Therefore, the effectiveness and impact of the Project are high.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

Municipality of Tegucigalpa established Municipal Unit for Integrated Risk Management in 2014 to centralise disaster management and coordinate all of the relevant units. This unit is the final decision-making body concerning the disaster management making both technical and administrative judgements. Its staff strength has gradually increased to six (of which five are civil engineers) as of February 2017. It is in a position of providing technical advice for operation and maintenance of the Project. In addition to this unit, the Municipality has other organizations related to disaster management such as Risk Assessment Unit and CODEM.

The Risk Assessment Unit has two civil engineers and conducts risk assessment by means of risk maps and field visits for building permission applications in order to prevent inappropriate construction in disaster risk areas.

The main business of CODEM is to respond to disaster-related emergencies. It deals with forest fires in dry season and landslides and flooding in rainy season in accordance with the procedures stipulated in the emergency response manual. It issues early warnings and conducts emergency response through communication and coordination with such relevant public bodies as COPECO and other ministries concerned as well as community disaster management organizations. It also provides training and equipment for the community disaster management organizations. As it is also in charge of maintenance of disaster prevention works, it conducts regular monitoring and maintenance of the facilities introduced by the Project. As of February 2017, it has 49 staff members of which 11 have a bachelor's degree or higher. However, it does not have any civil engineers.

Of the staff members of CODEM, 10 belonging to the section responsible for early warning and risk management are in charge of operation and maintenance of the Project. As all of these 10 staff members have other assignments, however, the staff strength of this section is insufficient. CODEM has four vehicles, while all of them require renewal in view of their deterioration. In addition, the number of vehicles is insufficient at the time of an emergency. In the case where monitoring of other landslide sites begins in the future, the current organizational set-up will find it difficult to deal with new demands, most likely making it necessary to establish a dedicated monitoring section.

In the two sites targeted by the Project, while the security service for the new facilities was originally contracted to a private security company, the poor public security in these districts led

to incidents of assault against the security guards who were outsiders. Following the change of the mayor in subsequent years, this contract came to an end. The new mayor has concluded a security and cleaning contract with a small company established by several residents (including a member of the community disaster management organization). For major cleaning and repair works before and after the rainy season, paid-for cooperation of other residents is also obtained.

As described above, institutional arrangement for disaster prevention in Municipality Tegucigalpa has gradually improved and there are no major problems regarding institutional aspect of operation and maintenance of the Project. However, manpower and vehicles assigned by CODEM to Project-related works are not necessarily sufficient and establishment of a dedicated section with appropriate human resources and vehicles is believed to be necessary when monitoring of other landslide sites begins in the future.

3.5.2 Technical Aspects of Operation and Maintenance

Staff members of CODEM who are responsible for operation and maintenance have obtained sufficient knowledge, through the training organized as part of the soft component, on operation and maintenance of the landslide prevention facilities as well as monitoring equipment and gathering of monitoring data. They are also very familiar with the handling of data retrieval equipment (network controller) and analytical software. Even though some of them have left their positions since the completion of the Project, key members remain and conduct operation and maintenance of the said facilities without any problems as routine works based on manuals. *The Maintenance Guidelines for Landslide Prevention Facilities* and *Monitoring Guide of Landslide* produced under the soft component have been used. In the succeeding technical cooperation, a much more detailed operation and maintenance manual was prepared in addition to the above and practical training was conducted on monitoring data compilation and analysis.

Monitoring reports compiled by CODEM presents monitoring data and basic analysis. CODEM is capable of conducting inclinometer installation work without external help and also of providing guidance on this work.²¹ However, CODEM still has room for improvement regarding the flexible use of analytical methods in response to the quality of data (for extensometers), analysis of small sliding quantity at the sliding face (for borehole inclinometers) and correlation analysis between the rainfall intensity and displacement of landslide blocks (based on rain gauges and extensometers). Also, there are restrictions on data and analysis software.²² Deformations of open canals are recorded for the purpose of conducting repair work, but there is no mechanism to utilize such information, in combination with the records of slope deformation

²¹ In the training organized by JICA on the prevention of road disasters for the Ministry of Public Works, Transportation and Housing, one CODEM staff member was invited to lecture at a session featuring landslide monitoring.

²² Measurement by CODEM is not for continuous data as manual ground water gauges are used. In addition, it is not frequent due to its limited manpower / vehicles. While the acquired data from observation stations is analysed using a dedicated software, it is not convenient because the data recorded by other equipment cannot be incorporated.

(cracks and rock falls from a sliding cliff), to analyse movement of landslide in a systematic manner.

Municipal Unit for Integrated Risk Management of Tegucigalpa which provides technical assistance for CODEM has civil engineers. However, none of them is a landslide specialist.

Based on the above, Municipality of Tegucigalpa is judged to generally possess adequate technical capability concerning operation and maintenance of the Project. However, in order to further enhance landslide prevention, it would be necessary to acquire more advanced professional capability concerning analysis of monitoring data and landslide study, otherwise to establish cooperation with universities or other organizations that have a high level of expertise.

3.5.3 Financial Aspects of Operation and Maintenance

Budget scale of Municipality of Tegucigalpa in 2016 was some 5.1 billion lempira (approximately 2.4 billion yen), of which some 2.9 billion lempira (approximately 1.4 billion yen) was earmarked for investment in public works, recording an almost double increase of the municipal budget in four years. According to CODEM, new mayor is proactive in disaster prevention projects. As for the project to improve Choluteca River which caused massive damage at the time of Hurricane Mitch, detailed design has been completed and it is scheduled for gradual implementation in phases. In the past, construction of retaining walls to control cliff collapse used to be considered only after a relevant request had been submitted by residents. In contrast, present practice is for the Municipality to take initiative in disaster prevention projects even though no requests are received.

Table 2 Transition of Expenditure of the Tegucigalpa City

(Unit: million lempira)

	2013	2014	2015	2016
Operating Expenses	957	978	865	912
Personnel Cost	699	773	678	725
Goods and Services	244	185	167	162
Others	14	20	20	25
Others	1,603	1,493	2,136	4,216
Investment	680	633	1,169	2,894
Transfer	75	85	88	119
Public Bonds	843	774	879	1,203
Others	5	1	0	0
Total	2,560	2,471	3,001	5,128

Source: Municipality of Tegucigalpa

Note: 1 yen = 0.21 lempira (April, 2017)

According to CODEM, 400,000 lempira was allocated for operation and maintenance of the Project in 2016. This figure was more than the estimate (80,000 – 350,000 lempira/year) at the

time of the Preparatory Study. A range of equipment required for operation and maintenance has been procured and there are reserve batteries, extensometer wire (invar wire), etc. in stock. For 2017, it is expected to receive more funding than the amount for 2016.

Based on the above, there are no significant constraints regarding the financial aspects of operation and maintenance of the Project.

3.5.4 Current Status of Operation and Maintenance

CODEM conducts regular inspection of the facilities twice a year, i.e. before and after rainy season. Based on the results of these inspections, it conducts cleaning and repair works. Any damage visually detected on the canals and other facilities is repaired. Functional state of the catchment wells is judged based on groundwater level monitoring. It is assessed based on groundwater level and amount of groundwater collected, and if it is considered necessary, maintenance works such as cleaning of the collecting pipes using a high-pressure cleaning equipment are carried out in order to maintain their function. At the time of heavy rain, ad hoc cleaning may be conducted. During the field survey, some rubbish was observed in open canals, for which CODEM carry out cleaning, inspection and repair twice a year before and after the rainy season. The field survey confirmed that the landslide prevention facilities introduced under the Project were functioning properly without any major damages.

In general, all of the monitoring equipment are found to be steadily functioning.²³ Because of the poor public security in the two targeted areas, there have been several incidents of theft of the data cable between the monitoring devices to the observation station as well as the wire of extensometers. The extensometers, the groundwater gauges and the borehole pipes for groundwater gauges and inclinometers are protected by brick walls and an iron lid, being locked up for their protection from theft, malicious damage or interference with their functioning. The catchment wells are protected by a locked wire fence for the same purpose.

No major problems have been observed in regard to the institutional, technical and financial aspects of the operation and maintenance of the Project and, therefore, the sustainability of the project effects is high. However, further progress of landslide prevention measures would require the strengthening of personnel and vehicles and also more advanced professional capability of personnel for the future.

²³ Protection of the borehole pipe of one inclinometer was insufficient and the pipe was rendered unusable by a stone thrown in it. It is difficult for CODEM to repair or install a new pipe by itself as the material is to be imported.

4. Conclusions, Recommendations and Lessons Learned

4.1 Conclusion

The Project was implemented to mitigate the risk of landslide disaster in El Berrinche and El Reparto of Tegucigalpa by means of constructing landslide prevention facilities and developing a landslide monitoring system and an early warning and evacuation system, thereby contributing to promotion of landslide prevention in the Tegucigalpa metropolitan area. The Government of Honduras has consistently made conscious efforts regarding disaster management and there is a strong necessity in Tegucigalpa for disaster prevention targeting landslides and floods. The Project was relevant to Japan's ODA policy at the time of its planning and, therefore, the relevance of the Project is high. As the project cost was within the planned amount but the project period exceeded the planned period, efficiency of the Project is fair. Landslide prevention facilities introduced by the Project have been functioning properly and the targeted landslide blocks have been stabilized. Although the information dissemination to nearby residents has not been sufficient, landslide monitoring continues and an early warning system operated by CODEM and community disaster management organizations is functioning in the two targeted sites. Technical capability of the Municipality of Tegucigalpa to handle landslide prevention measures is being strengthened but the application of these measures in the metropolitan area is limited. While the concrete achievement of the new facilities to mitigate disaster damages cannot be verified because there has been no heavy rain since the completion of the Project, the Project has provided many residents with peace of mind. To summarize, effectiveness and impact of the Project are high. There are no major issues in regard to the institutional, technical and financial aspects of the Project in terms of its sustainability. Taking the good operation and maintenance conditions of the landslide monitoring system and the landslide prevention facilities into consideration, sustainability of the Project is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

As part of this ex-post evaluation of the Project, considering also the expert's analysis shown in Box1 and 2, following recommendations are made to the Honduran side.

(1) Enhancement of landslide prevention at El Berrinche

Municipality of Tegucigalpa should tackle the following issues in cooperation with COPECO, universities, research institutes and others, in consideration of the facts that (i) scale of the landslide in El Berrinche is huge and there are more than one landslide blocks, (ii) potential damages due to re-activation of the landslide which may be triggered by an earthquake or exceptionally heavy rain will be very extensive, and (iii) the Project has not eliminated the

landslide risk to zero.

- In order to establish a monitoring system that can accurately observe any displacement of the entire landslide site, such measures should be examined as installing a series of linked extensometers covering the entire landslide site from top to bottom and periodic and whole area monitoring using a total station.
- In order to establish the relationship between rainfall intensity, groundwater level and movement of landslide blocks and issue more appropriate warnings based on it, it is necessary to improve the data acquisition and transfer methods and perform further detailed analysis while receiving advice from experts.
- In preparation for an event in which Choluteca River is clogged by reactivated landslide, simulations on the desk should be conducted focusing on emergency responses, including early warning, evacuation and emergency measures to cope with the landslide dam. Results of such simulation should be considered when more effective counter measures are examined.

(2) Strengthening of CODEM's arrangement for operation and maintenance

In order to conduct operation and maintenance of the Project in a more appropriate manner, Municipality of Tegucigalpa should consider strengthening of manpower of the relevant section of CODEM, establishment of a new section dedicated to landslide prevention and renewal/enhancement of vehicles.

(3) Information dissemination to the residents near landslide risk areas

Retraining of the members of community disaster management organizations and information dissemination to residents are required in order to strengthen early warning and evacuation system by community disaster management organizations in the two targeted areas of the Project. Municipality of Tegucigalpa should examine and implement appropriate activities, including evacuation drills with the participation of residents, study visits to landslide prevention facilities and disaster management fairs.

(4) Containment of inflow of household waste water to the landslide

In El Reparto, groundwater collected by catchment wells contains much household waste water. It is inferred that household waste water not caught by the open canals flows into groundwater from a major settlement located at the upper part of the slope. In the neighbouring Nueva Santa Rosa, reactivation of landslide has been observed at a slope and this movement may well be caused by the infiltration of household waste water as a result of urban development. It is desirable to contain such infiltration of household waste water to landslides by means of

developing a sewerage system even though gradually.

(5) Fostering of landslide experts

Fostering of landslide experts to ensure the domestic existence of the professional skills required by the administration is an important long-term issue to be tackled by Honduras in view of promoting landslide prevention. The Government of Honduras (COPECO, Ministry of Public Works, Transportation and Housing and other ministries), university research institutes (National Autonomous University of Honduras and Engineering Polytechnic University of Honduras) and Municipality of Tegucigalpa should establish appropriate cooperation to foster and utilize landslide experts. As short to medium-term measures, exchanges with and technical assistance from the organizations specialized on landslides in Japan and other countries should be also examined.

4.2.2 Recommendations to JICA

JICA should examine possibility of providing relevant assistance through technical cooperation in order to facilitate implementation of the above recommendations.

4.3 Lessons Learned

Provision of reference materials obtainable at construction stage

If there is an opportunity to obtain important reference materials at the construction stage of a facility construction project which introduce new technologies, conscious efforts should be made to preserve such materials by means of clearly indicating it in the scope of works for the construction contract, so that the obtained reference materials can be provided to the recipient country for technology transfer. In the case of the Project, cross-sectional photographs to be taken during construction of catchment wells, soil samples of sliding faces and data on groundwater level were not preserved. Despite their importance, they could not be offered to the Honduran side.

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