Democratic Socialist Republic of Sri Lanka

FY2023 Ex-Post Evaluation Report of

Japanese ODA Loan Project

"Landslide Disaster Protection Project of the National Road Network"

External Evaluator: Tomoko Tamura, Kaihatsu Management Consulting, Inc.

0. Summary

The project aimed to reduce the risk of landslides on national roads in Sri Lanka by implementing slope protection measures on major national roads with a high risk of landslides, strengthening the safety of the road network and the lives of the people living nearby, and thereby contributing to the economic and social development of the country.

At both the time of the project appraisal and ex-post evaluation 90% of ground passenger and freight transport travelled by road in Sri Lanka, as the rail network only covers part of the country. The road network therefore plays a crucial role in economic and social activities, and disaster prevention and reducing the risk of landslides affecting the roads are consistent with the country's development policies and needs. The project was also consistent with Japan's ODA policy at the time of project appraisal. However, expected synergies with JICA's subject-specific training, which was expected to be linked with this project, could not be confirmed, and no linkages with projects implemented by other donors were planned. Therefore, its relevance and coherence are high.

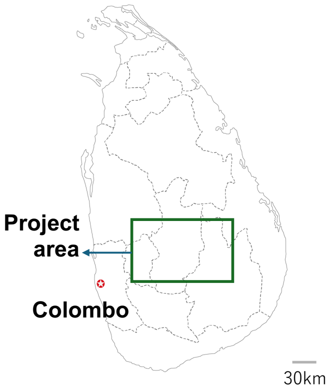
The outputs of the project were in line with the plan, apart from the number of countermeasure sites increasing from 16 to 22 due to a reduction in project costs. The project cost was within the plan. It was concluded that the project period matched the level of outputs produced, even though it exceeded the plan, because the output of countermeasure works significantly increased. Therefore, efficiency of the project is high.

All the operation and effect indicators of the project have been achieved. The qualitative effects of the project, such as improved safety for road users and nearby residents, and improved capacity of staff at the executing agency for landslide prevention on national roads, have also been achieved as expected. The impact of the project on the smooth implementation of economic and social activities, the use of Japanese technologies and transfer of technologies to local contractors has also been confirmed. This project has achieved its objectives more than planned. Therefore, effectiveness and impacts of the project are very high.

There are no problems with the operation and maintenance of the project in terms of relevant policies and systems, organization and structure, financial situation, environmental and social considerations, and risk response. Slight issues have been observed in the technical aspects; however, there are good prospects for improvement/resolution. Therefore, sustainability of the project effects is high.

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

1. Project Description



Project Location
(Source: Provided by JICA)

Landslide Countermeasure at A5-091 Keppetipola
(Photo: Taken by the evaluator)

1.1 Background

Due to the geographical conditions of the country and climate change, Sri Lanka has a high risk of landslides, slope failure, rockfalls and other landslips on slopes along the roads, especially in mountainous and hilly areas. The Road Development Authority (RDA), which is responsible for the operation, maintenance and development of the country's national roads, responded to landslides that occur every year during the rainy season by taking temporary measures such as blocking off roads, removing fallen rocks and slope collapse sections, and reshaping slopes. The Government of Sri Lanka requested JICA to implement this project to provide permanent measures against these disasters.

1.2 Project Outline

The objective of this project is to reduce the risk of landslides on national roads, which are basic infrastructure, by implementing slope protection measures on major national roads in the six districts that have a high risk of landslides; enhancing the safety of the road network and the lives of people living nearby; and thereby contributing to the economic and social development of the country.

Loan Approved Amount/ Disbursed Amount	7,619 million yen/6,319 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	March 2013/March 2013
Terms and Conditions	Interest rate: Civil works and equipment procurement: 1.4% Consulting services: 0.01% Repayment Period: 25 years (Grace Period: 7 years) Conditions for Procurement: General untied
Borrower/ Executing Agency	Democratic Socialist Republic of Sri Lanka/ Ministry of Transport. Highways, Ports and Civil Aviation[1]
Project Completion	May 2020
Target Area	Nuwara Eliya and Kandy Districts in Central Province, Badulla District in Uva Province, Kegalle and Rathnapura Districts in Sabaragamuwa Province, Kurunegala District in North Western Province
Main Contractors (Over 1 billion yen)	R R Construction (Pvt.) Ltd. (Sri Lanka)/ Soltec Co., Ltd. (Japan) (JV) State Development & Construction Corporation (Sri Lanka)
Main Consultants (Over 100 million yen)	Oriental Consultants Co., Ltd. (Japan)/ Kokusai Kogyo Co., Ltd. (Japan) (JV)
Related Studies (Feasibility Studies, etc.)	The Data Collection Survey on Road Protection against Natural Disaster (JICA, 2012)
Related Projects	Technical Cooperation for Landslide Mitigation Project (JICA, 2014 -2018)

[1] The Executing Agency was the Ministry of Ports and Highways at the time of project planning, and the Ministry of Transport, Highways, Ports and Civil Aviation at the time of the ex-post evaluation.

2. Outline of the Evaluation Study

2.1 External Evaluator

Tomoko Tamura, Kaihatsu Management Consulting, Inc.

2.2 Duration of Evaluation Study

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

Duration of the Study:	November 2023 - January 2025
Duration of the Field Study:	February 25, 2024 - March 22, 2024, June 24, 2024 - July 22, 2024

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

3.1 Relevance/Coherence (Rating: ③[3])

3.1.1 Relevance (Rating: ③)

3.1.1.1 Consistency with the Development Plan of Sri Lanka

(1) National Development Plan

Mahinda Chintana (2006 - 2016), the national development policy of Sri Lanka at the time of project appraisal, identified the road sector as a priority, and emphasized the need to improve road safety. The *National Policy Framework (2020 - 2025)*, the national development plan of the country formulated in 2020, identified both roads and disaster management as priority sectors, and aims to establish preventive measures and early warning systems[4].

(2) Road Sector Plan

At the time of project appraisal, the *National Road Master Plan (2007 - 2017)* of Sri Lanka emphasized the importance of ensuring road safety, as does the *National Road Master Plan 2021 - 2030* at the time of the ex-post evaluation. In the latter, the plan focuses on road disaster prevention, including landslide prevention, in view of climate change.

(3) Disaster Management Sector Plan

The *National Disaster Management Plan (2013 - 2017)* of Sri Lanka at the time of project appraisal, and the *National Disaster Management Plan (2022 - 2030)* at the time of ex-post evaluation, both identify landslides as one of the main hazards, and emphasize the need to implement necessary measures. The latter also identifies structural measures to reduce the risk of landslides as a priority.

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

[3] ④: Very High, ③: High, ②: Moderately Low, ①: Low

[4] At the time of the ex-post evaluation, the plan document was not referred to as a national development plan in Sri Lanka, and sectoral plans were referred to as development policies. This is because the prime minister and president, who formulated the plan, took responsibility for an economic crisis and stepped down in 2022.

In summary, the project, which aims to reduce the risk of landslides, is consistent with the national development plans and sector strategies at the time of the project appraisal and ex-post evaluation.

3.1.1.2 Consistency with the Development Needs of Sri Lanka

At both the time of the project appraisal and ex-post evaluation 90% of overland passenger and freight transport in Sri Lanka travelled by road, as the rail network only covers part of the country. The national roads play a crucial role in economic and social activities. Therefore, it is highly needed to ensure the safety of the users of national roads by implementing landslide protection measures. At the time of the project appraisal, the RDA did not have sufficient knowledge and techniques for prevention of slope disasters. They were not able to take long-term measures against landslides and permanent measures against deep-seated landslides, so there was a great need for Japanese assistance.

The selection of the project sites was appropriate. Sites with a high risk of landslides and an urgent need for countermeasures were selected based on the results of slope surveys, disaster risk, whether any countermeasure works had been implemented, and environmental and social considerations. The national roads, where countermeasure works were carried out in this project, are the main infrastructure of the country, and the sites where countermeasure works were applied (hereafter referred to as 'countermeasure sites') play an important role in transport and tourism both at the time of project appraisal and ex-post evaluation,

The above shows that the objectives of the project were consistent with development needs at the time of planning and ex-post evaluation.

3.1.1.3 Appropriateness of the Project Plan and Approach

A detailed preliminary survey was carried out after the project started to investigate and analyze the characteristics and causes of landslides. Appropriate combinations of countermeasure works were selected for each countermeasure site based on the results of the survey, considering both economic and design requirements, and using geological engineering modelling software. During the ex-post evaluation, through discussions with the RDA and the National Building Research Organisation (NBRO)[5] and based on the findings from the field survey, the countermeasures were confirmed as appropriate for addressing the problems, when also considering economic aspects at the countermeasure sites.

[5] The NBRO is a technical assistance and research and development organization under the Ministry of Disaster Management. It specializes in environmental science, landslide engineering and risk management, resettlement planning, geotechnical engineering and construction material engineering. It acted as the technical partner in the project.

The project planned to develop user-friendly manuals with diagrams and photographs referring to the lessons learned from the "Baseline Roads Project Phases I and II" and the "Disaster Management Capacity Enhancement Project Adaptable to Climate Change." The training materials for countermeasures and maintenance are clearly presented with photographs and diagrams; although the maintenance and management manuals prepared under the project have bullet lists to make them concise. All of them were referred to at the time of the ex-post evaluation. It can be said that the lessons learned were utilized.

3.1.2 Coherence (Rating: ②)

3.1.2.1 Consistency with Japan's ODA Policy

At the time of project appraisal, the Country Assistance Policy for the Democratic Socialist Republic of Sri Lanka (June 2012) stated that its basic policy was to promote economic growth with due consideration for less developed areas. Under the priority area "vulnerability reduction", the policy was using Japanese expertise to support the reduction of risk factors for flood and landslide disasters, and the development of early warning systems. Therefore, there was consistency between Japan's ODA policy at the time of project appraisal and the objectives of the project.

3.1.2.2 Internal Coherence

Before implementation of this project, it was planned that several RDA and NBRO staff would participate in the JICA training program "Maintenance of Mountain Roads", which started in 2012, every year to improve civil engineering skills for mountain road maintenance and management. It was confirmed that two RDA officials and one NBRO official participated in this training in 2013. However, no information was available on the specific contribution of the training to the project, so this was not known. The Technical Cooperation for Landslide Mitigation Project (July 2014 - September 2018) was planned and implemented as an ancillary project to the project. The contribution of the ancillary project to this project is discussed in the section of "Effectiveness and Impacts" of this report.

3.1.2.3 External Coherence

There was no plan to collaborate with projects of other donors, and no synergy effects have emerged.

The project was consistent with the development policy and development needs of Sri Lanka, and the plan and approach of the project were appropriate. The project was consistent with Japanese ODA policy at the time of project appraisal. The contribution of the sector-wise training, which was envisaged to be collaborated with the project, could not be confirmed due to lack of information. There was no plan to collaborate with the projects of other donor agencies. Therefore, its relevance and coherence are high.

3.2 Efficiency (Rating: ③)

3.2.1 Project Outputs

The outputs of the project were: (1) implementation of countermeasures against landslides (see Figure 1); (2) procurement of equipment for an early warning system; and (3) consultancy services. There was a significant increase in outputs for (1), including the number of locations and work content. Outputs (2) and (3) were conducted as planned.

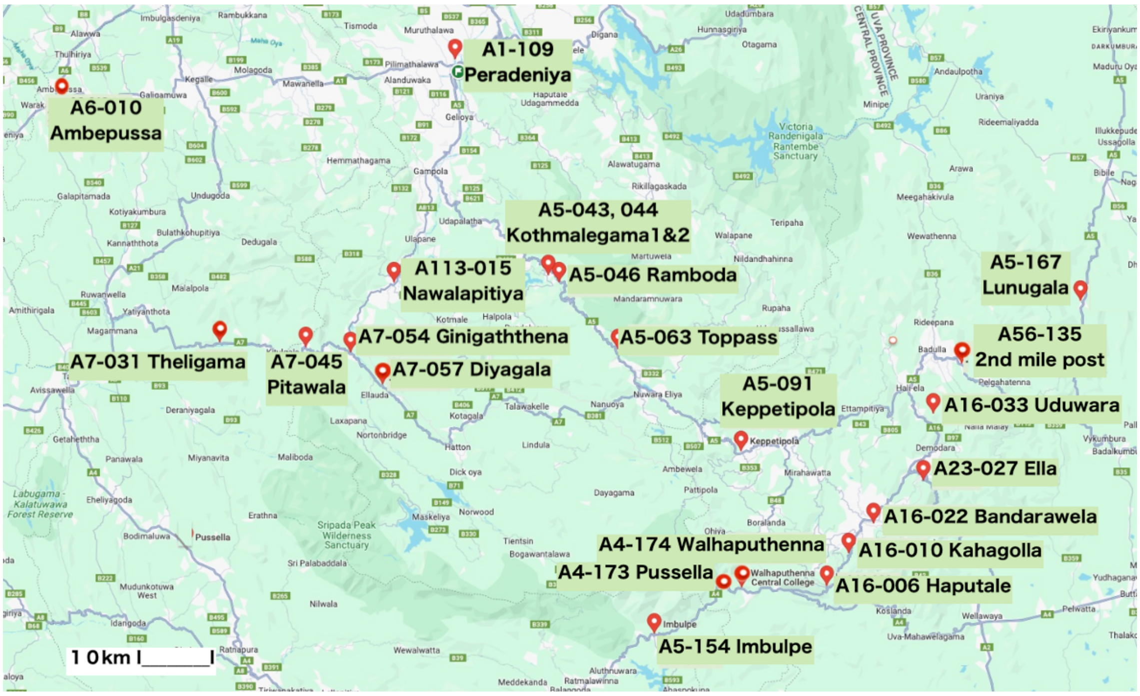

Figure 1: Location of Landslide Countermeasures of the Project

Source: Illustrated by the evaluator on Google Maps.

(1) Implementation of countermeasures against landslides

- Increased content of measures

Number of countermeasure types increased as a result of reviewing their optimum combination of them, considering both economic efficiency and design requirements, and based on the characteristics and causes of landslides identified in the preliminary survey carried out after the project started. The number of countermeasure types applied at the 6 sites where international competitive tendering was planned increased from 17 to 44, and the number of countermeasure types applied at the 10 sites where domestic competitive tendering was planned increased from 24 to 41. As a result, the total number of countermeasure types more than doubled, from 41 to 85.

- Increase in the area of countermeasures and volume of works

  As a result of the above-mentioned review, the area of crib work, surface drains, gabions, anti-rockfall nets and sediment removal increased from 4 to 75 times[6]. In addition, the quantities were increased several times due to newly added countermeasures such as counterweight embankments, lightweight concrete embankments and shotcretes.

- Changes in bidding methods

  At the time of project appraisal an international competitive bidding was planned for six sites, called 'model countermeasure sites,' where local contractors in Sri Lanka were not able to undertake the construction. A local competitive bidding was planned for the remaining 10 sites. However, international competitive bidding was conducted for all 16 sites. This was because the preliminary investigations resulted in an increase in the area where countermeasures would be applied and included types of countermeasures that could not be applied using existing technology in Sri Lanka.

- Increase in number of countermeasure sites against landslides

  At the time of project appraisal, it was planned that countermeasures would be applied in 16 sites, as mentioned above. After effective competitive bidding, it was anticipated that there would be a surplus amount of ODA loans after completion of these sites. RDA and JICA agreed that 6 sites would be added, making a total of 22 sites.

As described above, the number of countermeasure sites increased from 16 to 22, and both the type and quantity of works increased significantly. This means that the output of countermeasures was significantly higher than planned. These increases were reasonable and necessary, reflecting the results of preliminary surveys and efficient bidding, and had no negative impact on the effect of the projects.

The evaluator inspected the sites and carried out a questionnaire survey with RDA and NBRO and confirmed the location of the sites and type of countermeasure applied and concluded that the countermeasures were in good condition and there were no problems.

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[6] The crib work is expressed in terms of area (m^2) for plans, and in terms of the horizontal extension of countermeasures (m) for actuals. As these cannot be compared as they are, the area of actuals was obtained by following the evaluator's field observations, and, for convenience, assuming an average vertical extension of 10 m for the actuals.

Examples of Countermeasures of the Project against Landslides

Gabions, Surface Drain and a Drainage Well (A5-167 Lunugala)

Crib Work (A23-027 Ella)

Ground Anchors (A16-010 Kahagolla)

Shotcrete (A4-174 Walhaputhenna)

Lightweight Concrete Embarkment (A5-063 Toppass)

Anti-rockfall Net (A5-043 Kothmalegama 1)

Photos: taken by the evaluator.

(2) Procurement of equipment for early warning system

Thirty sets of equipment for the early warning system have been procured and installed by the project as planned. NBRO has installed the equipment for the early warning system in landslide-prone areas throughout Sri Lanka, to obtain the rainfall data needed to give early warning of landslides. The 30 sets of equipment procured under the project were mainly installed in the Central and Uva Provinces to cover areas that were not covered by existing equipment. The equipment included 30 automatic rainfall gauges with data loggers, 30 solar systems and 1 set of data monitoring equipment.

(3) Consulting services

The consultancy services included geological survey, detailed design, bidding and bid evaluation assistance, construction management, assistance for procurement of the early warning system, and capacity enhancement of the Project Management Unit (PMU). These were implemented as planned. Capacity enhancement for PMU staff was carried out through construction management work and planning and implementing seminars, and for RDA staff responsible for maintenance of project outputs through site visits and seminars. Technology transfer was provided to staff at NBRO through discussions and exchanging views on issues that arose during construction.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The planned project cost was 7,619 million yen from Japan and 1,971 million yen from Sri Lanka, totaling 9,590 million yen. The actual project cost was 6,319 million yen from Japan and 1,033 million yen from Sri Lanka[7], totaling 7,352 million yen, which was within the plan (77% of plan). The main reason why the project cost was within the plan was effective competitive bidding. The construction costs for the joint venture formed by a Japanese specialized contractor and medium-sized Sri Lankan contractor were significantly lower than planned, which contributed to the decrease in project costs.

3.2.2.2 Project Period

The planned project period was 58 months from March 2013 to December 2017, while the actual project period was 87 months from March 2013 to May 2020. In this ex-post evaluation, the project period of the originally planned sites was considered as the actual project period and compared to the planned project period to evaluate the efficiency. The construction period for the additional six sites added by mutual agreement was excluded, by considering these sites as an extra output. In addition, a total of four months were deducted from the actual period as *force majeure*: two months when the contractor's Japanese staff were unable to travel to Sri Lanka due to the Easter Sunday terrorist attacks that occurred in Sri Lanka in April 2019, and approximately two months during the island-wide lockdown from March 20, 2020 to May 11, 2020 due to preventive measures for Covid-19. In this way, the actual project period was deemed to be 83 months.

Thus, the project period for the initially planned countermeasure sites exceeded the plan (143% of the plan). However, as noted in the Section 3.2.1 on "Project Outputs," the number of

[7] Sri Lankan side's project costs stated in Sri Lankan rupees in documents provided by JICA were converted into Japanese yen at the IMF average rate for each year.

countermeasure types for the sites initially planned increased by more than 2.5 times from 17 to 44, and the quantity of countermeasures applied, including volume, area and extension, also increased by several times. Therefore, it was concluded that the project period matched the level of outputs produced, although it exceeded the plan.

3.2.3 Results of Calculations for Internal Rates of Return (Reference only)

At the time of the appraisal, the economic internal rate of return (EIRR) was calculated for the six model countermeasure sites. At the time of the ex-post evaluation the EIRR for these six sites were recalculated under the same conditions applied as at the time of the appraisal, and found to be as follows:

EIRR at the time of project appraisal: **8.1%.**

- Costs: Project costs (excluding taxes), and cost for operation and maintenance
- Benefits: Reduced travel time, travel costs, personal and property damage, disaster recovery costs, road repair costs, and mental stress compared to when diversions were used when disasters occurred.
- Project life: 50 years.

EIRR at ex-post evaluation: **19.1%.**

- The cost/benefit items and project life are the same as at the time of project appraisal.

The recalculated EIRR was significantly higher than planned because the actual construction costs were significantly lower than planned, although the benefits of the project were slightly less than planned because the actual volume of traffic and GDP were slightly lower than planned.

The financial internal rate of return (FIRR) was not calculated at the time of planning and was not calculated in the ex-post evaluation.

Therefore, efficiency of the project is high.

3.3 Effectiveness and Impacts[8] (Rating: ④)

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

It was expected that there would be no road closures or emergency restoration work due to landslides at the countermeasure sites after project implementation, and these were set as indicators. The target year was two years after project completion, and the target value was zero for both these indicators.

[8] When providing the sub-rating, Effectiveness and Impacts are to be considered together.

No landslides have occurred at the countermeasure sites of the project since completion of the construction works, and, therefore, the number of days of road closure and cost of emergency restoration work were zero. Both indicators have been achieved 100%. Stability of the slopes was also confirmed by slope measurement and monitoring conducted by the NBRO after completion of the project[9].

Table 1: Target and Actual Values of the Operation and Effect Indicators of the Project

Indicators	Baseline Value	Target Value	Actual Value			
	Average between 1993 to 2012	2022 2 Years After Completion	2020 Completion Year	2021 1 Year After Completion	2022 2 Years After Completion	2023 3 Years After Completion
Indicator 1: Number of days roads closed at each project site due to landslides (days/year)	1.75	0	0	0	0	0
Indicator 2: Cost of road restoration at each countermeasure site after landslides (Million Rupees/year)	0.9	0	0	0	0	0

Sources: Target values are from the Preliminary Evaluation Report of the project; actual values are from documents provided by the Executing Agency and site inspection.

[9] The NBRO carried out post-monitoring twice a year using pore pressure gauges, inclinometers and movable piles at six sites - A16-010, A5-135, A5-091, A5-167 and A113-015, where multiple countermeasures had been combined and the countermeasures were applied at larger area; and A7-057, where a landslide occurred during construction. As the slopes were found to be stable and there was no increase in groundwater pressure, the NBRO concluded the monitoring at the end of 2023.

Examples of Countermeasure Sites -

at the time of Project Appraisal and Ex-post Evaluation

At the time of Project Appraisal	At the time of Ex-post Evaluation
A16-010 Kahagolla 	
A5-167 Lunugala 	
A5-135 2nd mile post 	
A4-173 Pussella 	

Sources: Photos at project appraisal are taken from the Information Collection Survey of the Project, and those at the ex-post evaluation were taken by the evaluator.

3.3.1.2 Qualitative Effects (Other Effects)

The qualitative effects of the project were expected to: (1) improve safety of road use and neighborhood, and (2) improve the capacity of RDA and NBRO to prevent landslides on national roads.

(1) Improved safety of road use and neighborhood

During the field survey, drivers of oil tankers, trucks transporting timber and long-distance buses, who were using the national roads covered by the project, were interviewed. They said that they used to be afraid to go through the countermeasure sites of the project during the rainy season, but after implementation of the project they can drive through these areas without worrying. In addition, we visited residents living near the countermeasure sites who said that since implementation of the project they were no longer scared of there being landslides or rockfalls, and they felt calmer. At the time of project appraisal some households had been warned to relocate, but this was no longer necessary as the risk of landslides had been eliminated. In this manner, it was confirmed that there are examples that road use and neighborhood safety was improved as a result of the project implementation.

(2) Improved RDA and NBRO capacity to prevent landslides on national roads

In the project the RDA has accumulated expertise on landslide countermeasure works through experience in its role as implementing agency and by participating in seminars conducted by the consultants. As discussed in "3.4 Sustainability," the PMU staff played the role of lecturers in the maintenance and management training conducted during the ex-post evaluation, which shows that the capacity-building of PMU staff had been achieved effectively and sustainably. The NBRO, as the technical partner of the project, also assisted the consultants in carrying out preliminary surveys and resolving issues during construction. Through these tasks technology transfer for landslide protection was also achieved for the NBRO. NBRO also acquired comprehensive technical know-how on key landslide countermeasures in the ancillary project of this project, the "Landslide Protection Strengthening Project" (July 2014 - September 2018).

At the time of the ex-post evaluation, the NBRO has used the experience gained from the Project and know-how gained from the ancillary project, and countermeasures such as crib work, rock bolts, shotcretes and rock nets introduced under the Project in an Asian Infrastructure Investment Bank (AIIB) -supported project,[10] and a World Bank-supported project[11]. As mentioned above, the implementation of the project and ancillary project increased the capacity of the RDA and NBRO in landslide prevention on national roads.

(3) Synergies with AIB and World Bank-assisted projects

Some of the above-mentioned countermeasure sites implemented by the projects assisted by

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[10] Reduction of Landslide Vulnerability by Mitigation Measures Project.

[11] Climate Resilience Improvement Project.

the AIIB and World Bank are located on the same national roads as the countermeasure sites of this project. For example, the countermeasures implemented by the project assisted by the World Bank are located between countermeasure sites A5-063 and A5-091 of this project, and both contribute to disaster prevention on A5 national road. In this way, it can be said that the synergistic effect of this project and those assisted projects had further strengthened landslide disaster prevention on national roads in the country.

3.3.2 Impacts

3.3.2.1 Intended Impacts

The impact of the project was expected to facilitate the smooth implementation of economic and social development activities. To ascertain if there were any examples of such an impact being created, 21 people were interviewed, including 5 RDA staff, 11 residents living near the countermeasure sites and 5 road users (see case studies below). As a result, it was confirmed that, as the following case studies show, the project has contributed to the smooth implementation of economic and social activities.

<Case studies>

<u>Driver of timber truck (interviewed near A16-010)</u>

I have sometimes had to wait in truck for three to four hours or stay in nearby towns when roads were closed due to landslides. It was difficult to have to notify the police and village administrator and get a haulage permit again when the delivery schedule changed due to time spent waiting. No landslides have occurred at the countermeasure sites. There have been no more delays in the transport of timber. I would like to see this work carried out in other areas as well.

Truck of interviewed driver

Photo: Taken by evaluator.

<u>Foreign tour guide (interviewed near A5-045)</u>

In the past the road has been closed by landslides, and we have often had to make a diversion. As we are in a large bus we cannot go on narrow roads and have to make a long detour. If detours are necessary, the schedule of visits to tourist attractions has to be adjusted. The tourists have to give up their planned visits and were disappointed. This situation has been reduced as major landslide sites have been protected by the project.

Bus of the foreign tour guide interviewed

Photo: Taken by evaluator.

Technical officer, RDA Badulla District

Before the project, the A5-135 was subject to continuous landslides during the rainy season, with annual repair work lasting from one to three months; the A5-167 was impassable due to frequent road blockages caused by landslides. In the past, I was often informed by the police in the middle of the night and rushed to these landslide sites. Since the countermeasures have been put in place, no landslides have occurred. The project has solved the most serious landslide problem in my area of responsibility.

RDA engineer working in Nuwara Eliya District

In the past, weathered stones on the slopes often broke up and fell onto the road at A5-046, A5-043 and A5-044. They fell fast because of the steep slopes, and there was a great risk of accidents for passing vehicles. Since the installation of anti-rockfall nets in the project this risk has been eliminated, and the safety of traffic has been ensured.

The NBRO has deployed 30 rain gauges procured under the project in an early warning system across the country. This issues an early warning for landslides, slope failure, rockfalls, cut slope failure and land subsidence based on observed rainfall. Warnings are issued at three levels - alert, evacuation preparation and evacuation advisory - to help ensure the safety of residents and avoid loss of life. (The photograph on the right shows a rain gauge for the early warning system installed in the project. Source: photo taken by evaluator.)

3.3.2.2 Other Positive and Negative Impacts

1) Impacts on the Environment

The project was judged to fall under Category B according to the JICA Guidelines for the Confirmation of Environmental and Social Considerations (established in April 2010), as it does not fall under the sensitive sectors/characteristics and sensitive areas listed, and its undesirable effects on the environment are not considered to be significant.

The Environmental and Social Considerations Monitoring Report for the project confirmed that the observed values for dust and vibration, air quality, water quality and groundwater during construction did not exceed standards, and there were no problems with waste, as the necessary countermeasures were taken. For noise during construction, daytime observations exceeded the standard at three locations in June 2020, but as no heavy machinery was used during construction at these locations ambient noise may have affected the measurements. These countermeasure sites are in forested areas, and there are no houses or public facilities in the surrounding area. There was no complaints or problems because there was no influence on the residents. After completion of the project to the end of 2023, NBRO carried out surface, subsurface and groundwater level monitoring twice a year at six countermeasure sites. It was confirmed that any of these items had movements that would affect the surrounding environment. Observations of dust and vibration, air quality and water quality were deemed unnecessary, as no action was taken at the countermeasure sites that would affect them.

Based on the above, it is concluded that no negative environmental impacts have been caused by the project.

2) Resettlement and Land Acquisition

Four people from two households were resettled. Residents were provided with land free of charge, and compensation was paid according to an assessment of the re-acquisition price for the houses. Permanent land acquisition also occurred for land with shops (1 house), cattle sheds (6), a statue of Mary (1), a rubber plantation (1) and a tea garden (1). In all cases, a compensation was paid prior to the acquisition according to an assessment of the re-acquisition price. Temporary land purchase occurred in 16 sites (8 public and 8 private lands) as a result of the implementation of countermeasures. The temporary acquisitions were carried out in accordance with written agreements with the owners, and the land was returned to the respective owners after the works were completed. No complaints were lodged. The resettlement and land acquisition of the project was carried out without any problems and in accordance with JICA guidelines, and no issues were observed.

3) Gender Equality, and 4) Marginalized People

There was no particular impact.

5) Social Systems and Norms, People's Well-being and Human Rights

As noted in the section of "Qualitative Effects," there are examples of the implementation of the project eliminating concern about landslides and rockfalls, and residents are living in safety and no longer need to relocate or evacuate.

6) Unintended Positive/Negative Impacts

The project also created the following impacts:

(a) Use of Japanese technologies

Countermeasure works, such as crib work, lightweight concrete embankment, rock bolts, ground anchors, drainage wells and horizontal underground drainage, were implemented in the project. These countermeasures are common in Japan but had not been implemented in Sri

Lanka. It is worth noting that these technologies were introduced through this project, and that major landslides on national roads, which had been a problem for many years, were prevented.

(b) Technology transfer to local contractors

The construction of the project was divided into Lot 1, mainly in the Central Province, and Lot 2, mainly in Uva Province. In Lot 1, a Sri Lankan contractor undertook the works, with Italian and Japanese specialized contractors cooperating as subcontractors. In Lot 2, the works were carried out by a joint venture involving a Japanese specialized contractor and a Sri Lankan contractor. Local contractors' knowledge and experience of countermeasure works was strengthened as a result of local contractors and overseas specialized contractors working together on this project, and small-scale local contractors also being involved in the project as subcontractors. According to the RDA Provincial Director at the Central Province, earlier they used to receive bids from only two contractors for a tender notice of landslide countermeasure works. They can now secure 6 to 7 bids, which is effective in reducing the construction cost, because local contractors acquired skills on countermeasures in the project. The acquisition of skills by these local contractors has also facilitated application of the countermeasures introduced by the project in other parts of Sri Lanka.

As part of this evaluation, especially on effectiveness and sustainability, the evaluator studied changes in the slopes of countermeasure sites by analyzing satellite data. The result of the study is described in the column on page 24.

As mentioned above, no landslides, road closures or emergency restoration operations have occurred in the countermeasure sites since the project was implemented, and all operation and effect indicators have been achieved. As planned for qualitative effects, road use and neighborhood safety were improved, and RDA and NBRO improved their capacity on landslide disaster prevention. Examples of contributions to the smooth implementation of economic and social activities, which were expected as an impact of the project, were also confirmed. In addition, there were impacts of further strengthening landslide prevention on national roads using Japanese technologies, and the dissemination of these technologies to local contractors.

This project has achieved its objectives more than planned. Therefore, effectiveness and impacts of the project are very high.

3.4 Sustainability (Rating: ③)

3.4.1 Policy and System

The *National Road Master Plan* (2021 - 2030), at the time of the ex-post evaluation, has a plan to focus on road disaster prevention, including landslide prevention, considering the importance of road safety and climate change. The *National Disaster Management Plan* (2022 - 2030) places a high priority on landslide prevention measures, with structural measures for landslide risk reduction as a priority. These policies are expected to continue in future and support the sustainability of the project's effectiveness.

As mentioned above, there are no policy or system related issues on sustainability of the project.

3.4.2 Institutional/Organizational Aspect

(1) RDA

The RDA is responsible for the operation and maintenance of the project's countermeasure sites. The RDA is an organization under the Ministry of Transport and Highways, responsible for the development, construction and maintenance of national roads, and associated bridges and highways. It has a staff of approximately 10,057 (2023). The Road Maintenance and Management Department is responsible for the maintenance of roads and bridges, including countermeasure sites, at RDA headquarters. The department is responsible for monitoring and budget management of maintenance operations in the provinces. The provincial offices of the RDA are responsible for maintenance of the countermeasure sites. Engineers, technical officers, works supervisors and workers assigned to the regional offices under the provincial offices are engaged in maintenance work at the countermeasure sites.

The workers are the ones who carry out the daily maintenance work at the countermeasure sites of the project. Two full-time workers are assigned for daily maintenance on each of the countermeasure sites of the project at A16-010, A5-135 and A4-174, where countermeasure works were extensively applied. In other areas, the workers in charge of maintenance of roads and bridges carry out the daily maintenance work of the countermeasure sites. The works supervisor is responsible for carrying out the work and checking progress, and periodic inspections are carried out every three months by the technical officer. Periodic maintenance is carried out by the works supervisor and workers under the guidance of an engineer and technical officer. In Sri Lanka, due to fiscal austerity caused by an economic crisis new recruitment of civil servants has been restricted and the RDA tends to be understaffed, but the necessary personnel have been allocated for maintenance work of the project, and there have been no problems due to understaffing.

(2) NBRO

The Landslide Early Warning Centre of the NBRO's Landslide Research and Risk Management Department is responsible for operation and maintenance of equipment procured under the project for the early warning system. The Centre is staffed with the personnel required to operate and maintain the equipment.

As mentioned above, the responsibilities and roles of the RDA and NBRO are clear. The human resources necessary to sustain the project's effectiveness are in place, and no institutional or organizational problems were observed.

3.4.3 Technical Aspect

Daily maintenance of the countermeasures applied in the project did not require any special skills. Periodic inspections were carried out using knowledge gained from training, and there were no technical issues.

For regular maintenance, the inspection and cleaning of horizontal underground drainage pipes and removal of fallen rocks and trees in anti-rockfall nets had not been carried out at the time of the first field survey in this evaluation. The high-pressure cleaners, pipe inspection cameras and generators procured under the project for cleaning horizontal underground drainage were also never used. Although training on this task was provided during implementation of the project, at the time of the field survey RDA staff did not appear to have a full understanding of the need for these tasks, and how to carry them out. When the evaluator raised this issue with RDA headquarters, training was conducted on these tasks in June 2024 for 29 RDA officials from the Central and Uva Provinces. The staff of the former PMU played a role of instructors in the training.

Training on Maintenance Work Conducted by RDA in June 2024

Photos: Provided by RDA.

The second field survey confirmed that staff in these provinces were able to carry out these tasks, and that procurement equipment and maintenance manuals were being used. It is expected that this work will be carried out in the future, as required, to ensure that the technology is well established.

NBRO personnel have the skills and knowledge required to operate and maintain early warning system equipment.

As mentioned above, problems relating to operation and maintenance techniques were identified. These are highly likely to be resolved, as the staff have acquired the skills through implementation of training.

3.4.4 Financial Aspect

Expenditure of RDA was Rs.11.5 billion in 2021, Rs.9.6 billion in 2022 and Rs.9.6 billion in 2023. Of this, maintenance expenditure was Rs.4.1 billion in 2021, Rs.2.4 billion in 2022 and Rs.6 billion in 2023. There was an increase in 2023 in both budget and expenditure, indicating that the situation has recovered, although the economic crisis forced a reduction in budget allocation for maintenance in 2022 (Figure 8). According to RDA headquarters, the maintenance budget for 2024 is almost the same amount as in 2023.

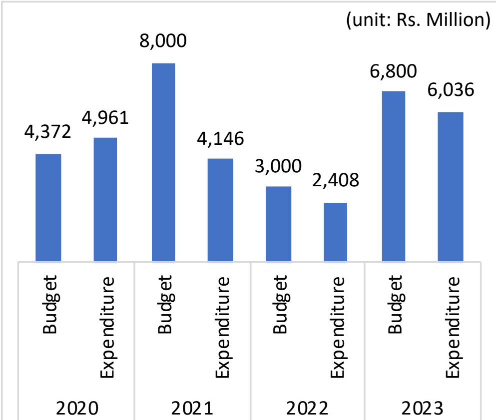


Figure 8: RDA's Annual Budget and Expenditure for Maintenance

Source: Document provided by RDA.

The evaluator studied the maintenance budget for RDA Uva Province, which is responsible for maintenance of 10 of the 22 countermeasures sites in the project. There was a marked decrease in 2022, but a significant increase in both budget and expenditure in 2023 (see Figure 9), similarly to the national budget. A budget allocation of Rs.500 million is planned for 2024, the same as in 2023. The Central Province's budget and expenditure were also studied and found to have similar trend to Uva Province, with a recovery in 2023.

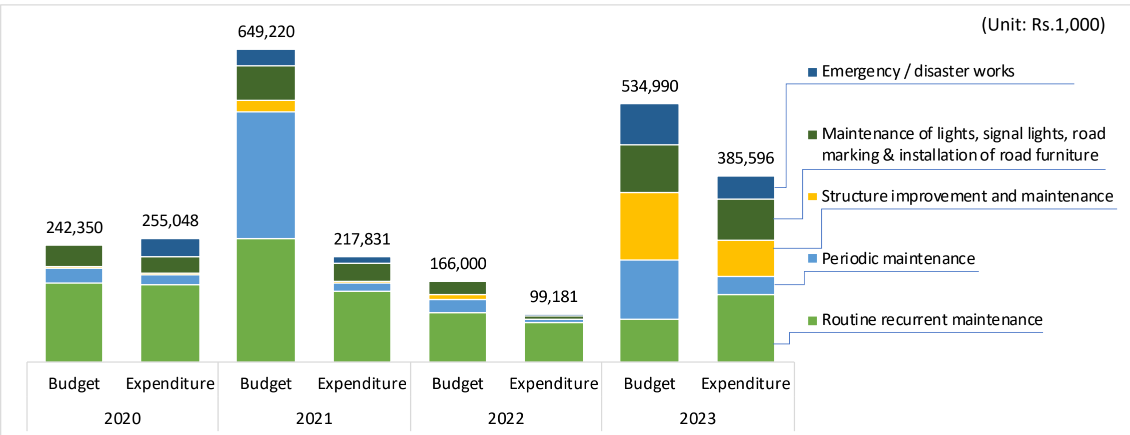


Figure 9: Budget and Expenditure of RDA Uva Province

Source: Document provided by RDA Uva Province.

At the time of the ex-post evaluation the necessary budget for maintenance of countermeasure sites was allocated to each province, and there had been no financial problems. The responsible officials in the provinces indicated that maintenance of the countermeasure sites of the project did not require a lot of money and could also be carried out within budget in the future.

As noted in "3.4.7 Status of Operation and Maintenance," the inspection and removal of fallen rocks and sediment in the four anti-rockfall nets in the Central Province should be carried out by a specialized contractor. The evaluator asked RDA headquarters if the necessary budget for this work could be secured and learned that the budget for implementation of this work can be allocated based on a request from the Central Province.

Revenue of NBRO in 2023 was approximately Rs.790 million, of which Rs.600 million was self-financed from consultancy and testing services. Both revenue and profit decreased in 2020 due to Covid-19, but both have increased since 2021. NBRO's operating balance has been in surplus consistently in recent years, with an operating profit before tax of approximately Rs.140 million in 2023. The budget for operating and updating equipment for the early warning system has also been secured.

As mentioned above, there are no financial issues related to sustainability of the project.

3.4.5 Environmental and Social Aspect

There were no negative environmental impacts from the project, and it contributed to the smooth implementation of economic and social activities. No negative environmental or social impacts were identified for the future.

3.4.6 Preventative Measures to Risks

No particular factors were identified that posed a risk to the continued effectiveness of the project, given the economic, social and political situation in the country.

3.4.7 Status of Operation and Maintenance

Status of operation and maintenance of countermeasure sites and the early warning system of the project are as follows.

(1) Countermeasure sites

(a) Daily maintenance and inspection

The main items for daily maintenance and inspection at the countermeasure sites were cleaning drains, drainage pits and drainage holes, and managing vegetation. These daily maintenance and management tasks were carefully implemented at 10 sites in Uva Province and 8 sites in Central Province. The evaluator noted during the first field inspection that drains were not adequately cleaned at 2 sites in Sabaragamuwa Province and 1 site in the North Western Province. They were properly cleaned at the second field survey, in response to a suggestion made by the evaluator.

(b) Periodic maintenance and inspection

The main items for periodic maintenance and inspection at the countermeasure sites are inspection and repair of cracks in the concrete, inspection and cleaning of horizontal underground drainage, and inspection and removal of rockfall and sediment in the anti-rockfall nets.

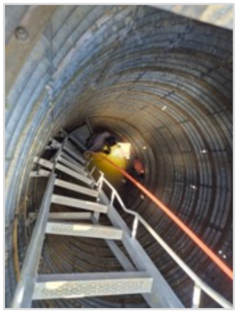
- Inspection and repair of cracks in concrete

  Several cracks in concrete sections, including the side walls of the drainage ditch, were found as a result of detailed observation of the condition of countermeasure sites at A5-135 and A16-010. This is probably due to expansion of the concrete and slight distortion of the ground. At the time of the second field survey, most of the defects that required urgent repair had already been attended to, and other areas were scheduled to be repaired in due course.

  At A5-135, there were several cracks and slight leaks by the anchor plate and on the wall of the drainage. Former PMU staff inspected this promptly when the leakage occurred and concluded that there were no structural or functional problems with the countermeasures, and no repairs were required. The evaluator confirmed that the consultant of the project agreed. Therefore, it can be concluded that there were no problems.

- Inspection and cleaning of horizontal underground drainage

  As mentioned in "3.4.3. Technical Aspect," training for staff in charge of maintenance was conducted during the ex-post evaluation. The training included a practical session on inspection and cleaning of horizontal underground drainage. During the second field survey, staff in RDA Uva Province confirmed that, soon after attending the training, they inspected the underground drainage pipes at three locations in the province with an inspection camera and found impurities, which were then cleaned. Cleaning was effectively carried out for A5-135 and A5-167. The discharge volume from a drainage pipe at A16-010 was found to have reduced when the second field survey was conducted; a blockage in the pipe was suspected. Cleaning was carried out using a high-pressure cleaner, but the discharge volume did not recover, and there was a possibility that foreign matter remained in the pipe. After that, a re-inspection of the pipes using the camera revealed there was a used PET bottle inside the pipes. When this was removed the amount of discharge recovered and the problem was solved. The staff of RDA Uva Province are learning from this incident and plan to monitor the amount of discharge and water level in the drainage wells and will try to detect foreign objects in the drainage pipes and blockages at an early stage.

Staff of RDA Uva Province Inspecting and Cleaning Horizontal Underground Drainage in the Drainage Well

Source: Provided by RDA.

- Inspection and removal of fallen rocks and sediment in anti-rockfall nets

Removal of Fallen Rocks and Sediment in the Anti-rockfall Nets by Staff of RDA Central Province

Source: Provided by RDA

Following the findings of the ex-post evaluation, RDA Central Province carried out an inspection and removed fallen rocks and sediment in the anti-rockfall nets at four locations in June 2024. During implementation of the work, RDA staff found they could loosen the nets at the start of the removal work manually, but they could not manually tension the nets properly after the work was completed. Currently, the nets are tensed to some extent and thus play a role in preventing falling rocks, but in order to further enhance the prevention function, it is desirable that an even and sufficient tension be applied to the nets by a professional contractor using specialized equipment. The RDA Central Province is aware of this and plans to procure a specialized contractor in future.

(2) Early warning system

During the ex-post evaluation, it was found that 24 of the 30 pieces of equipment of the project for the early warning system were in good working order. Six were not always transmitting rainfall measurements. This equipment had been installed for eight years, and the problem was caused by aging of the sensors for communication and solar panels. The NBRO was aware of the problems with this equipment and, at the time of the ex-post evaluation and with support from the World Bank, the equipment was being upgraded. By the first half of 2025, equipment in the entire country, including equipment from the project, is expected to be updated.

As described above, the operation and maintenance of this project is conducted well in general.

Slight issues have been observed in technical aspects of operation and maintenance; however, there are good prospects for improvement/resolution. Therefore, sustainability of the project effects is high.

< Satellite Data Analysis of Slope Movement in Project Sites >

As part of verification of the effectiveness and sustainability of the project, movement in the slopes of the project sites was studied by analyzing satellite data. Satellite data analysis was carried out with the cooperation of the Arthur C Clarke Institute of Modern Technology in Sri Lanka for A16-010 Kahagolla, and A5-135 Second Mile Post, where countermeasure works were extensively applied.

Method of Analysis

- Single-look complex images[12] of the SENTINEL-1 satellite in wide swathe mode[13] were obtained in time series from the time of project appraisal to the ex-post evaluation. Images were acquired in both ascending and descending orbit directions[14] to enable detailed analysis.
- These images were processed using PS InSAR analysis[15] to read the uplift and subsidence of the terrain. The height of the uplift and subsidence was calculated using a GECORIS tool[16]. The height is not the actual height of the uplift or subsidence, but the length along the line-of-sight (LOS) between the surface and the satellite.[17]

Result of Analysis

The heights of uplift and subsidence obtained in this way are composited on a yearly basis and represented on the maps in Figure 2 for A16-010 and Figure 3 for A5-135. They show that both locations were relatively stable in 2019 and 2020. This indicates that the slopes were stable just before and after completion of countermeasure works in May 2020. However, since 2021 A16-010 may have experienced an uplift of around 300 mm LOS (red areas), and subsidence of around 130 mm LOS (dark green areas). For A5-135, there has been little movement since countermeasure works were completed. In both locations, the uplift and subsidence in the

[12] A synthetic aperture radar (SAR) image format, which combines amplitude and phase information.
[13] A mode of operation of SENTINEL-1, which covers a wide observation range (250 km).
[14] When a satellite moves in a direction from the North Pole towards the South Pole it is called a descending orbit; when it goes from the South Pole towards the North Pole it is called an ascending orbit.
[15] PS Interferometric SAR analysis is a method for estimating spatial distribution and time series variation of land surface variability from many SAR images using only statistically accurate pixels, called permanent scatterers.
[16] An open-source tool for time series analysis using InSAR.
[17] An attempt was made to calculate the actual height using the angle formed by the LOS and ground surface, but this was difficult because of the uneven slopes observed in this study and the variety of angles.

ascending and descending orbit data do not match. This suggests that the slopes may have moved horizontally.[18]

In addition to the above analysis, uplift and subsidence status at the selected six locations in the area of countermeasure works was analyzed and shown in time series graphs (Figures 4 and 5). These figures also suggest the potential for uplift and subsidence of the slopes.

However, it is not possible to conclude from this analysis alone how important these suggestions are in terms of landslide countermeasures, and what are the causes of uplift and subsidence.[19] There is a need to conduct geotechnical engineering investigations and collect and monitor ground data to confirm them.

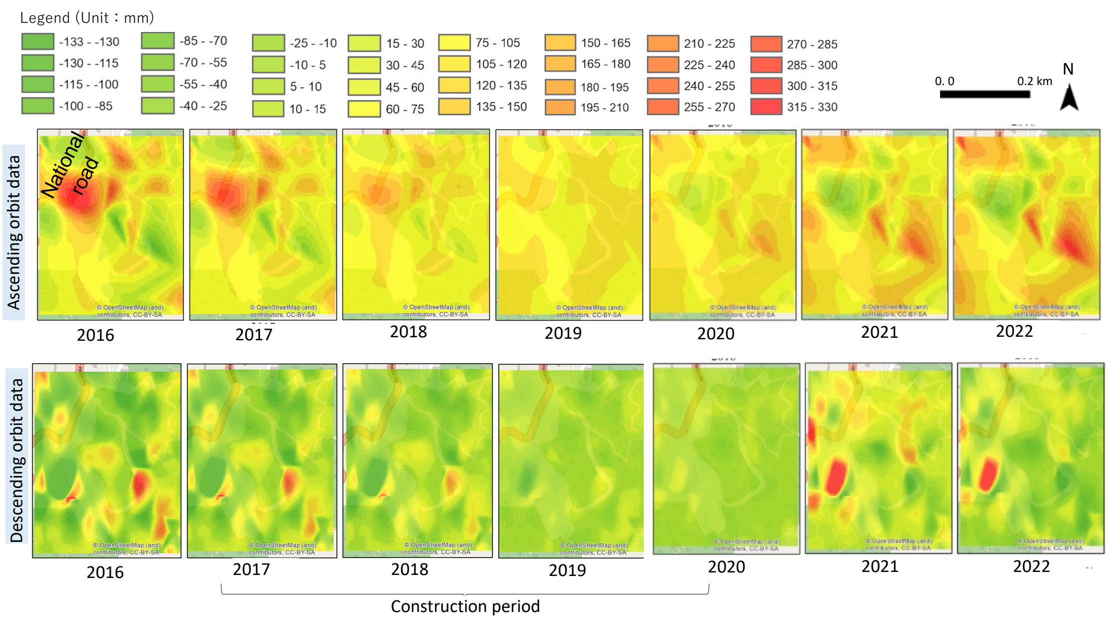


Figure 2: Maps of Uplifting and Subsidence Status of A16-010 Created by Satellite Images

[18] If there is horizontal movement on the surface of slopes the direction of the satellite can cause a phase shift in the radar signal, and there may be discrepancies between data from the ascending and descending orbits. However, these discrepancies may also be caused by observation values being affected by noise sources, such as atmospheric disturbance and signal processing errors.

[19] This may be due to geological changes, natural factors such as rainfall, or human or animal activity. In addition, drainage wells and horizontal underground drainage pipes have a function of preventing the groundwater level from rising. It is also possible that this function is working to lower the groundwater level, causing subsidence or uplift of the ground surface.

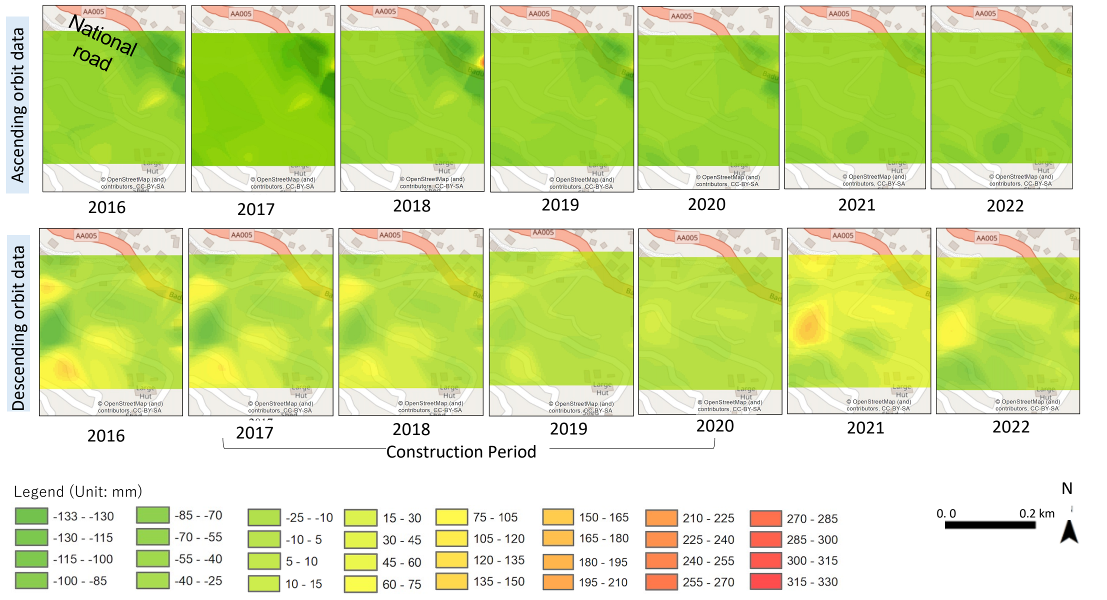


Figure 3: Maps of Uplifting and Subsidence Status of A5-135 Created by Satellite Images

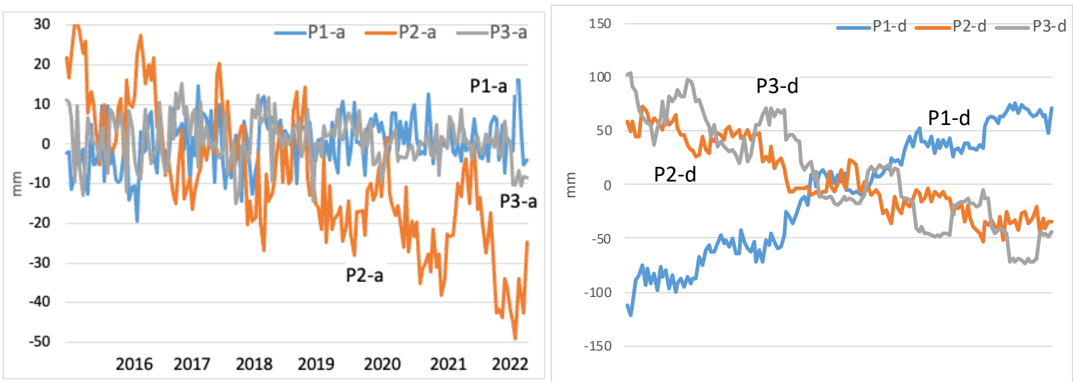


Figure 4: Changes in Height at the Selected Locations in A16-010

(Left: Ascending data, Right: Descending data)

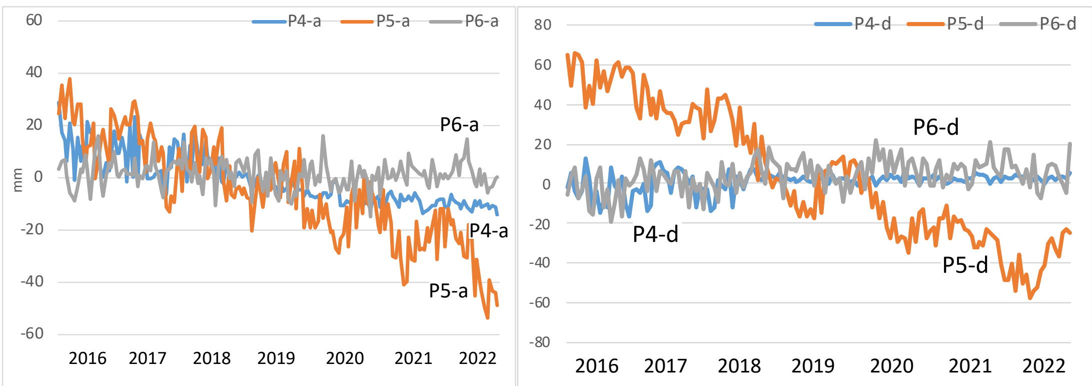


Figure 5: Changes in Height at the Selected Locations in A5-135

(Left: Ascending data, Right: Descending data)

Note: See Figures 6 and 7 for locations shown as P1-a, P2-a, P1-d and others.

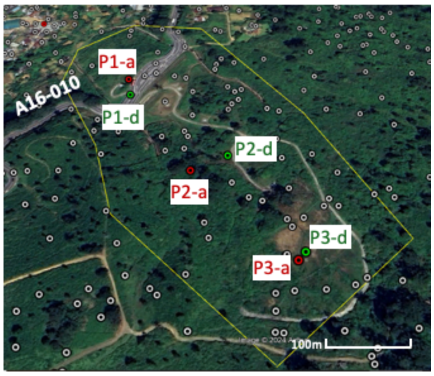


Figure 6: Selected Locations for A16-010

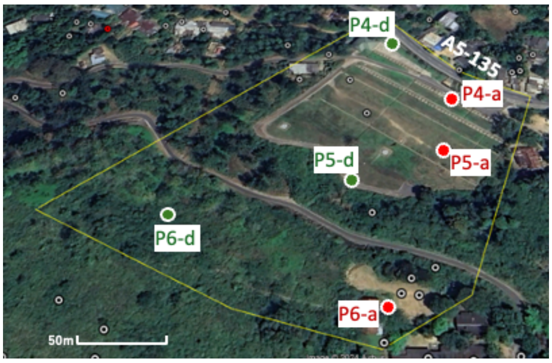


Figure 7: Selected Locations for A5-135

Source: All figures above were provided by Arthur C Clarke Institute of Modern Technology in Sri Lanka

<u>Subject and Method for Satellite Image Analysis for Slope Protection Project</u>

In slope protection projects, time series analysis of surface movement can be carried out by InSAR analysis of satellite data for the countermeasure sites.

<u>Potential use of satellite data in slope protection projects</u>

The SAR analysis described above can be used effectively in slope protection projects in the following ways:

(a) Use of satellite data in preliminary surveys for site selection of countermeasure works

As discussed in "3.1.1.3 Appropriateness of Project Plan and Approach" in this report, a detailed preliminary investigation was carried out over about a year after the project appraisal in order to adopt the most appropriate countermeasure works for the project. The analysis of satellite data, in addition to geotechnical investigations, would provide a reference to past surface movement.

(b) Conduct satellite data analysis at the beginning of an ex-post evaluation to make the site visit efficient

If the evaluator can identify points with a high probability of movement by conducting satellite data analysis at the beginning of an ex-post evaluation survey, they can focus on investigating changes in the ground surface and structures at these points during the field survey. This is useful for improving the efficiency of the survey. It may also be possible to combine results of the analysis with information from a field survey to confirm the causes of the changes and their effects.

(c) Utilize satellite data for identifying priority areas for post-construction monitoring and inspection

The results of satellite data analysis can also be useful in identifying priority sites for monitoring and inspection. The executing agency can discuss the need for additional countermeasure works if changes are identified by carrying out other necessary surveys after satellite data analysis. The occurrence can also be referred to in future implementation of countermeasure works.

(d) Improved efficiency of long-term monitoring by executing agency

Satellite data analysis can also be used by the executing agency to effectively carry out long-term monitoring of the countermeasure sites. As noted in "3.3.2.2 1) Impact on the Environment," slope measurement and monitoring were carried out by the NBRO after completion of the project, but this was stopped after three years. The transportation and labor costs involved in carrying out a monitoring survey at six locations across the country were one reason the NBRO decided to stop the survey. If satellite data analysis had also been carried out after completion of the project, the NBRO may have been able to identify sites and locations that required priority measurement and monitoring and continue the survey efficiently.

Limitations and challenges of satellite data analysis in disaster management projects on slopes

Although InSAR analysis of satellite data can be used as described above in disaster management projects on slopes, the importance and causes of suggestions derived from the analysis cannot be determined by satellite data analysis alone. Therefore, geotechnical engineering surveys and collection and monitoring of ground data need to be planned and carried out in order to make better use of satellite data in similar projects.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The project aimed to reduce the risk of landslides on national roads in Sri Lanka by implementing slope protection measures on major national roads with a high risk of landslides, strengthening the safety of the road network and the lives of the people living nearby, and thereby contributing to the economic and social development of the country.

At both the time of the project appraisal and ex-post evaluation 90% of ground passenger and freight transport travelled by road in Sri Lanka, as the rail network only covers part of the country. The road network therefore plays a crucial role in economic and social activities, and disaster prevention and reducing the risk of landslides affecting the roads are consistent with the country's development policies and needs. The project was also consistent with Japan's ODA policy at the time of project appraisal. However, expected synergies with JICA's subject-specific training, which was expected to be linked with this project, could not be confirmed, and no linkages with projects implemented by other donors were planned. Therefore, its relevance and coherence are high.

The outputs of the project were in line with the plan, apart from the number of countermeasure sites increasing from 16 to 22 due to a reduction in project costs. The project cost was within the plan. It was concluded that the project period matched the level of outputs produced, even though it exceeded the plan, because the output of countermeasure works significantly increased. Therefore, efficiency of the project is high.

All the operation and effect indicators of the project have been achieved. The qualitative effects of the project, such as improved safety for road users and nearby residents, and improved capacity of staff at the executing agency for landslide prevention on national roads, have also been achieved as expected. The impact of the project on the smooth implementation of economic and social activities, the use of Japanese technologies and transfer of technologies to local contractors has also been confirmed. This project has achieved its objectives more than planned. Therefore, effectiveness and impacts of the project are very high.

There are no problems with the operation and maintenance of the project in terms of relevant policies and systems, organization and structure, financial situation, environmental and social considerations, and risk response. Slight issues have been observed in the technical aspects; however, there are good prospects for improvement/resolution. Therefore, sustainability of the project effects is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

(1) Make sure inspection and maintenance work continues

Maintenance of the countermeasures is very important for maintaining the effectiveness of the project. Some maintenance items had not been implemented until this evaluation, satellite data analysis suggested surface movement, and field surveys observed cracks in the concrete and blockages in a horizontal underground drainage. The RDA needs to ensure that inspection and maintenance will continue to be carried out in future, paying particular attention to the following points:

(a) <u>Daily inspection and maintenance</u>: Ensure cleaning of drains, drainage holes and drainage pits, and vegetation management.

(b) <u>Routine maintenance</u>: Pay attention to inspection and removal of fallen rocks, sediment and trees in the anti-rockfall nets, and inspection and cleaning of horizontal underground drainage. For anti-rockfall nets, a specialist contractor should be engaged to maintain appropriate tension of the nets. Discharge flow rates and water levels in the drainage wells should be inspected to identify any blockages or abnormalities in horizontal underground drainage.

(c) <u>Joint annual inspection</u>: RDA and NBRO should conduct joint annual inspections, focusing on the countermeasure sites with horizontal underground drainage and anti-rockfall nets.

They should especially check for defects in (a) and (b), by referring to the as-built drawings of countermeasures and maintenance manuals. It is important for staff at the headquarters of the two organizations to participate in the inspection. The results of the inspection should be reflected in the maintenance and management work plan in future, and in planning of future countermeasure works.

(d) Develop a maintenance plan for countermeasure works and introduce a specific budget item: It is important for the RDA headquarters to ensure that maintenance work on countermeasure sites is included in the annual maintenance plan of the provinces, and to monitor their implementation. In addition, it is desirable to establish a budget item specifically for maintenance and management of countermeasures to facilitate carrying out the outsourced work. It will be necessary to outsource tensioning the anti-rockfall nets and work at height in the rockfall nets to external specialist contractors in future.

4.2.2 Recommendations to JICA

(1) Participation of RDA maintenance staff in JICA task-specific training

The maintenance of countermeasure works introduced by the project involves special techniques and work items that are different from road and bridge maintenance work. Countermeasure works have just been introduced in Sri Lanka, and there are no opportunities to attend training in these maintenance techniques in the country. It would be useful to improve maintenance and management techniques for countermeasure works if engineers in charge of maintenance in the Central and Uva Provinces of the RDA could participate in JICA task-specific training courses relating to maintenance of mountain roads and slope protection countermeasures.

4.3 Lessons Learned

(1) Provide practical training on maintenance and management works that require special operations

Although training on the maintenance of anti-rockfall net and horizontal underground drainage was conducted and the necessary equipment was procured during implementation of the project, this had not been carried out until the time of the ex-post evaluation. When asked why this had not been done, RDA staff said that, although they attended the training, they had never actually done the work themselves and were not confident that they could safely carry out this special work.

For maintenance of anti-rockfall nets, the process involves loosening the net fasteners, lifting the net using heavy machinery, climbing into the net or up the slope to remove rocks and trees, and then re-tensioning the net when the work is finished. For maintenance of horizontal underground drainage, the process involves measuring the gas concentration in the drainage well and inspecting the inside of the pipe using a camera, before going down into the drainage well and cleaning the pipe with a high-pressure cleaner. These operations are completely different from the maintenance work that RDA staff usually carry out on roads and bridges, and it may have been difficult to learn these tasks just by observing them.

For the drainage, it was recognized that the pipes were not blocked until the time of the ex-post evaluation and that there had been no need for cleaning. In Uva Province the staff member who attended the training transferred elsewhere after project completion, and before any maintenance work had been carried out. Their successor did not seem to have a clear idea of the work to be carried out. As the work was not routinely carried out, it may be difficult to transfer the learning through training and teaching materials to the successor.

This shows that intensive training needs to be provided until staff in charge are confident in their ability to carry out the work before the project is completed for maintenance work that requires the use of special equipment, or special work that the executing agency has never done before. In addition, for maintenance work that is carried out less frequently, the executing agencies need to pay particular attention to the transfer of learning from the training and carry out re-training as necessary.

(2) A business model that enables Japanese specialized contractors to expand their overseas market and disseminate their technologies

In this project, a Japanese specialist slope countermeasure contractor formed a joint venture with a Sri Lankan contractor to carry out the works. The consortium contributed to the efficient implementation of the project and ensured the quality of the works. It also contributed to a reduction in the project cost and transfer of technology for countermeasure works. In this way, it is possible for a joint venture of a Japanese and counterpart country to undertake construction contracts where there is construction that requires a high level of expertise, such as disaster prevention work. This is a useful business model, which enables Japanese specialist contractors to expand their overseas markets and disseminate Japanese technologies.

5. Non-Score Criteria

5.1 Performance

5.1.1 Objective Perspective

(1) The technology and expertise of the Japanese contractor contributed to the quality and efficiency of construction in the project

The construction work of this project was complex, with the construction sites scattered about and a wide variety of construction types. The RDA and the consultant of the project stated that the competence of skilled workers from the Japanese contractor in charge of construction of the project, leading to there being no need to do work twice and there being no major failures, contributed to the efficient implementation of the work. The NRBO also believed that the quality of the contractor's work was outstanding.

(2) Teamwork among stakeholders contributed to effective project implementation

The teamwork and dedication of the JICA-related staff, RDA and NBRO contributed to the smooth implementation and quality design and construction of the project. According to PMU staff, there was good communication and cooperation within the team, and problems were shared, discussed and solved to achieve the objectives. The consultant of the project stated that the NBRO's expertise in geotechnical engineering, and knowledge in analyzing landslides, was useful in solving the challenges and analyzing the problems faced in implementing the project. For example, the consultant was able to effectively implement the project by discussing and determining solutions with the NBRO when they need to deal with an unexpected slope failure during construction on A7-057, and to analyze dynamic observations of slopes, which required a high level of expertise.

5.2 Additionality

Based on the experience gained through the preliminary investigations and implementation of the project, the Director General of the NBRO presented a paper entitled *Structural mitigation of a deep-seated slow-moving landslide along a major national road in Sri Lanka* at the International Conference on Soil Mechanics and Geotechnical Engineering and shared the achievements of the project widely abroad.[20]

(END)

[20] *Structural mitigation of a deep-seated slow-moving landslide along a major national road in Sri Lanka*, Asiri Karunawardena, M. Toki, T. Thlakarathne and W. Galhena, 20th International Conference on Soil Mechanics and Geotechnical Engineering (Sydney), May 2022.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs	• Landslide countermeasures: 16 sites • Equipment for early warning system: 30 sets	• Landslide countermeasures: 22 sites • Equipment for early warning system: 30 sets
2. Project Period	March 2013 - December 2017 (58 months)	March 2013 - May 2020 (87 months)
3. Project Cost Amount Paid in Foreign Currency	6,450 million yen	3,724 million yen
Amount Paid in Local Currency	3,140 million yen	3,628 million yen
	(5,304 million LKR)	(4,999 million LKR)
Total	9,590 million yen	7,352 million yen
ODA Loan Portion	7,619 million yen	6,319 million yen
Exchange Rate	1LKR = 0.592 yen (As of November 2012)	1LKR = 0.726 yen (IMF rate average from 2013 to 2020)
4. Final Disbursement	May 2020	