

Country Name	<b>Development of Landslide Risk Assessment Technology along Transport Arteries in Viet Nam</b>
Socialist Republic of Viet Nam	

**I. Project Outline**

Background	<p>Viet Nam had a wide area of mountainous terrain with a dangerous cleavage terrain due to earth crust's powerful tectonics. It also had the complex geological structures with grave cleavages of soil layers. Besides, as Viet Nam's geographical location was bordered by the Pacific Ocean, it was influenced by the monsoon climate with the average annual rainfall from as much as 3,000-4,500 mm per year. In this regard, it was said that the phenomenon of landslides was one of the most serious natural disasters in Viet Nam. According to statistics, the annual volume of landslides on the roads after rainy season in Viet Nam amounted to several hundred thousand cubic meters, which not only interrupted the arterial roads causing serious economic loss but also victimized some people, affecting communities in the mountainous areas. (Figures at the time of ex-ante evaluation.)</p>												
Objectives of the Project	<p>Through (i) wide-area landslide mapping and identification of the landslide risk area, (ii) development of landslide risk assessment technology based on soil testing for computer simulation, (iii) development of early warning technology based on landslide monitoring, and (iv) development of integrated guidelines for the application of developed landslide risk assessment technology, the project aimed to develop landslide risk assessment technology incorporating outcomes of all working groups (WGs)* to reduce landslide disasters along main transport arteries and to develop human resources for effective use of the technology in Viet Nam, thereby contributing to realization of social implementation of the developed landslide risk assessment technology and early warning system for safety ensuring of transport arteries in Viet Nam.</p> <p>*Three WGs were established for (i) mapping, (ii) test, and (iii) monitoring above.</p> <ol style="list-style-type: none"> <li>Expected Overall Goal: Social implementation of the developed landslide risk assessment technology and early warning system is realized to contribute to the safety ensuring of transport arteries in Viet Nam.</li> <li>Project Purpose: Landslide risk assessment technology incorporating outcomes of all WGs is developed to reduce landslide disasters along main transport arteries through the collaborative research based on the Japanese pioneer technology, and capacity development for the effective use of this technology is undertaken in Viet Nam.</li> </ol>												
Activities of the Project	<ol style="list-style-type: none"> <li>Project site: Hai Van Station landslide in the National Railways from Hue to Da Nang and Ho Chi Minh Route from A Luoi town to Thanh My.</li> <li>Main activities: (i) To complete wide-area landslide mapping and identification of risk area, (ii) To develop landslide risk assessment technology based on soil testing for computer simulation, (iii) To develop early warning technology based on landslide monitoring, and (iv) To develop the integrated guidelines for the application of developed landslide risk assessment technology.</li> <li>Inputs (to carry out above activities) <table border="0" style="width: 100%;"> <tr> <td style="width: 50%;">Japanese Side</td> <td style="width: 50%;">Vietnamese Side</td> </tr> <tr> <td>1) Experts: 2 persons (long-term), 51 persons (short-term)</td> <td>1) Staff Allocated: 53 persons</td> </tr> <tr> <td>2) Trainees Received: 6 persons (long-term training), 7 persons (short-term training) in Japan</td> <td>2) Operation cost</td> </tr> <tr> <td>3) Equipment: ring shear apparatus, total station, Global Navigation Observation System (GNSS), extensometer, etc.</td> <td></td> </tr> <tr> <td>4) Operation cost</td> <td></td> </tr> </table> </li> </ol>			Japanese Side	Vietnamese Side	1) Experts: 2 persons (long-term), 51 persons (short-term)	1) Staff Allocated: 53 persons	2) Trainees Received: 6 persons (long-term training), 7 persons (short-term training) in Japan	2) Operation cost	3) Equipment: ring shear apparatus, total station, Global Navigation Observation System (GNSS), extensometer, etc.		4) Operation cost	
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Project Period	November 2011- November 2016	Project Cost	(ex-ante) 323 million yen, (actual) 377 million yen										
Implementing Agency	Ministry of Transport (MOT); Institute of Transportation Science and Technology (ITST)												
Cooperation Agency in Japan	International Consortium on Landslides (ICL); Forestry and Forest Products Research Institute (FFPRI); Tohoku Gakuin University												

**II. Result of the Evaluation**

## &lt; Special Perspectives Considered in the Ex-Post Evaluation &gt;

- In the terminal evaluation, achievement status of the Project Purpose Indicator 1 (“Landslide risk such as area, depth, volume, speed of landslide motion is identified by incorporating results of mapping, testing and monitoring”) was judged based on the progress on the research conducted by the WGs and incorporation of the results into the integrated guidelines. In order to maintain the same perspective as that of the terminal evaluation, the same criteria were used in making evaluation judgement in this ex-post evaluation.

**1 Relevance**

## &lt;Consistency with the Development Policy of Viet Nam at the Time of Ex-Ante Evaluation&gt;

At the time of ex-ante evaluation, the project was consistent with the development policies of the Vietnamese government, including “The National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020”, which highlighted disaster prevention, response and mitigation as a priority issue for economic and social development, and “The National Transport Strategy to 2020”, which put “Conducting research on and establishing standards...in surveys, design, construction, handover and O&M” as one of the main solutions.

<sup>1</sup> SATREPS: Science and Technology Research Partnership for Sustainable Development.

<Consistency with the Development Needs of Viet Nam at the Time of Ex-Ante Evaluation >

As stated in “Background”, the project was consistent with the development needs of Viet Nam for development of landslide risk assessment technology at the time of ex-ante evaluation.

<Consistency with Japan’s ODA Policy at the Time of Ex-Ante Evaluation>

The project was consistent with “The Country Assistance Program for Viet Nam” (2009) that included the assistance to strengthen the capacity to maintain the infrastructure of transportation and traffic as well as the capacity to maintain the quality and safety management under the pillar of “Promotion of economic growth and strengthening of competitiveness in the international market” and the assistance to strengthen the capacity of disaster responses for central and local administrations under the pillar of “Improvements in Living and Social Conditions and Corrections of Disparities”.

<Evaluation Result>

In light of the above, the relevance of the project is high.

## 2 Effectiveness/Impact

<Status of Achievement of the Project Purpose at the time of Project Completion>

The project achieved the Project Purpose at the time of project completion. All the three WGs (mapping, test, and monitoring) completed their respective research and achieved their respective intended objectives. Incorporating the results, the draft of “Integrated Guidelines for landslide risk assessment” with 33 chapters was developed and submitted to MOT, which was expected to be finalized in the consultation process of MOT after the project completion (Indicator 1). Capacity of ITST staff in the field of landslide risk assessment was improved through participating in the joint research. Further, through training in Japan, six ITST researchers obtained the advanced degrees (one Ph.D. and five Masters of Science (M.Sc.)) in the fields of mapping, test, or monitoring, who, back in ITST, gave explanation in Vietnamese to and worked with their colleagues, thus significantly contributing to the capacity development of overall ITST staff. By the project completion, one more ITST researcher obtained the advanced degree (Indicator 2).

<Continuation Status of Project Effects at the time of Ex-post Evaluation>

The project effects have been continued. ITST has continued research activities related to the research outputs using the technology developed by the project and the equipment provided under the project except for a few items for landslide monitoring.<sup>2</sup> For example, landslide monitoring in Hai Van Station was continued until 2019 with approval of MOT. Compiling the monitoring results during and after the project, ITST has produced the draft of “Integrated Guidelines for early warning of large-scale land slide” with reference to the draft of “Integrated Guidelines for landslide risk assessment” developed under the project as well as landslide risk alert criteria for Hai Van area, which have been submitted to MOT. MOT has given instruction to Vietnam Railways (VRs) to utilize the criteria to monitor the landslide risk in Hai Van area and to plan solutions to mitigate landslide risks. ITST has also submitted a proposal to MOT to upgrade the draft of “Integrated Guidelines for landslide risk assessment” based on the results of continued monitoring in Hai Van, and to develop Basic Standards<sup>3</sup> for landslide risk assessment based on the upgraded guidelines. In August 2020, MOT approved ITST’s proposal to develop the Basic Standards and requested ITST, upon the completion of the Basic Standards, to propose some of the Basic Standards that can be upgraded to Vietnam Standards.<sup>4</sup> ITST has also shared the research outputs with the related government organizations, private sector, other research institutions, etc. under the format of seminars, technical exchanges, or meetings. Directorate for Roads of Vietnam (DRVN) has used the landslide mapping and Hai Van monitoring data as reference to draft a road maintenance technical manual, which has a component on management of landslides along transport arteries. VRs is planning solutions to mitigate landslide risks in Hai Van area, using the research outputs on landslide risk distribution and mechanism as well as Hai Van monitoring data. Lao Cai Provincial Department of Agriculture and Rural Development are using the landslide mapping for its project for capacity building of local community for slope disaster risk (2020-2023). In addition, four new research projects based on the research outputs have been initiated by University of Natural Science-Vietnam National University, Ministry of Science and Technology, ICL-JICA<sup>5</sup>, and ITST-Tohoku Gakuin University, respectively. The researchers of ITST have sustained and improved their research capacity through joining landslide related research, providing consultation to other organizations about landslide risk management or following Ph.D. courses (three researchers have obtained Ph.D. degrees and three are pursuing Ph.D. program).

<Status of Achievement for Expected Overall Goal at the time of Ex-post Evaluation>

The Expected Overall Goal has been achieved. Early warning system in Hai Van landslide area has been established by the landslide risk assessment technology developed and the equipment provided under the project as well as the landslide risk alert criteria for Hai Van area, such as rainfall thresholds, developed by ITST after the project completion, which MOT has instructed VRs to utilize (Indicator 1). Landslide risk slopes have been identified and assessed by ITST at three locations each within and outside the project site in Viet Nam (Indicator 2).

<Other Impacts at the time of Ex-post Evaluation>

No negative impacts have been observed. Other positive impacts have been mentioned by ITST. Scientific literacy of the related government organizations was improved by the project through approving related research proposals and reviewing their reports. In the three years of monitoring of Hai Van Station (2017-2019), ITST shared landslide monitoring data with VRs regularly and proposed them to have a plan for regular monitoring of landslide risks, using certain criteria such as rainfall thresholds (the same criteria which MOT has just instructed to VRs to use) and adjust train schedule when necessary in rainy season. VRs followed the recommendations by ITST. In those

<sup>2</sup> Due to thunder, a borehole inclinometer was broken before the project completion in 2016 and two out of five pieces of GNSS were broken in 2018. They have not been repaired or replaced because ITST was able to identify the ways to continue the monitoring by using project experience and could still collect the necessary data using other equipment types provided under the project. It is noted that the provided equipment for landslide monitoring is temporarily not utilized as of ex-post evaluation because Hai Van landslide monitoring was completed in 2019. However, ITST has submitted a proposal to MOT to duplicate the landslide risk assessment model developed in and after the project to other important arteries. If the proposal is approved by MOT, the provided equipment would be used again.

<sup>3</sup> Technical standards for a sector in Viet Nam.

<sup>4</sup> National standards of Vietnam.

<sup>5</sup> Through a technical cooperation project “Development of early warning technology of rain-induced rapid and long-travelling landslides in Sri Lanka” (2020-2025).

three years, landslide risks were sufficiently shared with VRs and railway safety in the typhoon season was ensured.

<Evaluation Result>

Therefore, the effectiveness/impact of the project is high.

Achievement of Project Purpose and Overall Goal

Aim	Indicators	Results					
(Project Purpose) Landslide risk assessment technology incorporating outcomes of all working groups (WGs) is developed to reduce landslide disasters along main transport arteries through the collaborative research based on the Japanese pioneer technology, and capacity development for the effective use of this technology is undertaken in Viet Nam.	1. Landslide risk such as area, depth, volume, speed of landslide motion is identified by incorporating results of mapping, testing and monitoring.	Status of the Achievement: achieved (continued) (Project Completion) -Landslide risk assessment technology was developed, incorporating results of mapping, testing, and monitoring, and the draft of the integrated guidelines was made. (Ex-post Evaluation) -ITST has continued landslide related research, including continued monitoring in Hai Van Station (2017-2019), using the developed technology and most of the equipment provided by the project and has shared the research outputs with other research institutes, government organizations, and private sector. -Other research institutes have started new research based on the research outputs. -MOT is considering the proposal from ITST to upgrade the draft of the integrated guidelines developed by the project based on the Hai Van monitoring data (2017-2019) and develop Basic Standards for landslide risk assessment based on the upgraded guidelines. DRVN has used and VR is using the research outputs to reduce landslide risks. *Also see the results of Expected Overall Goal.					
	2. Capacity of ITST staff in the field of landslide risk assessment is developed.	Status of the Achievement: achieved (continued) (Project Completion) -Capacity of ITST staff in the field of landslide risk assessment was improved through participating in the joint research. -ITST researchers, who obtained the advanced degrees through training in Japan, gave explanation in Vietnamese to and worked with their colleagues back in ITST. (Ex-post evaluation) -The researchers of ITST sustained and improved their research capacity through joining landslide related research, providing consultation to other organizations about landslide risk management or following Ph.D. courses.					
(Expected Overall Goal) Social implementation of the developed landslide risk assessment technology and early warning system is realized to contribute to the safety ensuring of transport arteries in Viet Nam.	1. Early warning system in Hai Van landslide area is established by using technology and equipment of the project.	(Ex-post Evaluation) achieved -Early warning system in Hai Van landslide area has been established by the landslide risk assessment technology developed and the equipment provided under the project as well as the landslide risk alert criteria for Hai Van area developed by ITST based on the monitoring data during and after the project, which MOT has instructed VRs to utilize.					
	2. Landslide risk slopes are identified and assessed both within and outside the target areas	(Ex-post Evaluation) achieved <Location of landslide risk slopes identified and assessed by ITST> <table border="1" style="width: 100%;"> <tr> <td>Within the project site (=target area)</td> <td>Hai Van Station, National Road 7, Ho Chi Minh National Road</td> </tr> <tr> <td>Outside the project site</td> <td>National Road 6, National Road 4D, Ha Long-Van Don Highway</td> </tr> <tr> <td>(Ref) Outside Viet Nam</td> <td>Xekman Hydropower in Laos</td> </tr> </table>	Within the project site (=target area)	Hai Van Station, National Road 7, Ho Chi Minh National Road	Outside the project site	National Road 6, National Road 4D, Ha Long-Van Don Highway	(Ref) Outside Viet Nam
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Source : Terminal Evaluation Report; Japan Science Technology Agency (JST) Terminal Evaluation Report; questionnaire and interview survey to ITST

3 Efficiency

While the project period was within the plan (ratio against the plan: 100%), the project cost exceeded the plan (ratio against the plan: 117%). The Outputs of the project were produced as planned. Therefore, the efficiency of the project is fair.

4 Sustainability

<Policy Aspect>

“The National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020” as well as “The National Transport Strategy to 2020” mentioned in “Relevance” is still effective.

<Institutional/Organizational Aspect>

Organizational structure required to utilize the research outputs/outcomes is well established. MOT, ITST, Vietnam Landslide Association for Transport (VLAT) and universities are involved in landslide related research. MOT is responsible for evaluation of research proposals or policy recommendations from universities and research institutes as well as budget allocation. Universities and research institutes, including ITST, conduct independent research or joint research. VLAT is invited to make comments to the research reports. The research outputs are also shared by ITST with local authorities through training courses and/or seminars. In addition, ITST has established Institute of Geotechnical and Disaster Prevention, a specialized agency for disaster prevention including landslide induced disaster, which will use and develop the research outputs, utilizing the researchers involved in the project and the provided equipment.

<Technical Aspect>

The researchers of ITST have sustained and improved their research capacity as mentioned in “Effectiveness/Impact” and MOT has sustained and improved their scientific literacy through appraising research proposals, approving research reports, attending workshops and seminars. The researchers of ITST have been also sustaining and improving their skills and knowledge to properly operate and maintain the provided equipment through continued monitoring in Hai Van Station and joining new research after the project completion.

<Financial Aspect>

ITST has secured financial resources by budget allocation from MOT and ITST's own budget for continuing and starting related research activities. The budget has been sufficient for regular operation and maintenance as well as small repair and replacement of the provided equipment. ITST also stated that, as MOT approved the proposal from ITST to develop the Basic Standards, it will allocate the necessary budget to organize consultation and appraisal meetings from their own budget.

<Evaluation Result>

Therefore, the sustainability of the effects through the project is high.

5 Summary of the Evaluation

The project achieved the Project Purpose (i.e. Landslide risk assessment technology incorporating outcomes of all working groups (WGs) is developed to reduce landslide disasters along main transport arteries through the collaborative research based on the Japanese pioneer technology, and capacity development for the effective use of this technology is undertaken in Viet Nam). The project effects have continued, and the Expected Overall Goal (i.e. Social implementation of the developed landslide risk assessment technology and early warning system is realized to contribute to the safety ensuring of transport arteries in Viet Nam) has been achieved. Regarding the Sustainability, no problems have been observed in terms of policy, institutional/organizational, technical, and financial aspects. As for the Efficiency, the project cost exceeded the plan. Considering all of the above points, this project is evaluated to be highly satisfactory.

**III. Recommendations & Lessons Learned**

Recommendations for Implementing Agency:

- It is recommended that ITST continuously follow up with MOT to get approval on the proposal to develop the Basic Standards so as to increase the utilization of the research outputs of the project.
- It is recommended that, in the future, ITST take necessary measures to prevent equipment to be installed from thunder and other possible effect of weather.

Lessons Learned for JICA:

- Some equipment items provided by the project were broken by thunder at the project site during and after the project implementation due to lack of preventive measures. When installing equipment in high locations and prone to weather hazards, some preventive measures like installing lightning rods could have been taken to protect the equipment.



Data analysis at ITST



Monitoring at Hai Van area