

**Republic of India
Uttarakhand Forest Department (UKFD)**

**The Project for Natural Disaster
Management in Forest Areas in
Uttarakhand
Republic of India**

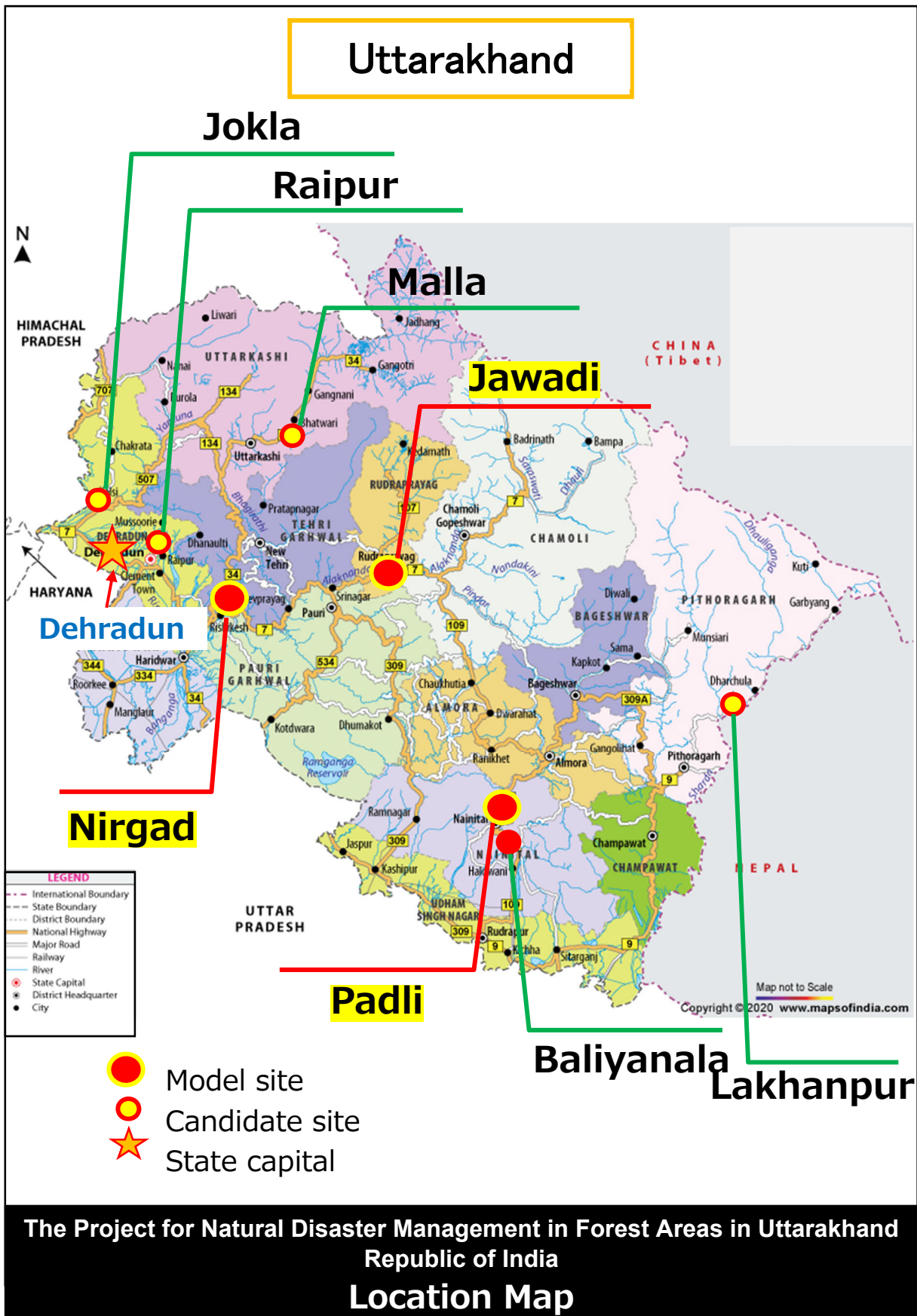
Final Report

April 2024

Japan International Cooperation Agency (JICA)

**Kokusai Kogyo Co., Ltd.
OYO Corporation
Japan Conservation Engineers & Co., Ltd.**

GE
JR
24-017



Contents

Location map

Contents

Currency exchange rate and date

Abbreviations

1	Project Outline.....	1
1.1	Background of the Project.....	1
1.2	Current Status and Challenges of Erosion Control in Uttarakhand.....	1
1.2.1	Current Status	1
1.2.2	Challenges.....	2
1.3	Purpose of the Project.....	2
1.4	Framework of the Project	2
1.4.1	Overall Goal.....	2
1.4.2	Project Purpose	3
1.4.3	Outputs	3
1.4.4	Activities	3
1.5	Target Area of the Project	4
1.5.1	Model Sites.....	4
1.5.2	Candidate Sites	4
1.5.3	Additional Site.....	5
1.6	Implementation Agency.....	5
2	Status of the Achievement to the Project Purpose and Output	5
2.1	Transition of the PDM and PO	5
2.2	Status of Achievement of Expected Output	5
2.2.1	Output 1.....	5
2.2.2	Output 2.....	6
2.2.3	Output 3.....	6
2.2.4	Output 4.....	7
2.3	Status of Achievement of Project Purpose.....	8
3	Implemented Activities	9
3.1	Record of Implemented Activities.....	9
3.2	Achievement of Each Activity.....	11

3.2.1	Common Activity.....	11
3.2.2	Activity Related to Output 1	12
3.2.3	Activity Related to Output 2	47
3.2.4	Activity Related to Output 3.....	54
3.2.5	Activity Related to Output 4	56
3.3	Record of Training (Field, Period, Number of Participants, outline).....	68
4	Inputs	69
4.1	Inputs from Japanese Side	69
4.1.1	Dispatch of Experts (Name, Field, Period, Outline)	69
4.1.2	Procurement of Equipment to Be Taken	74
4.2	Inputs from Indian Side	74
4.2.1	Project Office and Equipment.....	75
4.2.2	Human Resource.....	75
4.2.3	Other.....	76
5	Ingenuities and Lessons Learned in the Project Implementation.....	77
5.1	General Project Matters	77
5.2	Survey and Investigation.....	79
5.3	Design	80
5.4	Project Supervision	81
6	Recommendations for the Future Implementation of Erosion Control Works in India.....	83
6.1	Planning of Erosion Control Works	83
6.2	Establishment of Cell in Department for Erosion Control and Education of Engineers.....	83
6.3	Continuation of Promotion and Introduction of Japanese Advanced Erosion Control Technology.....	84
6.4	Thorough Examination of Financial Status in Prequalification for Bidding .	84
6.5	Utilization and Dissemination of Construction Supervision Plan and a Manual for Preparation of Construction Plans	84

Contents of figures, tables and photos

Figure 3.1	Plan of Operation of the Project: Plan and Action	9-10
Figure 3.2	Work Schedule for Creation of the Slope Disaster Location Map and Inventory ...	15
Figure 3.3	Slope Disaster Location Map (Bageshwar DFO).....	16
Figure 3.4	Cross Section of the Nirgad Site Streambed.....	20
Figure 3.5	Mechanism of Disaster Occurrence at Nirgad Site.....	22
Figure 3.6	Geological Cross Section of the Slope in Jawadi 1	25
Figure 3.7	Mechanism of Slope Failure at the Jawadi 1 Site	26
Figure 3.8	Geological Cross Section of the Slope in Jawadi 1	29
Figure 3.9	Mechanism of Slope Failure in Padli	30
Figure 3.10	Plan View of the Erosion Control Works in Nirgad	32
Figure 3.11	Final Alignment of Channel 2-2 in Nirgad.....	33
Figure 3.12	Plan View of the Erosion Control Works in Jawadi 1.....	34
Figure 3.13	Plan View of the Erosion Control Works in Padli.....	36
Figure 3.14	Design Drawings of Temporary Road in Padli	37
Figure 3.15	Implementation Structure for Construction Management	38
Figure 3.16	Organizational Structure for Technology Transfer.....	49
Figure 3.17	Transition of the Test Results	53
Figure 3.18	Plan View of the Site in Jokla	57
Figure 3.19	Plan View of the Upper Slope	58
Figure 3.20	Arrangement Plan of Countermeasure Works on the Slope in Malla	59
Figure 3.21	Arrangement Plan of Countermeasure Works on the Slope in Lakhanpur....	60
Figure 3.22	Topography Outline of Raipur	61
Figure 3.23	Plan of Countermeasure Works in Raipur Area (Basic Design)	62
Figure 3.24	Construction Work in Jokla	63
Figure 3.25	Construction Conditions in Raipur.....	64
Figure 3.26	Plan of Topographical and Drilling Survey	66
Figure 3.27	Comparison Study for Three Plans (Above) and the Selected Countermeasure Plan for Baliyanala (Below)	67
Figure 4.1	Short-term Experts Assignment Schedule: Plan and Action	71-73
Table 3.1	List of Available Map Data for Slope Disaster Location Map	13
Table 3.2	Items of Inventory of Slope Disaster.....	14
Table 3.3	Work Item for Creation of the Slope Disaster Location Map and Inventory	15
Table 3.4	Components of Report Submitted by the Contractor.....	16
Table 3.5	Comparative Considerations for Selecting Model Sites.....	17
Table 3.6	Common Causes and Vulnerability for Slope Failure and Debris Flow	18
Table 3.7	Type of Investigation and Information Obtained for Identifying Causes and Vulnerability	18
Table 3.8	Bidding Procedures and Timing through Signing of Contract.....	38

Table 3.9	Construction Progress in Nirgad.....	40
Table 3.10	Construction Progress in Jawadi	42
Table 3.11	Construction Progress in Padli	43
Table 3.12	Warning Threshold for Each Model Site	44
Table 3.13	Costruction Cost of Each Model Site	45
Table 3.14	Key Factors for Technology Transfer in Erosion Control Works.....	48
Table 3.15	Erosion Control Candidate Sites	56
Table 3.16	Main Technical Training Conducted in the Project.....	68
Table 4.1	List of Japanese Experts	69
Table 4.2	List of Procured Equipment to Be Taken.....	74
Table 4.3	Project Offices and Equipment Provided by the UKFD	75
Table 4.4	Human Resources Provided by the UKFD	75
Table 4.5	Budget of Project Provided by UKFD	76
Photo 3.1	Debris flow on model site in Nirgad.....	19
Photo 3.2	Site conditions of the lower stream	19
Photo 3.3	Steep slopes (Slope No. 1 (left), Slope No. 2 (right)).....	22
Photo 3.4	Site conditions in Jawadi 1.....	23
Photo 3.5	Main geological distribution in the area of Jawadi 1.....	24
Photo 3.6	Condition of the site in Padli.....	27
Photo 3.7	Unstable geology on the slope in Padli.....	27

Currency exchange rate and date

Currency exchange rate	Date of sub-contract agreement	Rate
1 INR=1.70570 JPY	September 14, 2017	September 2017 JICA rate
1 INR=1.62099 JPY	August 31, 2018	August 2018 JICA rate
1 INR=1.57344 JPY	September 6, 2018	September 2018 JICA rate
1 INR=1.57344 JPY	September 10, 2018	September 2018 JICA rate
1 INR=1.53092 JPY	February 21, 2022	January 2022 JICA rate

Abbreviations

		English
CAD	:	Computer Aided Design
COVID-19	:	Coronavirus Infectious Disease, emerged in 2019
CPD	:	Chief Project Director
C/P	:	Counterpart
DFO	:	Divisional Forest Officer
DPD	:	Deputy Project Director
DPR	:	Detailed Project Report
DWD	:	Double Wall Dam
EOI	:	Expression of Interest
GIS	:	Geographical Information System
GNSS	:	Global Navigation Satellite Systems
GPS	:	Global Positioning System
HDPE	:	High Density Polyethylene
HPC	:	High Power Committee
JCC	:	Joint Coordination Committee
JICA	:	Japan International Cooperation Agency
JET	:	Japanese Expert Team
MoEF & CC	:	Ministry of Environment, Forest and Climate Change
NHAI	:	National Highway Authority of India
Off-JT	:	Off the Job Training
OJT	:	On the Job Training
PDM	:	Project Design Matrix
PO	:	Plan of Operation
PPK	:	Post Processing Kinematics
PVC	:	Poly Vinyl Chloride
PWD	:	Public Work Department
RC	:	Reinforced Concrete
R/D	:	Record of Discussions
RFP	:	Request for Proposal
RTK	:	Real-Time Kinematics
SDLM	:	Slope Disaster Location Map
SOP	:	Standard Operating Procedures
ToE	:	Team of Engineer

UAV : Unmanned Aerial Vehicle
UFRMP : Uttarakhand Forest Resource Management Project
UKFD : Uttarakhand Forest Department
USGS : United States Geological Survey
UTM : Universal Transverse Mercator

1 Project Outline

1.1 Background of the Project

The forests of Uttarakhand are nestled in the mighty Himalayan mountain ranges. In recent years, floods and landslides have been occurring every year in these mountainous forests, making disaster risk reduction an important challenge in the management of forests. As these forms of natural disasters originate mostly in the forest areas under the control of the Uttarakhand Forest Department (hereinafter referred to as the “UKFD”), forest restoration and disaster risk reduction using erosion control technology is required.

Given this background, a Japanese ODA loan project, the “Uttarakhand Forest Resource Management Project” (hereinafter referred to as the “UFRMP”) was signed with the UKFD in April 2014. Forest protection activities, erosion control works, the restoration of forest roads and the development of evacuation facilities are planned in the sediment disaster management component, covering INR. 122 crore¹ out of the total loan budget of INR. 807 crores. However, for the effective implementation of the component, it is necessary to establish systemized erosion control technology and to improve the organizational structure in the UKFD.

In 2014, a complementary study on disaster in forest areas was undertaken in Uttarakhand by the Japan International Cooperation Agency (hereinafter referred to as “JICA”) to verify needs on the Indian side and to agree upon a framework for technical cooperation. As a result, the Government of India (hereinafter referred to as “GoI”) requested that the “Project for Natural Disaster Management in Forest Areas in Uttarakhand” (hereinafter referred to as “the Project”) be implemented in December 2015.

In response to the request, JICA undertook a field survey in February 2016 and agreed to a framework for technical cooperation with the GoI. Subsequently, the UKFD and JICA signed a Record of Discussion (hereinafter referred to as “R/D”) on 29 August 2016, which indicated the content of the framework.

Based on the R/D, the Project was begun with the UKFD as the Counterpart (hereinafter referred to as “C/P”) for a period of five years (from March 2017 to March 2022). The activities of the Project aim at achieving the overall goal of the Project, namely the “effective implementation of erosion control works for slope disaster management in forest areas in Uttarakhand” and “dissemination of knowledge and technology on erosion control works to other Himalayan states of India”.

1.2 Current Status and Challenges of Erosion Control in Uttarakhand

1.2.1 Current Status

India is a major developing country with a land area of 3.28 million km² (the seventh largest in the world) and a total population of 1,245 million (as of 2014). The main Himalayan Ridge (the Great Himalaya, with an altitude above 7,000 m) is formed in the northern part of India, where the topography allows the Ganges River to flow through to the southern part of the country. The northernmost Himalayas block the seasonal wind from the Indian Ocean, causing a lot of rain to fall at the foot of the mountain during the monsoon season (June to September). Vegetation zones with diverse natural conditions are developing according to differences in climate, temperature and precipitation.

¹ One crore equals ten million.

Uttarakhand State, of which 45.3% of the land is forest area, has the sixth largest forest coverage of 29 states in India. However, according to the “India State Forest Report (2015)”, the forest coverage in Uttarakhand State rapidly decreased to 268 km² (a decrease of 11%) from the report in 2013. The reason for the decrease of forest is logging to excess in the area and development in forest land, especially in the Moderately Dense Forest which has 40~70% canopy sparsity.

Under these circumstances, unprecedented heavy rains in the Himalayan Region caused a massive disaster of flooding and landslides in June 2013 in the State of Uttarakhand. About 6,000 people died or were missing in 4,200 villages, mainly in the northern region of the state. It is thought that most of land collapse and landslides that occurred in conjunction with the flood originated in the forest areas under the control of the UKFD. With the increase of such large-scale landslides, which are difficult for the UKFD to handle, comprehensive technology to effectively deal with soil conservation and erosion control is necessary.

1.2.2 Challenges

The basic way of thinking with regard to forest protection areas in the Indian Forest Act is similar to Japan. However, regarding soil erosion and river basin protection, an article of the National Forest Policy (1988) contains only a conceptual clause, which establishes the following as one its basic objectives: “Checking soil erosion and denudation in the catchment areas of rivers, lakes, and reservoirs in the interest of soil and water conservation, for mitigating floods and droughts and for the retardation of siltation of reservoirs”. The Uttarakhand State Forest Policy (1988) also mentions soil erosion prevention superficially in an article that says, “Increasing forest cover will protect against soil erosion and runoff.”, but there is no specific policy regarding erosion control. This means that policies regarding erosion control and the promotion of countermeasures are not clear at either the level of Uttarakhand State or at the level of the GoI, and administrative and political movements to prepare for natural disaster management in forest areas have not existed.

After the disaster that happened in the forest areas in June 2013, vegetation was considered fundamental to protecting soil and water, and the UKFD recognized anew the necessity of recovering devastated mountainsides. However, the organization structure and resources (human, budgetary and technical) to carry out erosion control works were absent or inadequate.

1.3 Purpose of the Project

The Project aims to establish a system to properly implement slope disaster management (erosion control works) using erosion control technology in Uttarakhand by developing appropriate erosion control technology for Uttarakhand, improving the knowledge and skills of the UKFD and other relevant agency staff, and sharing the developed erosion control technology within the state and with other states.

The Project will contribute to the appropriate implementation of erosion control works in the state and to the dissemination of knowledge and technology of erosion control in other states in the Himalayan region.

1.4 Framework of the Project

1.4.1 Overall Goal

- 1) Erosion control works for slope disaster management in the forest area are appropriately implemented in Uttarakhand state.

- 2) Knowledge and technology on erosion control works are disseminated to other Himalayan states.

1.4.2 Project Purpose

System to appropriately implement erosion control works for slope disaster management in the forest area is established in the Uttarakhand State.

1.4.3 Outputs

- Output 1: Technology for erosion control to be adapted in Uttarakhand is developed.
- Output 2: Knowledge and skills on erosion control of staff in UKFD and another related organisation are improved.
- Output 3: Appropriate technology developed for erosion control in the forest area is shared in Uttarakhand and with other Himalayan states in India.
- Output 4: Collaboration with the UFRMP for implementing the interventions under the erosion control and sediment disaster mitigation component and also including UKFD's task of completing the Detailed Project Report (DPR) for countermeasure works for Baliyanala are achieved.

1.4.4 Activities

【Activities to achieve Output 1】

- 1-1 Prepare and update slope disaster location map in the forest area.
- 1-2 Select model sites based on the prescribed selection criteria, in which erosion control model having effect of demonstration are constructed.
- 1-3 Implement survey in the model sites and analyze mechanism of occurrence of slope disaster.
- 1-4 Make design of erosion control works in the model sites.
- 1-5 Select company for the erosion control works in the model sites and contract with the selected company.
- 1-6 Supervise the erosion control works in the model sites until the completion based on the approved design.
- 1-7 Periodically implement monitoring of the facilities in the model sites.
- 1-8 Prepare the erosion control works guideline.
- 1-9 Prepare the manual on the design of erosion control works.
- 1-10 Set the standard operation procedure for erosion control works.
- 1-11 Implement evaluation of erosion control model constructed in the model sites by staffs of UKFD.

【Activities to achieve Output 2】

- 2-1 Implement basic study for preparation of technology transfer plan.

2-2 Prepare the technology transfer plan including basic concept for erosion control works, preparation of plan on erosion control works, method of surveys for designing erosion control works, and design and works for erosion control facilities, etc.

2-3 Implement Off-JT and OJT based on the technology transfer plan.

2-4 Evaluate improved level on the knowledge and skills of the staffs.

【Activities to achieve Output 3】

3-1 Prepare a plan for the information sharing of erosion control works.

3-2 Organise seminars and workshops for stakeholders within the Uttarakhand State.

3-3 Organize seminars and workshops for the stakeholders in other Himalayan States in collaboration with MoEF & CC.

3-4 Prepare policy recommendation for mainstreaming erosion control works for slope disaster management into forest and other key development sectors.

3-5 Set up policy-level council for erosion control works among UKFD and other related organisations.

3-6 Organise the periodical meeting of policy-level council for erosion control works.

3-7 Study the condition and level of the information sharing.

【Activities to achieve Output 4】

4-1 Identify and prioritise the candidate sites of erosion control works under UFRMP based on Activity 1-1 as above.

4-2 Enhance the capacity of Engineers through Off-JT and OJT in model sites.

4-3 Support for the field surveys, designs and supervisions of erosion control works on the candidate sites under UFRMP.

4-4 Support for the field surveys and designs and supervisions of countermeasure works at the landslide site in Baliyanala, Nainital District, which collapsed in September 2018.

1.5 Target Area of the Project

The forest areas in the State of Uttarakhand, including the following sites.

1.5.1 Model Sites

- 1) Nirgad in Tehri District
- 2) Jawadi in Rudraprayag District
- 3) Padli in Nainital District

1.5.2 Candidate Sites

- 1) Raipur in Dehradun District
- 2) Jokla in Dehradun District
- 3) Malla in Uttarkashi District

4) Lakhanpur in Pithoragarh District

1.5.3 Additional Site

1) Baliyanala in Nainital District

1.6 Implementation Agency

The implementation agency is the Uttarakhand Forest Department (UKFD), the members of which are as follows.

- 1) Project Director
- 2) Additional Project Director
- 3) Task Managers and members of each Task Team
- 4) Concerned staff in Forest Division Offices where the model sites are located
- 5) Teams of Engineers (ToE) which are contracted under the UFRMP

2 Status of the Achievement of the Project Purpose and Output

2.1 Transition of the PDM and PO

The following changes occurred during the project implementation period.

- With regard to the Baliyanala collapsed area that occurred in September 2018, the decision was made to support countermeasure works through the Project. Modification of the R/D and the Project Design Matrix (PDM) was proposed at the third JCC meeting, held on 28 February 2019. As a result, the R/D was revised in November 2019.
- Through amendment of the R/D because of the temporary delay in the travel of Japanese experts due to the COVID-19 that raged from 2020, in February 2022 the UKFD and JICA agreed to an extension of the Project duration by two (2) years. This also delayed the PO by two years for post-2020 activities.

2.2 Status of Achievement of Expected Output

2.2.1 Output 1

Output 1	Technology for erosion control to be adapted in Uttarakhand is developed.
Indicator	1-1 Models of erosion control for slope disaster management which are adapted at the given sites are established. 1-2 80% of the staff in charge of the erosion control works in UKFD evaluate the models of erosion control works as high by January, 2022.

Achievement:

- Experts and ToE have begun work to achieve the desired output. The models of erosion control work were set as torrent works and hillside works. In particular, double-wall check dam works as torrent work and grating crib works as hillside work are useful for other sites as well. Through construction activities at each model site, Task Team members and ToE could acquire knowledge about these.
- The evaluation of the erosion control construction model was conducted by TOE and UKFD officials at the Padli site on December 29, 2023, the Nirgad site on December 30, 2023, and the Jawadi site on January 22, 2024. The results

showed that more than 80% of the raters rated 331 of the 336 evaluation items highly.

2.2.2 Output 2

Output 2	Knowledge and skills on erosion control of staff in UKFD and another related organization are improved.
Indicator	2-1 80% of the staff in UKFD that participated in the training planned and implemented based on technology transfer plan, pass the understanding test. 2-2 Staff in charge of UKFD implements the erosion control works for nine (9) places by January 2022.

Achievement:

- Task Team members regularly attend the monthly meetings of the project, and ToE has gained much experience through its daily work with the Japanese Expert Team (JET), including the survey, design, and preparation of bid documents for the three model sites and four candidate sites. The project members also gained a great deal of experience in the construction of each site. The project members have also supervised the construction of each site, and ToE and Task Team members have acquired basic knowledge of erosion control works.
- The first test was a baseline test on 3 June 2019. In total, 14 members from the Task Teams and ToE took the test. The second test was a comprehension test on 21 October 2021. In total, 12 members from the Task Teams and ToE took the test. Based on these tests' results, as well as the abilities confirmed in daily work, various efforts have been made to improve the ability of the members by the next test. The third test, another comprehension test on 8 January 2024, was the final test for the Project to see how much project members were able to deepen their knowledge of erosion control works. 10 ToE took the test, and as a result to date, all 16 candidates in total, Task Team members and ToE, have passed the exam.
- The technology transfer plan for Task Team members and the ToE was created to effectively transfer advanced erosion control work knowledge from Japan. The number of target sites was reported as nine, including the Baliyanala site, at the third JCC meeting held on 28 February 2019. Due to their unfeasibility, some target sites were cancelled.
- UKFD is in the process of constructing seven erosion control sites (three model sites and four candidate sites). None of the sites has been completed.

2.2.3 Output 3

Output 3	Appropriate technology developed for erosion control in the forest area is shared in Uttarakhand and with other Himalayan states in India.
Indicator	3-1 Seminars and workshops for other related organizations in Uttarakhand are organized in October 2018. 3-2 Recommendation of the policy for mainstreaming erosion control works for slope disaster management is submitted to the state government. 3-3 Seminars and workshops for stakeholders in other Himalayan states are organized twice by March 2022, in collaboration with Ministry of Environment, Forest and Climate Change (MoEF&CC).

Achievement:

- The workshop for officials of other related organizations in Uttarakhand has been held twice. The first workshop was held on 27 February 2019, which was attended by 70 participants. The second was held on December 15, 2023 and was attended by 48 participants, including officials from other Himalayan states.
- The concept was discussed in May and June 2023. The final discussion was held with the C/P in March 2024 and the basic policy recommendations were prepared.
- The workshop for Uttarakhand stakeholders as well as from other states in Himalayas was scheduled to take place in Dehradun in March 2020. Due to the sudden spread of COVID-19, however, it was cancelled.
- A national workshop, including stakeholders from Uttarakhand and other states in Himalayas, was held on 1 February 2024 with 71 participants.

2.2.4 Output 4

Output 4	Collaboration with the UFRMP for implementing the interventions under the erosion control and sediment disaster mitigation component and also including UKFD's task of completing the Detailed Project Report (DPR) for countermeasure works for Baliyanala are achieved.
Indicator	<p>4-1 Inventory of slope disaster in the forest area of the State is implemented.</p> <p>4-2 Designs of erosion control works on the candidate sites under the UFRMP are made for nine places (including three model sites and Baliyanala landslide) by March 2022.</p> <p>4-3 Support for the field surveys, designs and supervisions of erosion control works on the candidate sites under the UFRMP.</p> <p>4-4 Support for the field surveys and designs and supervisions of countermeasure works at the landslide site in Baliyanala, Nainital District, which collapsed in September 2018.</p>

Achievement:

- The inventory of slope disaster location maps (SDLMs) in the forest areas of the state was prepared by Himalayan Surveying Services Pvt. Ltd of a local sub-contractor that was contracted for the job. After preparing the SDLMs, the ToE prepared a manual for updating geographic information system (GIS) data in the SDLMs. The Project made requests to all District Forest Office (DFO)s for revised data for the entire state, which will be useful for future assessment and planning of works in the UKFD.
- The following candidate sites were proposed by the UFRMP and authorized during the third JCC meeting, held on 28 February, 2019. Site 1 Jokla (Chakrata Forest Division Office), Site 2 Company Garden (Mussoorie Forest Division Office), Site 3 Malla (Uttarkashi Forest Division Office), Site 4 Tadikhet (Almora Forest Division Office), and Site 5 Lakhanpur (Pithoragarh Forest Division Office)
- Further, at the third JCC meeting, support from the Project for field surveys, designs, and supervision of countermeasure works at the Baliyanala landslide site in Nainital were authorized. It should be noted that the site collapsed in September 2018, and was added as an additional site apart from the model and candidate sites. As a result, a revision of the R/D was made to review content to be supported by the Project. The dispatch of Japanese Short-term Experts was also reviewed. As a result, the designs for Jokla and Malla were prepared in August 2021. However, the tender for the two sites could not be completed in February 2022. The designs for Lakhanpur and Raipur were also prepared by August 2022. Finally, the contractor for all four sites was successfully selected

and a contract was signed in December 2022.

- Finally, the design of the erosion control works for a total of 8 of the candidate sites in the UFRMP, including 3 model sites, 4 candidate sites and Baliyanala was implemented.
- Since the contract for the construction of four candidate sites between the UFRMP and the contractor was signed in December 2022, supervision of the work has started.
- Three (3) plans/designs for countermeasure works for Baliyanala (See figure on page 62) were prepared by the JICA Expert Team (JET) and submitted to the activity committee for Baliyanala slope control (High Power Committee: HPC) through the UFRMP. Due to the unavailability of the JET during the COVID-19 pandemic, and a strong request for prompt action from the local community, the HPC decided to appoint an Indian consultant to prepare the Detailed Project Report (DPR). All related material prepared by the JET as Project activities — designs, survey result, equipment — were handed over to the HPC in March 2022.

2.3 Status of Achievement of Project Purpose

Project Purpose	System to appropriately implement erosion control works for slope disaster management in the forest area is established in the Uttarakhand State.
Indicator	<ol style="list-style-type: none"> 1. The erosion control technical handbook is developed and approved by responsible authorities and put into use by UKFD. 2. Specified function which sustainably implement erosion control works is set up in UKFD.

Achievement:

- The handbooks are disseminated at the workshop in Dec.2023 and February 2024. The handbook dissemination tools were completed as “the Guideline Book of Forest Conservation: Survey, Plan and Design of Stream Work and Hillside Work”. The standard operating procedures (SOP) were published in December 2022. It is also published on the UFRMP website.
- JET members, Task Team members, and the ToE have been working well. All Task Team leaders and members participated in one of the three batches of training in Japan held in November 2017, November 2018, and November 2019.
- Therefore, they have acquired an understanding of the concept of erosion control works for disaster management in forest area (erosion control works). All Task Team members and the ToE have had opportunities to learn more from JET members by accompanying them on site visits, attending regular Project meetings, and through the implementation of the model sites’ activity.
- However, changes to officer personnel in the UKFD and the resignation of engineers have affected the Project activities. In particular, three ToE members, including one participant in the training program in Japan, the resident supervisors in Nirgad and Padli, and the surveyor/designer, retired, which had the effect of requiring new hires to start from scratch to replace them.
- The project has satisfied the above two indicators, although there are issues in terms of sustainability, and the conditions for achievement of the Project Purpose are in place.

3 Implemented Activities

3.1 Record of Implemented Activities

The actual results of the activity implementation schedule are shown as follows.

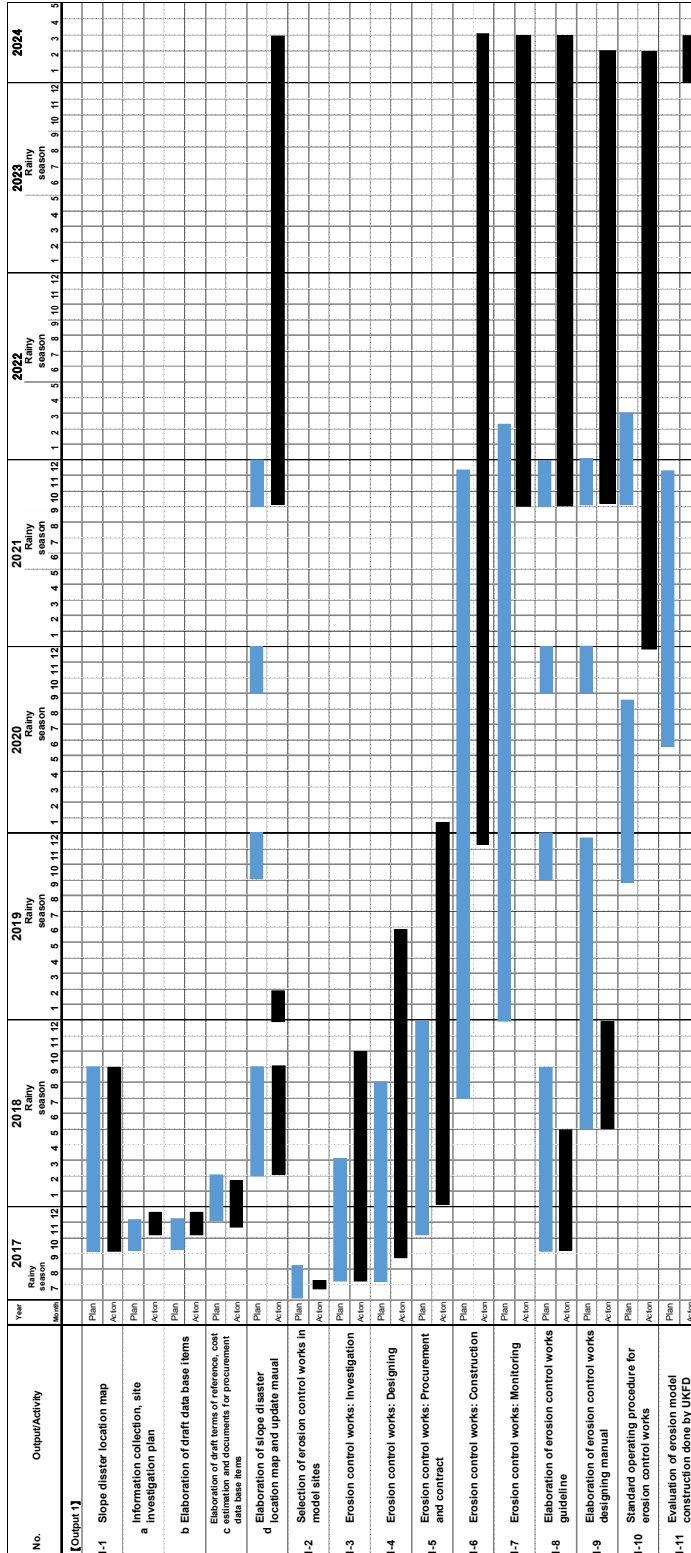


Figure 3.1 Plan of Operation of the Project: Plan and Action (1 / 2)

3.2 Achievement of Each Activity

3.2.1 Common Activity

Joint Coordination Committee

The Joint Coordination Committee (JCC) meetings held for the Project are as follows.

(a) 1st Joint Coordination Committee Meeting

Date: 10 August 2017

Venue: Uttarakhand Sadan, Chanakya Puri, Delhi

Main Agenda:

- Report on site reconnaissance results for the model site candidates
- Selection of the model sites
- Plan of Operation of the Project
- Work Plan for the first year

(b) 2nd Joint Coordination Committee Meeting

Date: 13 February 2018

Venue: Manthan Hall, UKFD Office, Rajpur Road, Dehradun

Main Agenda:

- Report on work progress
 - Summary of the work progress
 - Conditions of each model site, and work progress of Nirgad site
 - Guidance of the first training in Japan
- Issues in carrying out the work
 - Coordination with National Highway of India on the widening construction highway at the Nirgad site
 - Coordination with Ashram (Indian Temple) on land ownership at the lower end of the stream
 - Assignment of the Task Team members
 - Selection of candidate sites of the UFRMP

(c) 3rd Joint Coordination Committee Meeting

Date: 28 February 2019

Venue: Office of Chief Secretary, Govt. of Uttarakhand

Main Agenda:

- Report on work progress
 - Summary of the work progress
 - Survey, design and cost estimation for three model sites have been done.
 - Progress of technology transfer
 - Involvement for slope disaster in Baliyanala
 - Explanation of the conditions of the candidate sites of the UFRMP
- Discussion
 - The proposed PDM, with a request to add technical assistance for the slope disaster in Baliyanala as a new component of the Project, and a proposed change to the PDM (adding Baliyanala technical assistance to Output 4) were approved.

- Confirmation that the procurement rule of contractors for the model sites shall be in accordance with the JICA procurement guidelines.
- The list of the candidate sites shall be sent to the Disaster Mitigation and Management Centre, Uttarakhand.
- The establishment of a separate cell for disaster management in the Uttarakhand Forest Department was proposed.

(d) 4th Joint Coordination Committee Meeting

Date: 12 December 2019

Venue: Office of Chief Secretary, Govt. of Uttarakhand

Main Agenda:

- Selection of a sub-contractor for each model site
 - Bidding process
 - Report on bidding results
- Discussion of response to Baliyanala collapsed area

(e) 5th Joint Coordination Committee Meeting

Date: 11 March 2024

Venue: Office of Chief Secretary, Govt. of Uttarakhand

Main Agenda:

- Report on work progress
 - Review of the progress as on 31st January 2024
 - Approval of the annual work plan for F.Y. 2023-24
 - Approval of the annual work plan for F.Y.2024-25.
 - Discussion of transfer of technology on erosion control and treatment of landslides to Uttarakhand Forest Department other stakeholders
 - Presentation of Evaluation of model sites by Japanese experts
- Discussion
 - The project activities achieved so far are highly commended and the importance of the establishment of erosion control works in Uttarakhand is confirmed.

3.2.2 Activity Related to Output 1

3.2.2.1 Activity 1-1 Prepare and update Slope Disaster Location Map in forest areas

- (a) **Collect and organize all information to be used for understanding disasters in mountainous areas, such as maps, reports, local information etc. The draft plan for local investigation will be finalized.**

The UKFD does not have a division that collectively manages the slope hazard situation in the entire state of Uttarakhand, and the Division/Divisional Forest Office (DFO office) in each district are aware of the slope hazards in their respective jurisdictions. The following maps and information were used to create a Slope Disaster Location Map in the forest area.

Table 3.1 List of Available Map Data for Slope Disaster Location Map

Map		Specification	Remarks
Satellite Image	Landsat	30 m resolution Raster data	<ul style="list-style-type: none"> Available free of charge through the website of the United States Geological Survey (USGS). The data was used for the UKFD's study on forest area loss in 2013.
	Resourcesat	25 m resolution Raster data	<ul style="list-style-type: none"> In possession of the UFRMP The data is available only for the project area of the UFRMP
	Cartosat	2.5 m resolution Raster data	<ul style="list-style-type: none"> In possession of the UFRMP The data is available only for the project area of the UFRMP
Toposheet		1 : 50,000 Raster data	<ul style="list-style-type: none"> Issued by the Survey of India In possession of the UFRMP The data is available for all of Uttarakhand State except for restricted areas.
Boundary data for the state, divisions and districts of Uttarakhand		Vector data	<ul style="list-style-type: none"> In possession of the UFRMP The data is available for all of Uttarakhand State
UTM grid data		Vector data	<ul style="list-style-type: none"> Issued by the Survey of India In possession of the UFRMP The data is available for all of Uttarakhand State.
Forest Cover Map		Vector data	<ul style="list-style-type: none"> Issued by the Forest Survey of India In possession of the UFRMP The data is available for all of Uttarakhand State.
Forest loss area data		30 m mesh Raster data	<ul style="list-style-type: none"> Prepared by the GIS Laboratory in the UKFD The data is created by infrared image analysis based on Landsat.
Slope Map		30 m mesh Raster data	<ul style="list-style-type: none"> Prepared by the GIS Laboratory in the UKFD The data is created based on Landsat. The slope is categorized into four ranges: 0-15°, 15-35°, 35-50° and more than 50°
Aspect Map		30 m mesh Raster data	<ul style="list-style-type: none"> Prepared by the GIS Laboratory in the UKFD The data is created based on Landsat. The aspect is categorized into four directions: north, south, east, and west.
Altitude Map		30 m mesh Raster data	<ul style="list-style-type: none"> Prepared by the GIS Laboratory in the UKFD The data is created based on Landsat. The aspect is categorized into eight ranges of 500 m intervals, from 0 m to 3500 m.
Geological Map		1: 250,000	<ul style="list-style-type: none"> Prepared by the Geological Survey of India (Downloaded from the Geological Survey of India website)

Map	Specification	Remarks
Landslide Zone Map	Under process of confirmation	<ul style="list-style-type: none"> Areas in Uttarakhand State categorized into three categories, depending on the severity of the hazard of landslide

Based on this information, a field survey plan was developed and implemented.

(b) Propose items of database for preparing Slope Disaster Location Map based on consistency and complementarity with existing maps and information

The inventory items considered from the results of the information collection survey are listed below. The inventory data can be utilized by linking the Slope Disaster Location Map to the inventory data.

Table 3.2 Items of Inventory of Slope Disaster

Required Item	Content
Slope ID number	ID number shall be assigned to each slope
Address of the slope	Province, region, district and village
Jurisdictional office	NP/Circle, Division and Range
Area of the UFRMP	Yes: in the area / No: out of the area
Categorized forest type	Based on the Forest Cover Map
Categorized slope range	Based on the Slope Map
Categorized altitude range	Based on the Altitude Map
Type of geology	Based on the Geological Map
Categorized hazard rank	Based on the Landslide Zone Map
Type of disaster	Slope failure or debris flow
Coordinate (Lon & Lat)	By GPS / Satellite image
Area/Scale of the disaster (m ²)	Identified by satellite image
Date of the disaster	Obtain by interview survey from DFOs
Damage by the disaster	Obtain by interview survey from DFOs <ul style="list-style-type: none"> - Forest area (m²) - Farmland (m²) - Length of road section (**m) - House (** houses) - Vehicle (** cars) - Public facility (school, temple, etc.) - Others, if any
Estimated conservation target	Obtain by interview survey, site observation or satellite image <ul style="list-style-type: none"> - Forest area (m²) - Farmland (m²) - Road grade (National Highway No., district road, village road) - Length of road section (**m) - House (** houses) - Public facility (school, temple, etc.) - Others, if any
Photo of the target slope	Image file (jpg/tif)
Category of hazard*	Categorize as 1, 2 and 3 depending on the magnitude of hazard.

Table 3.4 Components of Report Submitted by the Contractor

	Components	Form	No.
1	Slope Disaster Location Map	Hard copy (A1 size)	2
2	Report of interview survey	Hard copy	2
3	Inventory data	Soft coy (MS Excel)	1
4	Map data	Soft copy (PDF)	1
5	GIS data	Soft copy (shape file)	1
6	Final report	Hard copy	2
7	Final report	Soft copy (PDF/MS Word)	1

The Japanese experts confirmed the adequacy of the submitted deliverables to the specification and approved them. The contractor instructed the ToE and the Task Teams about the operation of GIS software after reports were submitted.

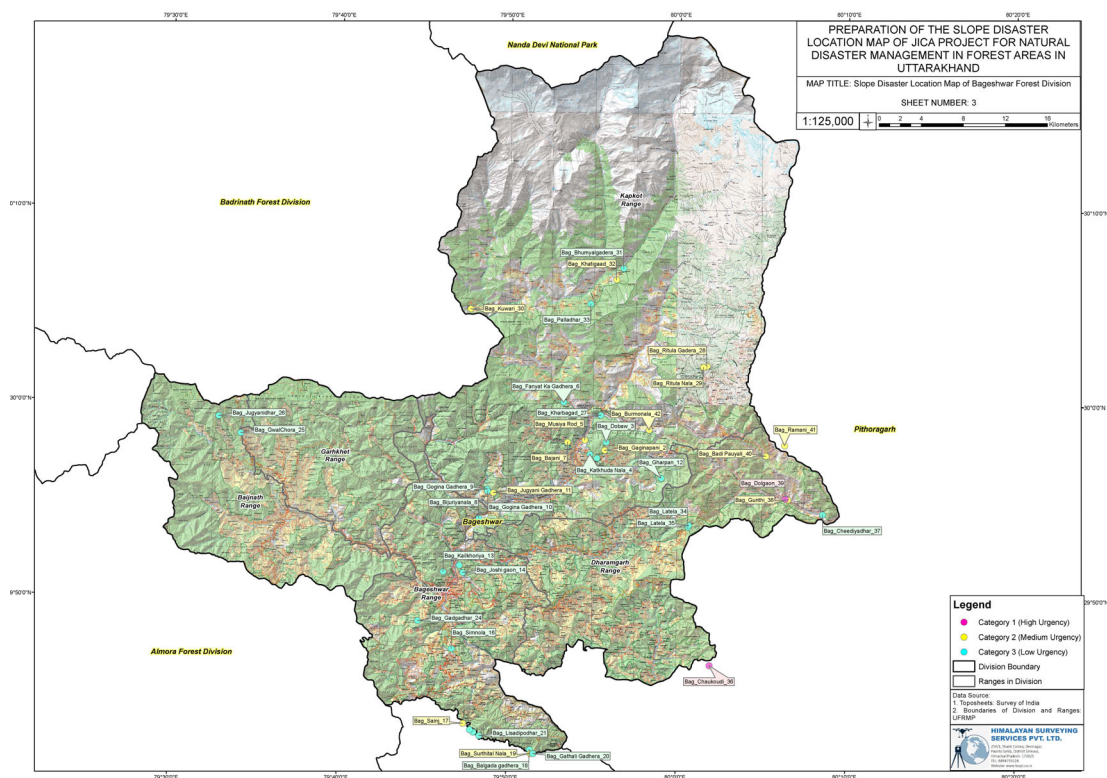


Figure 3.3 Slope Disaster Location Map (Bageshwar DFO office)

(d) **Prepare a draft manual for preparing and updating slope disaster location maps and propose it to the Long-term Experts.**

A “GIS User Manual for the Slope Disaster Location Maps” was prepared by the contractor, with training provided to members of the Task Teams and ToE. In addition, a “Manual for Updating Slope Disaster Location Maps” was prepared by the ToE for the slope disaster location maps; training for updating the data of the map was conducted for the Task Team members in January 2019. However, the “GIS User Manual” and the “Manual for Updating Slope Disaster Location Maps” were designed for operation in ArcGIS, which is a paid GIS software. Therefore, there was concern that the manuals would be of limited use to C/P staff working in remote areas, where access to paid GIS software is difficult. In response to this situation, a free GIS software operation manual was created to enable remote staff to create data with the free software that is compatible with paid GIS software at their assigned locations. The target free GIS software is Q-GIS, which is more versatile. In addition, to enable the C/P to extract slope hazard areas in the future, the applicability of hazard area

extraction methods using existing data was examined and a manual for hazard area extraction methods were prepared. Using these manuals, a training session was held for the members of Task Team and ToE in February 2023.

3.2.2.2 Activity 1-2 Select model sites based on prescribed selection criteria and construction of erosion control models for demonstration.

Site reconnaissance has been carried out on candidate model sites, as proposed by the C/P. According to the results of site reconnaissance, the model sites for the Project have been selected based on the following conditions.

- Accessibility from Dehradun, the capital city of Uttarakhand
- Exhibition/display effect as showcase model
- Technology transfer effect: type of works and distribution among district offices of the UKFD
- Cost of work
- Cost-benefit (economic importance of the targets to be protected from landslide)

As the result of the comparative considerations shown in the table below, three sites, Nirgad, Jawadi 2 and Padli, were selected as model sites for the Project out of the five candidate model sites and confirmed at the first JCC meeting, which was held on 11 August 2017.

Table 3.5 Comparative Considerations for Selecting Model Sites

Site name	Mobility and Access from Dehradun	Display Effect	Capacity Building Effect	Cost	Benefit	Result
Nirgad	◎ (2 h)	○	○	Middle	High	Model site
Jawadi 1	○ (6 h)	○	○	High	Middle	
Jawadi 2	○ (6 h)	○	○	High	High	Model site
Padli	△ (9 h)	○	○	High	High	Model site
Bahrakoon	△ (9 h)	△	○	Middle	High	

Legend: ◎ Very good, ○ Good, △ Moderate

Jawadi 2 was selected as a model site at the first JCC meeting, and surveying and geological reconnaissance proceeded on the site. Subsequently, the slope topography of Jawadi 2 was altered by PWD's rehabilitation work of the national road facing the Jawadi 2 slope, and the original topographic conditions changed. Under these conditions, it was determined that it would be difficult to continue the works on the Jawadi 2 as a model site. As a result, the Project Director approved the selection of Jawadi 1 as the model site instead of Jawadi 2 at an internal project meeting on June 5, 2018.

Finally, the following three sites have been approved as model sites of the Project:

- **Nirgad**
- **Jawadi 1**
- **Padli**

3.2.2.3 Activity 1-3 Survey of model sites and analysis of mechanism of occurrence of slope disaster.

[Survey plan for model sites]

The mechanism of slope disaster at each model site will be investigated and analyzed by the Task Teams and ToE to design erosion control works. This will help evaluate the causes

and vulnerability of each slope disaster. Landslides in Uttarakhand are mainly due to slope failures and debris flow. Therefore, by analyzing their causes and vulnerability, they may be used as indicators for hazard evaluation in other slope disaster areas in the state and even in other Himalayan regions. Common causes and vulnerability for slope failures and debris flow are represented in the table below.

Table 3.6 Common Causes and Vulnerability for Slope Failure and Debris Flow

Slope Failure	Causes: Geology (especially thickness of the sediment layer), geomorphology, groundwater, vegetation Vulnerability: Rainfall, human activities (cut slopes, earth works, watering)
Debris Flow	Causes: Geology (especially riverbed sediment), geomorphology, vegetation Vulnerability: Rainfall, human activities (cut slopes, earth works)

Site investigation through a detailed topographical survey is done in order to investigate the geology, geomorphology, groundwater and vegetation, the results of which will be compiled in sketches and topographic maps.

Regarding the geological causes of disaster, in order to identify the thickness of the sediment layer, simple penetration tests are carried out to analyze important parameters which are useful in designing, such as shear strength, with instruments such as a soil layer strength rod. In addition, measuring daily and hourly rainfall is important for analyzing the cause of slope disasters. For this, rain gauges are set up at designated sites such as near public facilities and private gardens to prevent theft or damage to the instruments.

Table 3.7 Type of Investigation and Information Obtained for Identifying Causes and Vulnerability

Investigation	Information Obtained
Detailed topo survey	Topographic Base Map
Site investigation	Geology (distribution and properties of riverbed sediments), geomorphology, vegetation, groundwater (estimated by spring waters)
Simple penetration test (soil layer strength rod)	Thickness of sediment layer, shear strength of the sediment
Rain Gauge	Rainfall and rain intensity

Based on the information obtained, the predisposing and triggering factors of disasters at each model site were examined and the causes of disasters analyzed.

The survey results and mechanisms of disaster for each model site were compiled into a survey report. The following is a summary of the survey results for each model site and the mechanism of disaster.

(a) **Nirgad**

Stream part

■ **Site Condition**

In 2013 in Nirgad, heavy rainfall triggered debris flow, causing damage to National Highway 58, leading to frequent traffic congestion. Since 2013, debris flow has occurred

during continuous rainfall, again depositing sediment on Route 58 and frequently disrupting traffic.



Site conditions in August 2014



Site conditions in August 2017

Photo 3.1 Debris flow on model site in Nirgad

There are religious and lodging facilities downstream from the NH. Usually, there is no water flow in the natural channel normally; rather, it occurs only temporarily, during heavy rains. Until 2013, when the major disaster occurred, water was channelled to the nursery of the UKFD on the right bank. During the 2013 disaster, the retaining wall at the channel conversion point was destroyed by the debris flow that occurred. Since then, water has flowed straight into the Ganges River without passing through the nursery (Photo 3.2). In addition, during the 2013 disaster, some lodging facilities downstream were also impacted by runoff that contained debris. The cause was a failure to properly divert high-energy debris flow at the channel conversion points.



Red line: direction until 2013
Blue line: direction after 2013



Stream after the existing retaining wall

Photo 3.2 Site conditions of the lower stream

The watershed area of the target slope is approximately 0.1 km² and the surface water collected in the watershed flows directly into the Ganges River. The watershed is generally covered with trees and is classified as “Very dense forest” (>70% cover) by the Forest Survey of India. Vegetation has already begun to recover naturally since 2013.

The geology around the model site consists of slate, quartzite, shale and limestone. From geological observation, it can be concluded that slate and quartzite layers are distributed in the upper strata of this area, and shale and limestone layers in the lower strata of the area. Geological joints have developed on each stratum. The surface of rock outcrop (rock exposure part) has come loose due to many exposed joints. This is particularly true of shale, which tends to break in small fragments along frequent joints due to weathering and erosion. In the shale layer, clumped or veined dolomite is also present. The quartzite tends to break in massive blocks when the geological joint develops on the rock about one to two meters apart.

Between the shale and quartzite layers, alternate layers of shale and limestone exist. The colluvium layer is distributed on the streambed. Boulders of one to two meters in diameter are found on the upper streambed. A secondary deposit material layer, which has been carried from the upper stream by debris flow, is found in the lower streambed. The secondary deposit material layer consists mainly of sand and semi-rounded gravel five to ten centimetres in diameter. The rock outcrop of the slate layer at the uppermost stratum of the area is found along the local road crossing at upper stream of the area. The schistosity of the slate layer develops five to 10 centimetres apart. The surface of the layer has become loose. The limestone layer is the lowest stratum in the area, exists around NH 58, and is moderately to highly weathered.

Based on the angle of streambed and sediment conditions, the watershed of the model site can be divided into two sections.

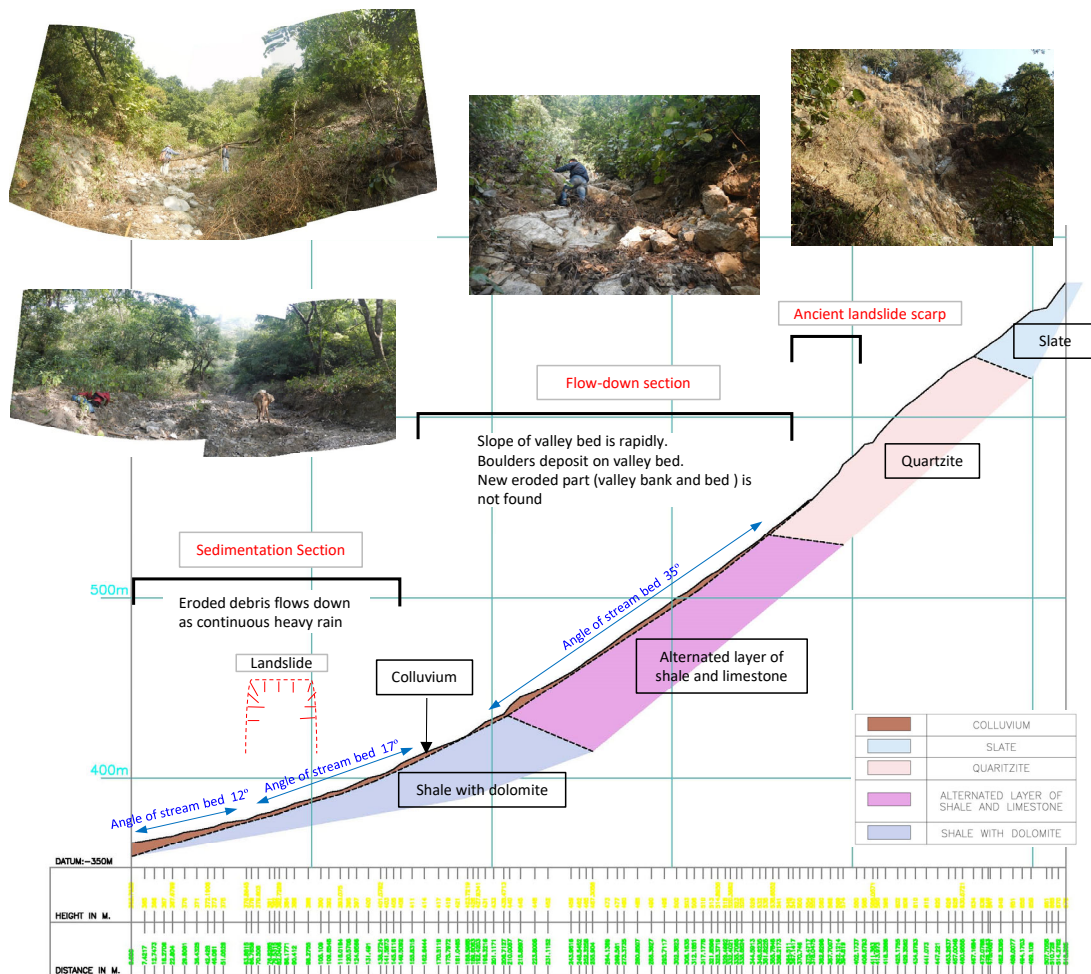


Figure 3.4 Cross Section of the Nirgad Site Streambed

Flow-down section

This section comprises the area’s upstream region with a steeper slope (approximately 35 degrees). An area that has traces of an old landslide is the main source of deposited debris. Boulders originating from the bedrock are deposited on the streambed of this section. Some rock outcrops (visible exposures of bedrock or ancient superficial deposits on the ground surface) with cliff features are found in the section. However, fresh traces of slope failure or erosion are not apparent at the streambed and banks level of the section.

Sedimentation section

This section consists of the area's downstream region with a gentler slope (approximately 15 degrees). Soil and gravel are deposited on the streambed. Fresh traces of slope failure and erosion are apparent in the streambed and the banks. Additionally, since old landslide blocks exist on the side of the main stream, it can be concluded that the landslide blocks will activate due to their erosion unless measures are taken to prevent further erosion. From these conditions, it can also be concluded that the source of debris flow is at the sedimentation level. The depth of the bedrock can be estimated to be around two meters from the ground surface, according to the topography and the rock outcrop of the bedrock.

■ Mechanism of disaster occurrence

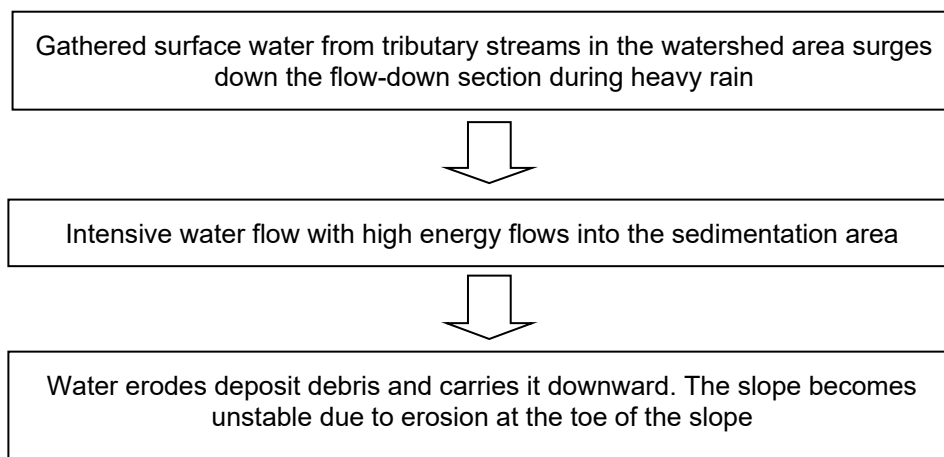
Predisposing factors for disaster:

- Low water retention capacity and steep slope in the upper stream (flow-down section)
- Loose debris deposit in the lower stream (sedimentation section)
- Many tributary streams develop in the watershed area and connect to the main stream

Triggers for disaster:

- Torrential rainfall on a steep stream (flow-down section) without infiltration into the ground
- Tributary streams feed the main stream
- Surface water flows from the local road in the upper part of the area
- Water flow towards the sedimentation section with great speed

Given the predisposing factors and triggers mentioned here, it can be concluded that the mechanism of disaster occurrence in Nirgad is as follows:



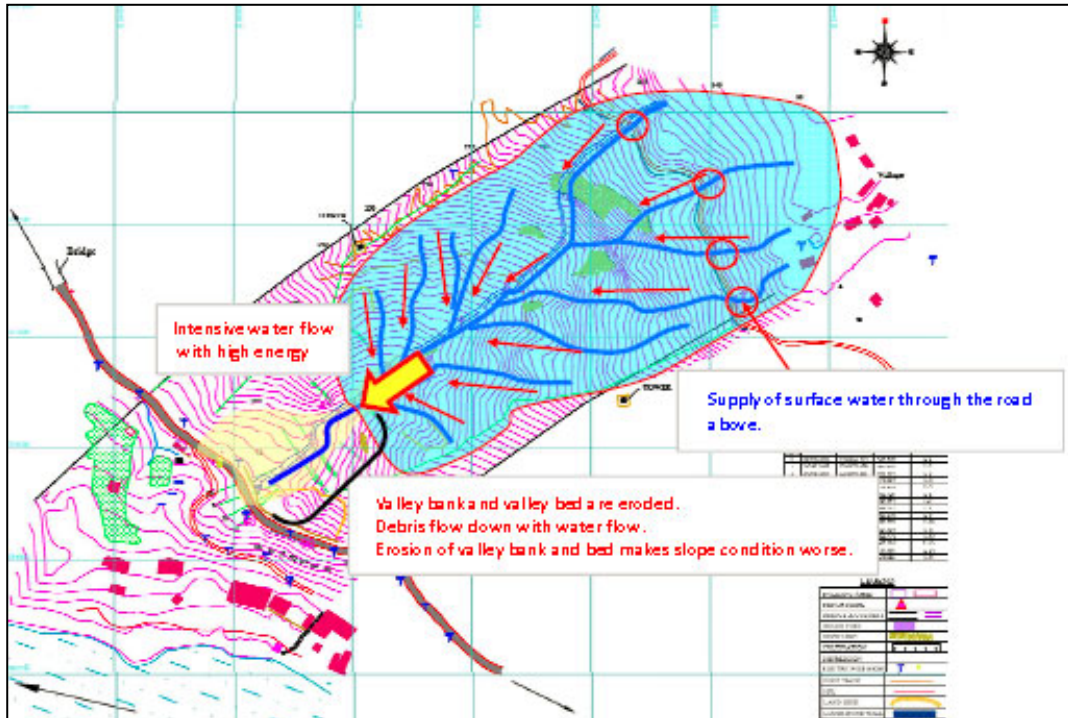


Figure 3.5 Mechanism of Disaster Occurrence at Nirgad Site

Slope Failure

■ Site Conditions

In 2013, traffic on NH 58 was disrupted due to fallen debris from steep rock slopes in Nirgad. Since this disaster, the traffic on NH 58 in this section has been disrupted during the rainy season every year. In 2016, the National Highway Authority of India and the PWD installed a 2.5 meter-high protection wall along the steep slopes to prevent debris from the steep slopes falling on the road.



Photo 3.3 Steep slopes (Slope No. 1 (left), Slope No. 2 (right))

The steep rock slopes are 30 m high at a 50°-60° angle and consist of shale, with clumped or veined dolomite in the Krol Formation. The shale is extremely friable and easily broken into smaller pieces. The cut slope areas used to be borrow pits, from which and shale was mined as construction material. Rock material is still mined by hand despite the protection wall.

The steep rock slopes can be divided into two slopes on the Rishikesh side (No. 1) and other side (No. 2). Slope No. 1 consists of more friable rocks than Slope No. 2. Slope No. 2 has seemed stable since the 2013 disaster and has been covered with vegetation since 2017. The surface of Slope No. 2 used to be in part highly weathered. However, the highly weathered rocks and debris on the slope might have been washed away in the 2013 disaster. Hard material remained on the surface of Slope No. 2.

Some gullies are found around Slope No. 1 and Slope No. 2, although there is no sign of landslide there. The slopes around No. 1 and No. 2 seem stable, but there is a possibility of slope failure due to further weathering and erosion.

The causes (vulnerability and trigger) for slope failure in 2013 were:

Vulnerability:

- Existence of weathered friable shale as base rock
- Erosion on surface of the slopes by surface flow water
- The cut slopes of the steep pitch

Trigger:

- Heavy rainfall

■ Mechanism of Slope Failure

Debris flowed down to NH 58 in 2013 as a consequence of the erosion of slope surfaces due to relentless and heavy rainfall. Small-scale slope failure has continued since the 2013 disaster due to erosion by surface water flow.

(b) **Jawadi 1**

■ Site Conditions

The Jawadi site is located on the opposite slope of Rudraprayag City, across the Alaknanda River. Heavy rains in June 2013 caused a slope failure, with the collapsed debris causing damage to a local road. Farmland also was damaged by debris that flowed downstream together with the surface water. Slope failure has occurred every year since 2013 during the rainy season, causing damage to downstream farmland. The expansion of the collapsed slope is also evident.



Photo 3.4 Site conditions in Jawadi 1

From the results of macroscopic topographical interpretation, it can be understood that the target slope is located on the escarpment which was created by an old, large-scale landslide.

The slopes surrounding the failed slope, exhibit a steep gradient of more than 45 degrees. The failed slope exhibits the topography of a watershed, where surface water tends to concentrate. A gabion retaining wall was constructed at the toe of the failed slope, but it has been damaged due to the annual surface failures. On the valley side of the local road, the slope continues with a gradient of about 30 degrees. The slope under the road is covered with vegetation, but the area where the collapsed debris flowed downward exhibits the topography of a valley and the vegetation has been denuded, leaving it in a degraded state. In addition, surface water from the upper slope, including the collapsed slope, and the local road is concentrated in this valley terrain, while several gullies have developed in the upper part of the slope due to erosion from water flow. The lower part of the slope has a gentle angle of about 10 degrees and sediments transported from the upper part of the slope are deposited in this slope area. The slope in this area is used as farmland, and during the 2013 disaster sediment reached the farmlands and caused damage. Currently, the land appears to be partially abandoned.

The geology in and around the target slope consists of green schist, slate, quartz schist, and shale. Green schist is distributed as the base rock in the failed slope area. The schistosity is finely developed and exhibits an anti-dip structure against the slope direction (N60°W 60°E). An older compacted colluvium layer is widely distributed above the base rock. The materials of colluvium are thought to have been generated during a large-scale landslide, as assumed by topographic interpretation, and are composed of 20 cm to 50 cm boulders of schist and sandy or gravelly slate. The well-developed schist is easily eroded to form gully landforms, as seen on the lower slope of the road. Loose debris and talus deposits transported by the 2013 failure and debris flow is distributed along the collapsed sediment flow path. Those soil layers are extremely loose, sandy soil with small to large gravel of the surrounding base rock.

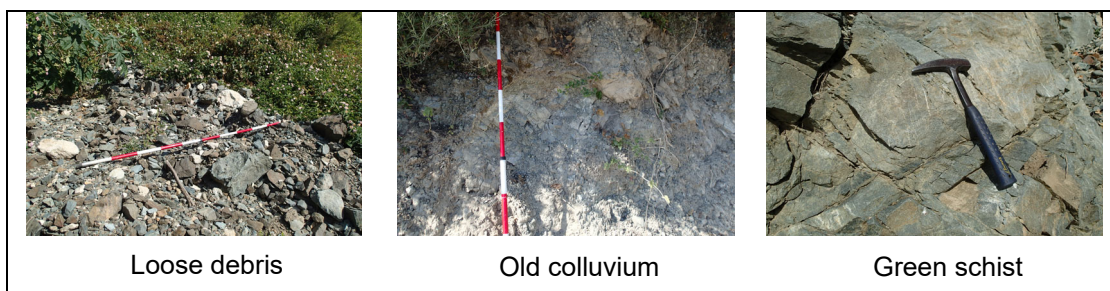


Photo 3.5 Main geological distribution in the area of Jawadi 1

The target slopes are divided into three main sections based on slope gradient and slope surface conditions: the failure section, the flow-down section, and the sedimentation section.

Failure section: The slope height is approximately 60 m and the slope gradient is 45° on the mountain side slope of the local road. The surface layer of the failed area is unstable due to a thin layer of sediment left by the collapse. The bedrock exposed in the failed area is also loose due to the development of many open joints. Cracks have also developed surrounding the failed slope, and there is a possibility that the failed area will expand without the installation of countermeasure works. This section is a source of sediment on the target slope.

Flow-down section: The slope height is approximately 200 m and the slope gradient is 28° on the upper valley side slope of the local road. The slope surface consists of old colluvium, and many gullies have developed due to erosion by surface water and debris flow from the upper area, including the failed slope. Because of constant erosion, there is no vegetation in this section. The debris and surface water from upstream also denude the colluvium material distributed in this watershed, increasing the amount of sediment downstream. This is also part of the source of sediment to the sedimentation section.

Sedimentation Section: This is located at the lower part of the target slope area and has a

gentle streambed slope of about 10 degrees. In the section, fine-grained sediment, which is the sediment that has flowed down to the watershed, is deposited. In this section, there is also sediment deposition, but surface water is dispersed and no clear stream channel has developed. A local road crosses the end of the slope and there is no evidence of sediment reaching this road so far.

The following geological cross sections, prepared based on the results of the geological reconnaissance and seismic exploration, show the sections discussed above.

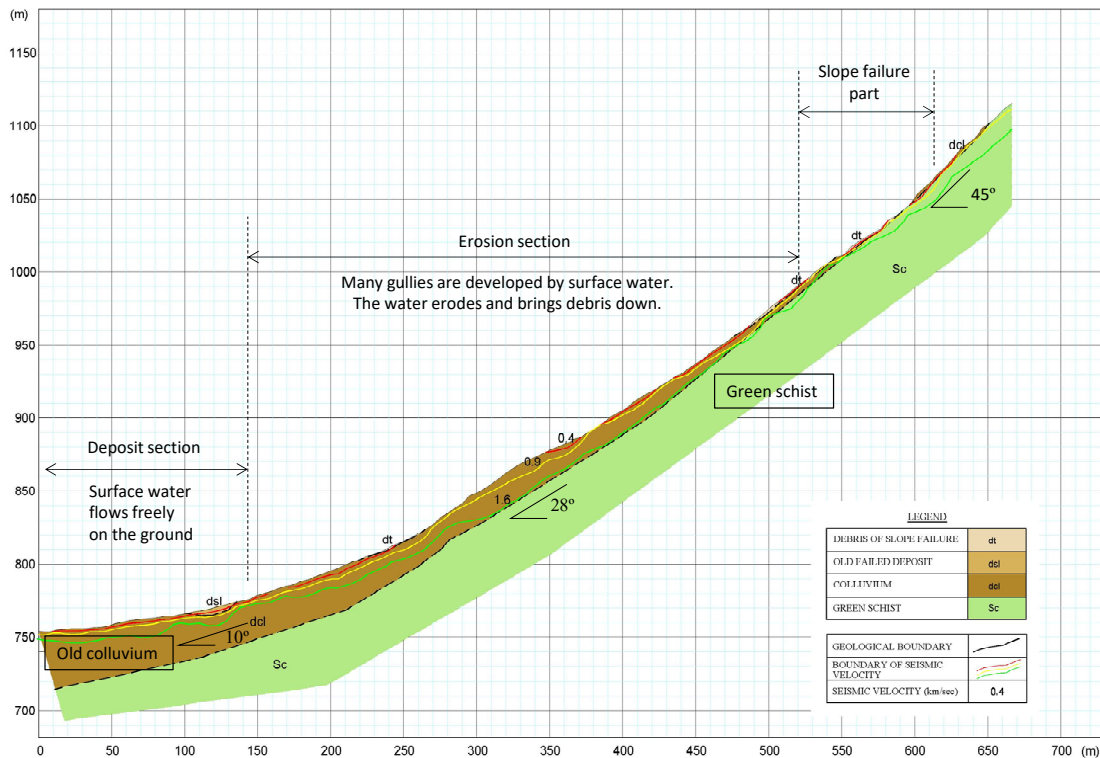


Figure 3.6 Geological Cross Section of the Slope in Jawadi 1

■ Mechanism of slope failure

Predisposing factors:

- The slope exhibits a concave feature and surface water tends to concentrate on the slope.
- The slope is steep (more than 40 degrees) due to being located on the scarp of an old landslide and has a thin layer of collapsed soil on the surface.

Trigger:

- Excavation of the edge of the mountain slope as road construction
- Infiltration of surface water into the slope due to continuous heavy rainfall (rise of groundwater table)
- Concentration of surface water from upslope
- Concentration of high-energy runoff in the sediment accumulation area

Based on the predisposing and triggering factors, the mechanism of slope failure in Jawadi can be considered to be as follows.

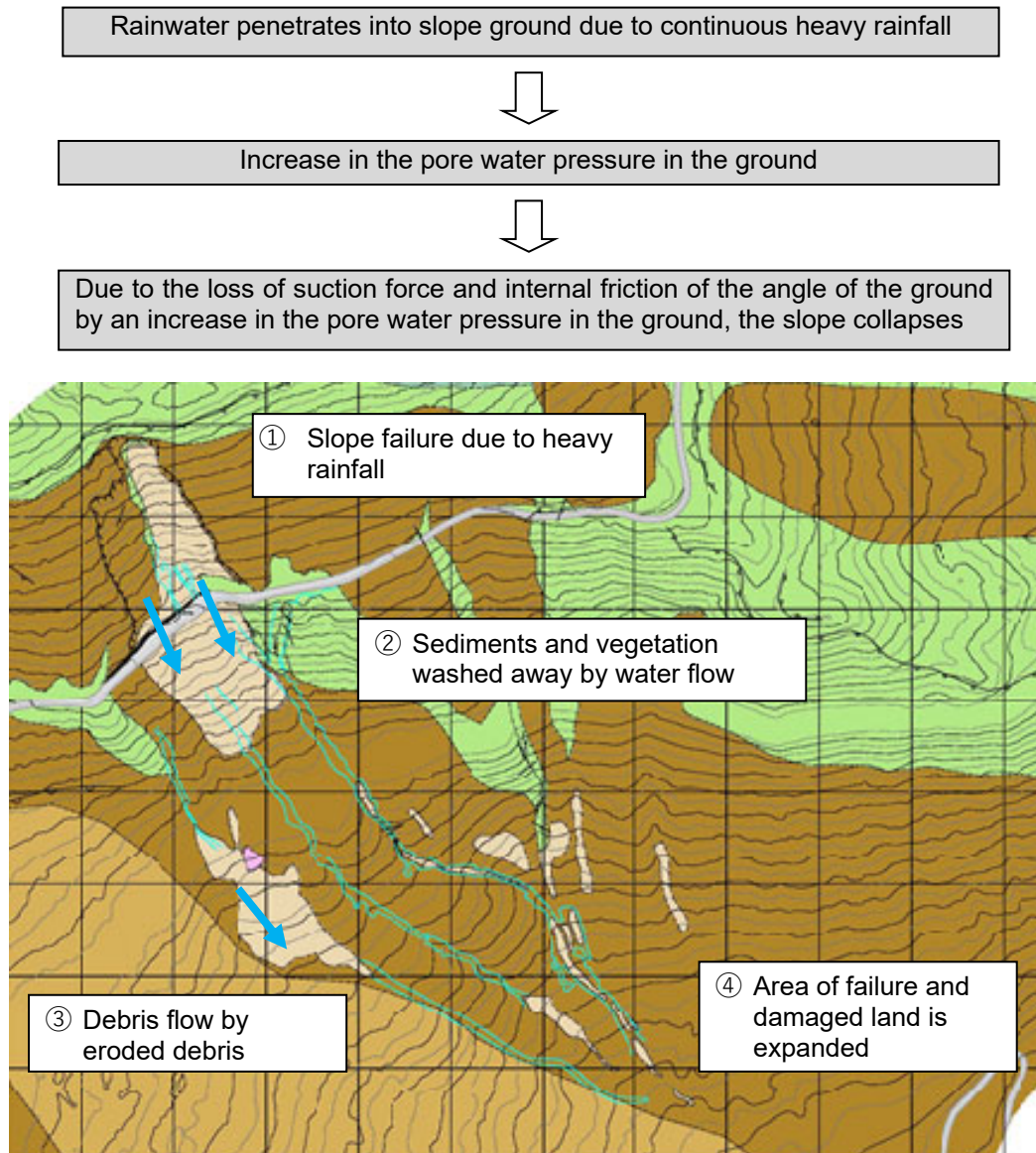


Figure 3.7 Mechanism of Slope Failure at the Jawadi 1 Site

(c) **Padli**

■ Site Conditions

The target site in Padli experienced a slope failure during the monsoon season in 2016, causing a large amount of debris to hit NH 109, severely disrupting traffic. During continuous rainfall events since 2016, debris flow from slopes and frequent rock falls even during normal times have had a significant impact on traffic.

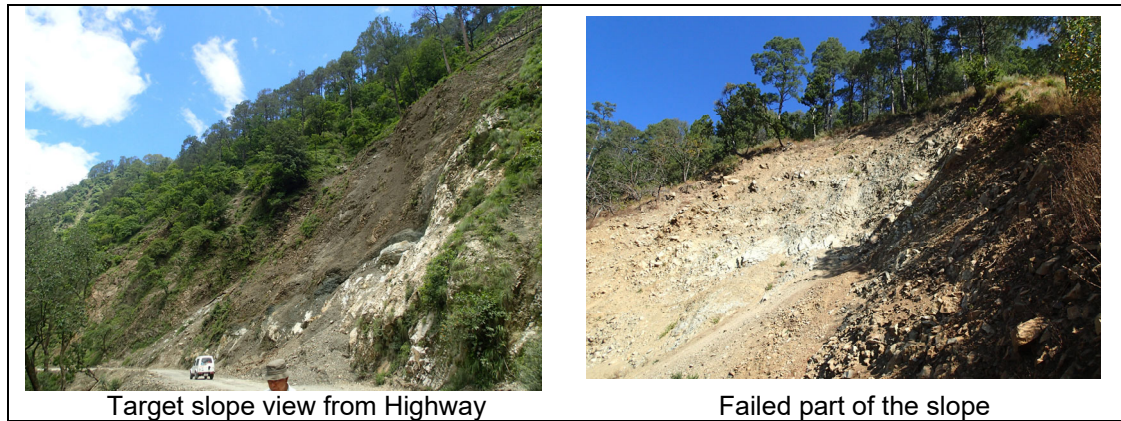


Photo 3.6 Condition of the site in Padli

The target slope is a long and large slope with a height of approximately 200 m. The slope gradient is steep with an almost uniform slope gradient of 40-45° from the slope failure area to the NH below the slope. Since the slope features before the failure occurred exhibit the topography of an old landslide, even though the whole slope is covered with dense trees, it can be surmised that the slope experienced failure before 2016. Multiple traces of springs were observed in the slope failure area, suggesting that the slope may have springs during the rainy season, which may be one of the factors contributing to slope instability. The slope has a watershed feature due to its landslide topography, and surface water from the surrounding area flows down this slope, forming several gullies in the mid-slope area. The slope behind the failure area is also steep, and several cracks have been observed, which may lead to future expansion of the failure area if no measures are taken.

The geology of the target slope consists mainly of green schist, shale, and quartzite as base rocks. The quartzite is massive and hard with few fractures. On the other hand, the green schist and shale are moderately weathered, with finely developed and opened schistosity at the surface, making them unstable and susceptible to collapse. The source of most of the debris on the slope is the green schist and shale. In the subject area, the strata are distributed in the order of quartzite, shale, and green schist, from the bottom. The geological structure exhibits an anti-dip structure against the slope direction (N70°E, 75°N). Old colluvium and collapsed debris are deposited above the base rock. The old colluvium is relatively compact, but the collapsed debris is extremely unstable because when the slope failed, the debris flowed downward and was left on the slope. This unstable debris falls easily due to wind and/or animal activity, not only during rainfall but also at normal times.

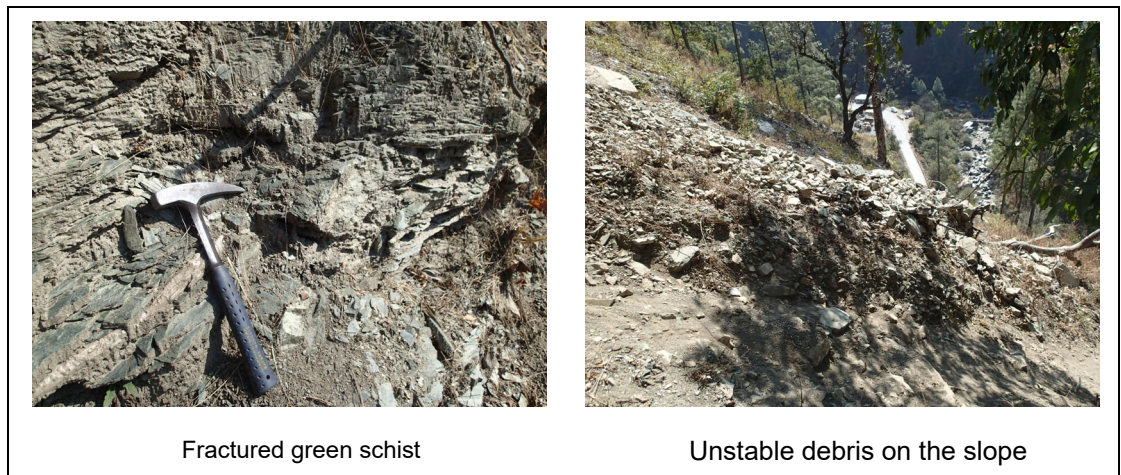


Photo 3.7 Unstable geology on the slope in Padli

It can be surmised from the results of site reconnaissance that the area of the failure that occurred in 2016 was located above the slope deemed to be the area of an old landslide; moreover, the area has not failed again, but the slope above the area failed and collapsed debris washed down the old landslide area. Further, in the process of flowing down the slope, the debris fell on the NH, denuding the surface sediment and vegetation.

The slopes can be divided into two sections based on the slope gradient and deposition on the slope: a failure section and a flow-down section. In the case of the slope in Padli, the steep slope continues from the failed part up to the NH, so the sedimentation section of the fallen debris is the riverbed below the highway.

Failure section: This is located approximately 200 m above the NH. The slope failure area is 40 m high and 30 m wide. The slope is more than 45° and the terrain is steep. Cracks have developed surrounding the slope failure area, and it is anticipated that the extent of the failure will expand in the future. The geology is composed of green schist with well-developed schistosity and colluvium, including large boulders. The presence of several water springs suggests that water inflow during rainfall or the monsoon season may have contributed to the destabilization of the surrounding slopes. A thin layer of unstable sediment left over from the fall is also deposited on the slope failure area.

Flow-down section: The flow-down section is between the failure section and the NH. The slope is steep, with a slope gradient of 40-45 degrees, and was covered with trees prior to the 2016 disaster, but the slope collapse has denuded the topsoil and vegetation from above, so it is now covered with extremely loose and unstable soil and the vegetation has not recovered. In addition, the surface of the slope has been eroded by the flow of collapsed soil containing water, and deep gullies have been formed. Therefore, when it rains, surface water flows over the gully, causing further erosion and entrapping surface sediments, which flow down to the NH.

The following geological cross sections, prepared based on the results of the geological reconnaissance and seismic exploration, show the sections discussed above.

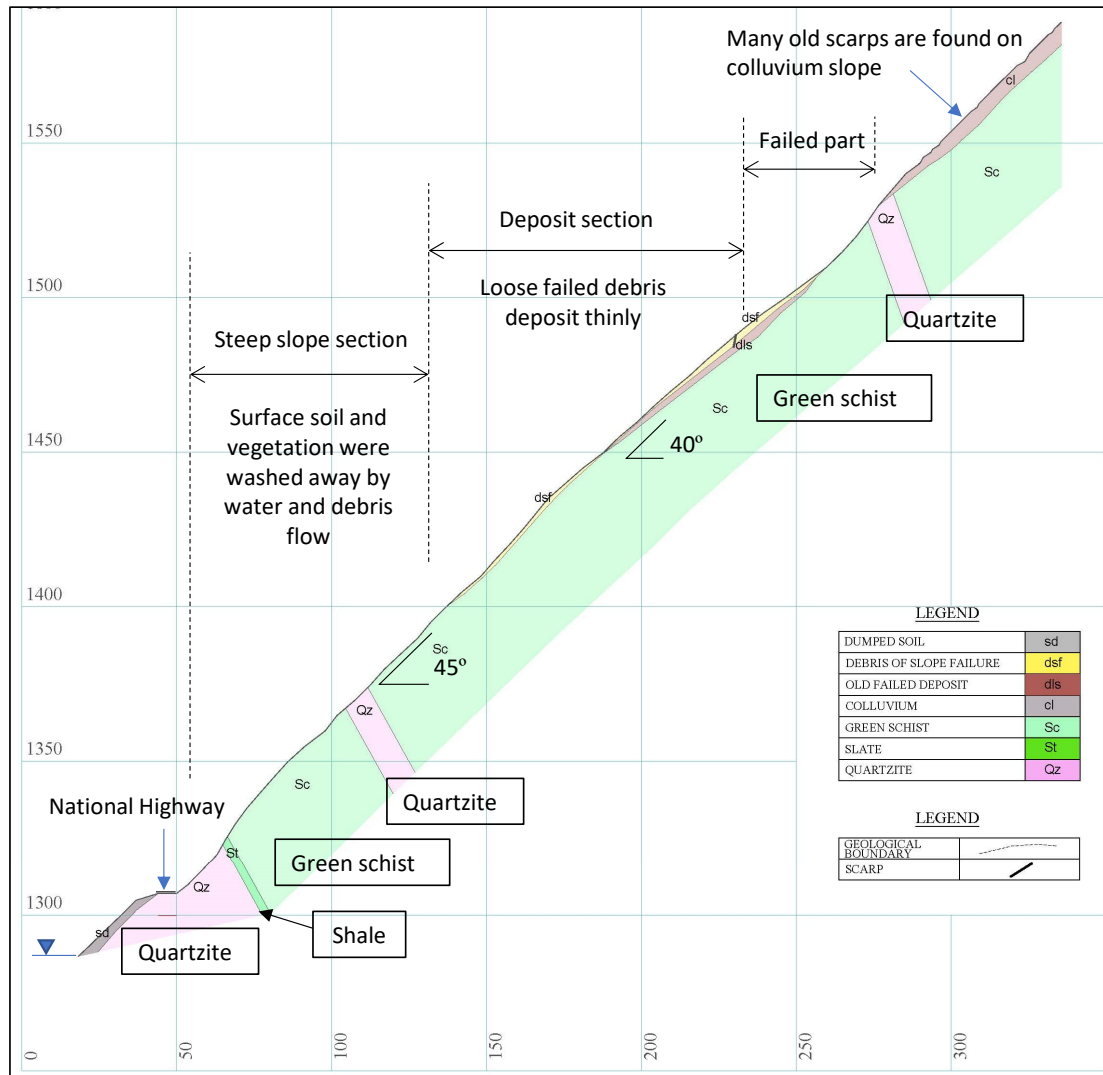


Figure 3.8 Geological Cross Section of the Slope in Jawadi 1

■ Mechanism of slope failure

Predisposing factors:

- Depression in the slope allows the surface water to concentrate there.
- A spring was confirmed on the slope, which means there is continuous water flow on the slope.
- The slope gradient is greater than 40 degrees and the colluvium on the slope is unstable.
- The slope was formerly unstable, as there was a disaster history.

Trigger:

- Infiltration of the surface water into the slope due to continuous rainfall (increase of groundwater).
- Concentration of the surface water from the upper side into the slope.

Based on the predisposing and triggering factors, the mechanism of slope failure in Padli can be considered to be as follows.

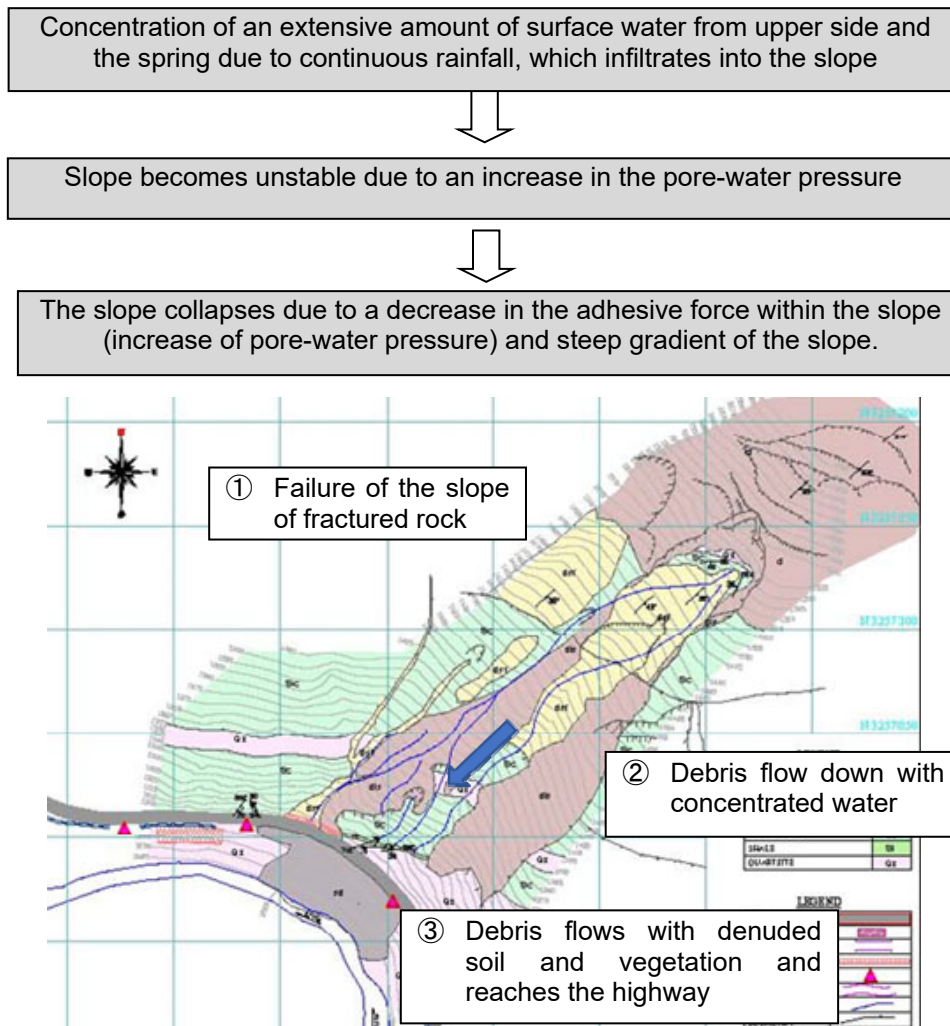


Figure 3.9 Mechanism of Slope Failure in Padli

3.2.2.4 Activity 1-4 Make designs for erosion control works in model sites.

The erosion control works at the three model sites need to be selected in consideration of the following four concepts. A combination of multiple erosion control works can be employed.

- Disaster source control measures based on the analysis of landslide mechanism
- Objects to be protected
- Ability of local contractors
- Combination of engineering and environment-friendly methods

The JET will assist the Task Teams and ToE in designing countermeasure works on the basis of the results of investigation and analyses. A topographical survey has been carried out in Activity 1-3. The schedule for design works will be as follows:

- Rough design of erosion control works will be carried out based on the results of investigations and topographical survey done in Activity 1-3.
- Additional investigation after the rough design
- Detailed design of erosion control works of each model site
- Cost estimation based on detailed design

(a) **Nirgad**

Based on the results of the analysis of mechanisms of disaster occurrence obtained in Activity 1-3, the following disaster preparedness policy was determined:

■ **Stream Section**

Upper stream (the flow-down section)

- Erosion control works such as check dams along the stream section do not contribute effectively to reducing the stream bed angle.
- Small-scale erosion control works such as masonry check dams can be useful in preventing stream bed erosion.
- Some erosion control works can prevent the inflow of surface water through the local road.

Lower stream (the sedimentation section)

- Erosion control works such as check dams make the stream angle gentler and are useful in reducing the force and speed of the water flow.
- Check dams are helpful because:
 - They prevent erosion of the stream bed and the stream bank.
 - They stabilize unstable debris on stream bed.
 - They prevent erosion on the slopes and the stream bank.
- Channel works are installed downstream from the check dams to control the water flow.

■ **Rock slope section along the NH**

The design works are in progress based on the following concepts:

- Rock slopes along the NH;
- Protection of the slope surface to prevent erosion; and
- Re-vegetation on the rocky areas of the slopes.

To protect the NH against debris flow and rock falls from the steep slope, the following three options for countermeasure works were studied.

- Option 1: Excavation work to create a gentle slope angle slope with a bench (slope step) + hydroseeding work on the slope surface
- Option 2: Removal of unstable rocks on the slopes + hydroseeding work on the slope surface. Shotcrete work on gullies to prevent further erosion.
- Option 3: Removal work of unstable rocks on the slope + wire network. Retaining wall with rock fence along the NH in front of Slope No. 2

The main types of work to be conducted on the model site in Nirgad are as follows:

- Check dam (steel frame dam is changed to a double-wall dam): 3 dams
- Consolidation works: 5 units
- Water channel works: 168.6 m
- Slope cutting: 3,533 m²

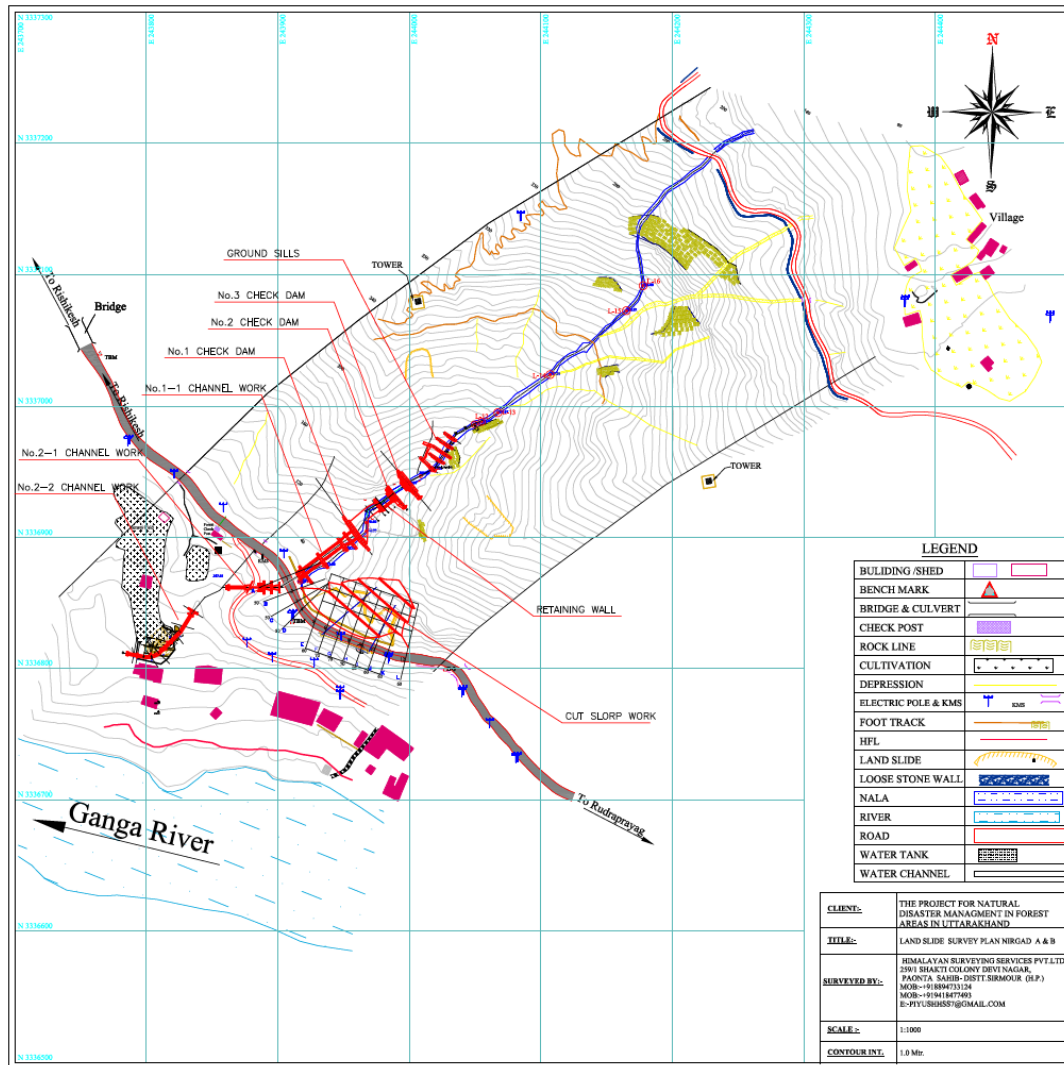


Figure 3.10 Plan View of the Erosion Control Works in Nirgad
<Measures taken to avoid an ashram in Nirgad>

During the process of the design work, it was ascertained that the original alignment of the channel work passes through the disputed area (a land ownership dispute) of a religious facility (an ashram). The proposed alignment was therefore modified to avoid the disputed area. However, as the result of discussion between the UFRMP and the ashram, the channel has been re-designed with the original alignment.

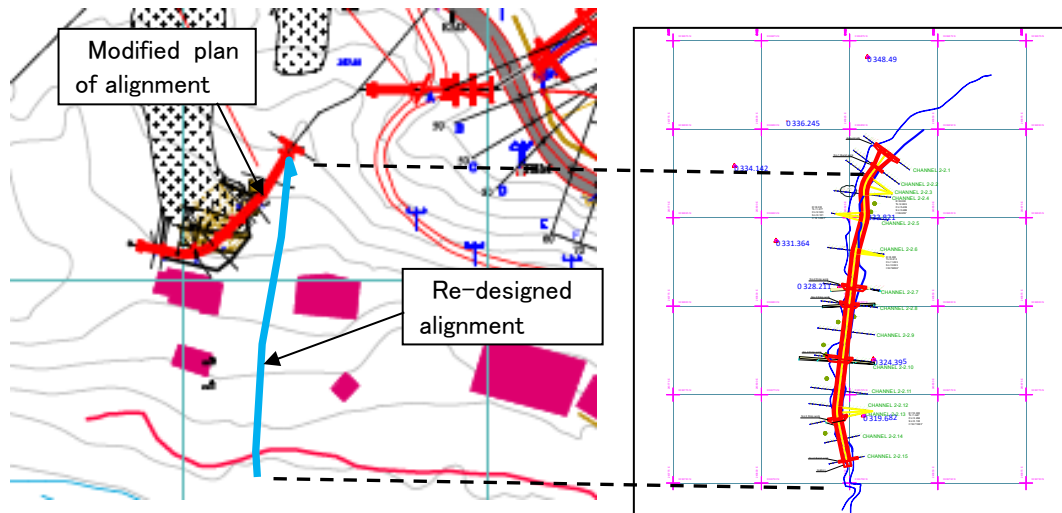


Figure 3.11 Final Alignment of Channel 2-2 in Nirgad

<Check dam has been changed from a steel frame dam to a double-wall dam>

Since the technology for the proposed check dam (steel frame) is unique to Japan, as stated in the technical specifications, the materials for one of the three planned dams were to be purchased from Japan, and the materials manufacturer was to provide guidance in the fabrication of the materials for the other two dams in India. However, following discussions between the contractor and the materials manufacturer, the manufacturer refused to deliver the materials for only one dam unit or to provide guidance for the fabrication of the materials in India. As a result, construction of the steel frame dam became practically impossible. As an alternative, the Japanese experts proposed a change to a double-wall dam, which was approved by the UFRMP and is a type that has a good track record as a check dam in Japan. The Japanese company which constructs double-wall dams and sells parts agreed to send engineers to India to provide guidance on component fabrication and installation as a result of discussions with the contractor.

(a) Jawadi 1

Based on the results of the analysis of mechanisms of disaster occurrence obtained in Activity 1-3, the following disaster preparedness policy was determined:

- Measure for failure section
 - To prevent further collapse and erosion by removing unstable sediment on the slope and protecting the surface.
 - To prevent the expansion of the area of failure since cracks are already observed surrounding the area.
- Measure for flow-down section
 - Multiple deep gully erosions have developed on the slope below the local road. Unless countermeasure works are installed, the gullies will deepen further and the slope will become unstable
 - The eroded collapsed sediments prevent slope revegetation. Therefore, countermeasure works should be constructed to reduce the energy of surface water runoff and control the flow of sediment into the gully.
 - Revegetation shall be applied to protect the slope surface and stabilize the slope itself.
- Measure for sedimentation section
 - The surface water flows freely over the slope. The free flow of water creates a debris

deposit area and inhibits slope revegetation. Surface water flow must be controlled so that it is properly discharged outside of the target area through drainage channels. The current main flow paths shall be maintained by structures to provide adequate drainage functions.

Based on the above countermeasure policy for the target slope, structural design was conducted for slope protection works, erosion prevention works and drainage channels in the flow-down section, and drainage channels in the sedimentation section.

The main types of work to be conducted on the model site in Jawadi 1 are as follows:

- Crib work and hydroseeding: 7,936 m²
- Wicker fence: 7,741 m
- Gabion work: 1,721 m³
- Erosion control mat: 29,880 m²
- Channel work: 835 m

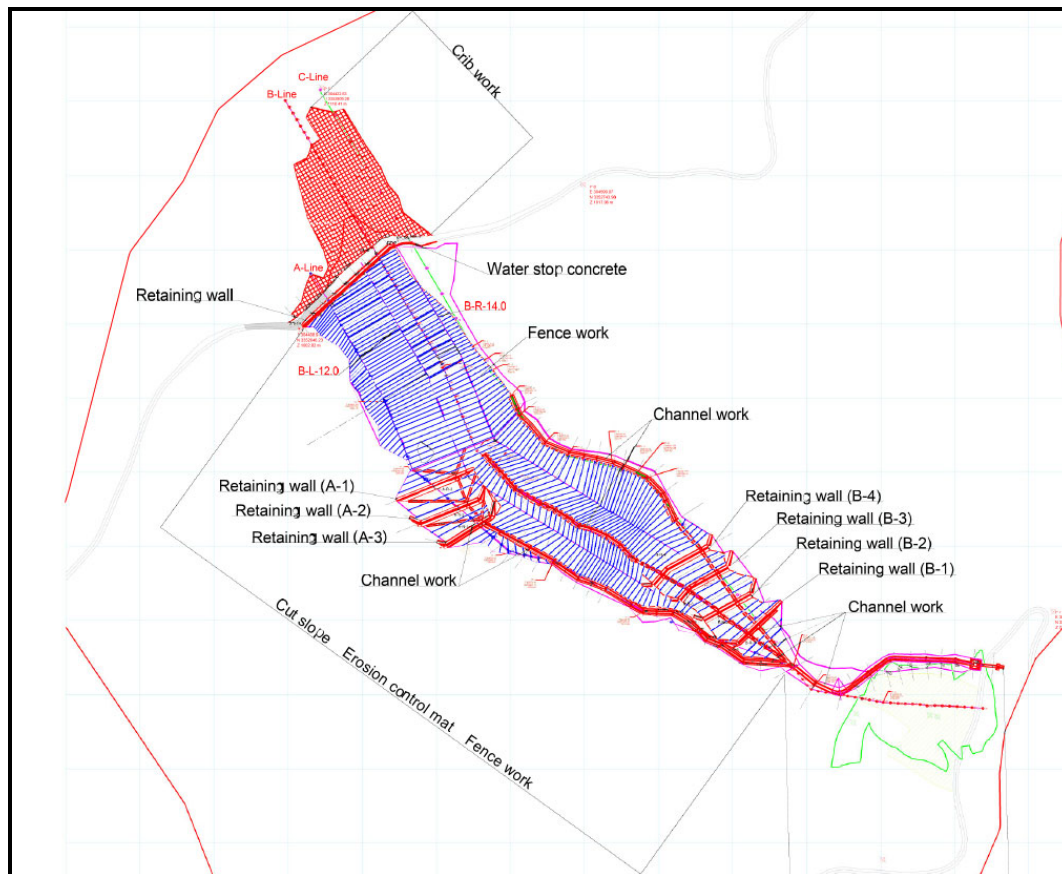


Figure 3.12 Plan View of the Erosion Control Works in Jawadi 1

(b) Padli

Based on the results of the analysis of mechanisms of disaster occurrence obtained in Activity 1-3, the following disaster preparedness policy was determined:

- Protection of the slope failure area (scarp of slope failure)
 - The condition of the failure area is still unstable. The scope of the failure area will expand further backward unless countermeasure work is installed. Protection work

shall be applied at the part directly to avoid further failure and expansion of the failure area to the surrounding area.

- The slope failure area is unstable and further failure may occur. Prevention works should be applied to avoid failure in the area.
- Reduction of energy of surface water flow/debris
 - The debris that flowed downward in the 2016 disaster came from not only the slope failure area, but also from existing debris distributed on the slope by erosion. Countermeasures shall be taken to reduce the energy of flowing surface water and debris.
- Protection by erosion
 - There is still debris deposited on the slope. Therefore, countermeasure works shall be installed to prevent erosion by surface water.
- Securing the safety of the road
 - Even though countermeasure works are applied to the slope, it is difficult to completely eliminated the risk of falling rocks or debris. Therefore, protection works to avoid damage to the road and road users shall be installed.

Based on the above countermeasure policy for the target slope, structural design was conducted for slope protection works, erosion prevention works and drainage channels in the flow-down section, and drainage channels in the sedimentation section.

The main types of work to be conducted on the model site in Padli are as follows:

- Crib work and hydroseeding: 6,020 m²
- Slope cutting: 18,974 m³
- Rock bolts: 510 locations
- Wicker fence: 1,050 m
- Gabion work: 76 m³
- Erosion control mat: 6,662 m²
- Channel work: 344 m
- Foot protection work: 23 m³

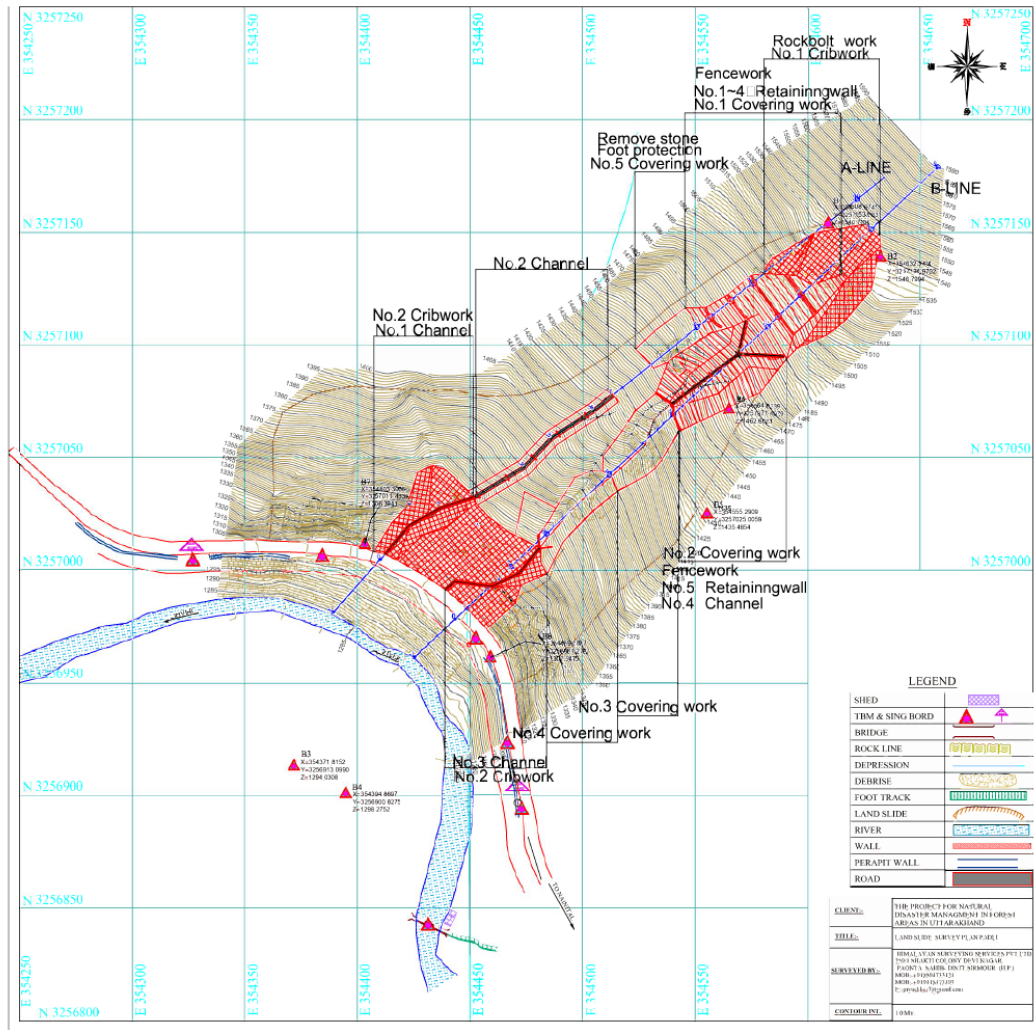


Figure 3.13 Plan View of the Erosion Control Works in Padli

The NH crossing under the slope needed to be temporarily moved away from the slope during construction of the erosion control works, and although not directly subject to the works, a plan and design for the temporary diversion of the NH was developed. Joint discussions were held onsite with the National Highway Authority of India (NHAI), which manages the NH, to confirm the design conditions. Based on these discussions, a road alignment plan was prepared and detailed design was carried out. The design of the NH was conducted in accordance with Indian Road Congress (IRC) Standard SP-73-2015. The road was intended only as a temporary road for common use during the construction period. Two types of retaining wall structures were proposed by the contractor: a cantilever retaining wall and a wet masonry retaining wall.

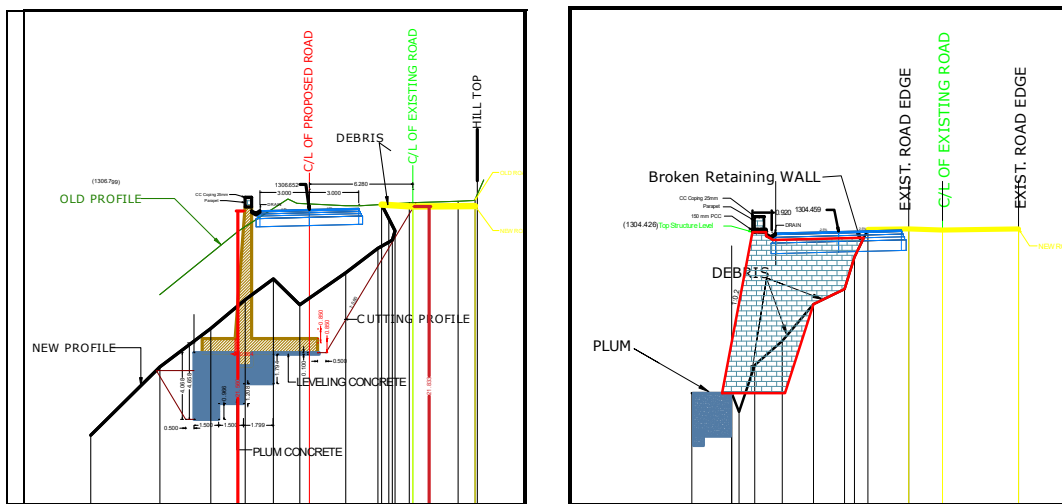


Figure 3.14 Design Drawings of Temporary Road in Padli
(Above: Road Alignment. Left: Cantilever Retaining Wall. Right: Wet Masonry Wall)

3.2.2.5 Activity 1-5 Select company for erosion control project in model sites and contract with the selected company

The original plan was to order the erosion control works at each of the model sites, but the UFRMP decided to use a lump-sum ordering method for the three sites after determining that there was concern that the construction costs for each site would not attract enough bidders because the scale of the work was not large enough. In response to this decision, technical specifications for the lump-sum ordering for the three sites were prepared.

A public announcement of the Request for Submission of Expression of Interest (EOI) for preparation of a short list was made on the UFRMP website on 29 September 2018. The deadline for submission of the EOI was 31 December 2018. In response to the request for the EOI, 14 Indian firms submitted applications. These were evaluated by the UFRMP, ToE, and the Uttarakhand Disaster Management Authority. Six firms were shortlisted. The bidding documents for the lump sum order for the erosion control works for the three model sites were prepared by the ToE and UFRMP with technical assistance from the JICA experts.

Subsequently, in accordance with the bidding rules and procedures in India, the following steps were taken, with the contract was signed by the successful bidder, BUMI JV, and the UFRMP on 11 January 2020.

Table 3.8 Bidding Procedures and Timing through Signing of Contract

S.No.	Item	Timing
0	Completion of design drawings, technical specifications, statement of quantity, cost estimation for the three model sites	February 2019
1	Finalization of tender docs by the ToE	April 2019
2	Review by JET	April 2019
3	Sent to Chief Project Director (CPD) for approval	April 2019
4	Review by CPD and Publishing of Request for Proposal (RFP)	20 June 2019
5	Pre-bid meeting	5 July 2019
6	Submission of bids by the participants	26 August 2019
7	Evaluation of technical bids	1 October 2019
8	Opening of financial bids	3 October 2019
9	Evaluation of successful bidders' bids	12 December 2019
10	Signing of contract agreement documents	11 January 2020

3.2.2.6 Activity 1-6 Based on approved designs, supervise erosion control works in model sites until completion

A contract for the construction of the erosion control works for the model sites was signed between the UFRMP and the contractor (Bumi JV) on 11 January 2020. Since the signing of the contract, the ToE and the Task Teams have been supervising the construction according to the construction supervision plan attached to the contract document, as shown in the figure below. The Japanese experts provided guidance and support to the ToE and the task team for construction supervision at the model sites, including confirmation of construction methodology contents and procurement materials, quality control of construction, safety measures, and so on.

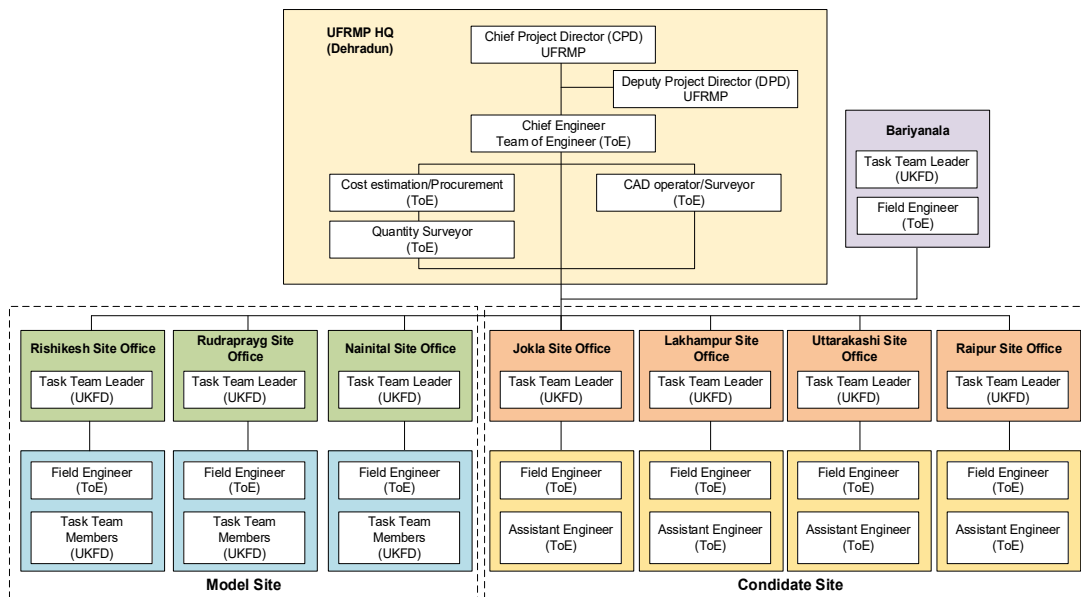


Figure 3.15 Implementation Structure for Construction Management

A kick-off meeting with the contractor was held on 21 January 2020 and the erosion control works at the model sites was initiated. However, immediately after this, the GoI put lockdown measures in place due to the spread of COVID-19, and therefore C/P activities and the work of the contractor were suspended on 21 March 2020. C/P activities and the work of the contractor resumed on 4 May 2020. Assistance from the Japanese experts in the verification and approval of these drawings by the ToE was provided remotely from Japan until travel to India was permitted. The Japanese experts resumed traveling to India on 4 October 2021.

In addition, a “Manual for the Preparation of Construction Plans” was prepared to ensure a common understanding with the contractor of the basic items that should be included in the details of the erosion control works, such as the content, methods, safety measures, and work schedule.

The construction work has been delayed from the originally planned schedule due to construction disruptions caused not only by COVID-19, but also for a number of other reasons. The reasons for delay and the actions taken by the experts are described below.

1) Inadequate Construction Plan

As stated in the technical specifications, the contractor is required to prepare and submit a construction plan and obtain approval from the client before beginning actual construction. The construction plan is also required to include a health and safety plan, quality control chart, and workmanship control chart. Since the Indian side, including the ToE, had little experience in preparing construction plans, a sample construction plan was presented to the ToE and the Task Teams, and an explanation of how to prepare the plan was given. The contractor was also instructed on how to prepare these plans. The resulting construction plan submitted by the contractor was not sufficient or appropriate, and the process was not realistic, so instructions were repeatedly given to the contractor to revise the plan. In addition, the experts provided explanations using the construction plan preparation manual mentioned above. However, since sufficient corrections were not made, the UFRMP and the Japanese experts decided to create and approve a construction plan for each construction work, instead of a construction plan for all of the construction works. Even then, it has taken an extremely long time for sufficient construction plans to be prepared, revised, and approved in order to start construction.

2) Delays in procurement of materials and equipment

It is taking time to procure materials and equipment needed for the construction work. If the work can proceed according to schedule, arrangements can be made so that the materials and equipment arrive at the site when they are needed. However, the contractor starts procurement as soon as the materials and equipment are needed, so onsite work is suspended during the procurement process. In addition, since construction equipment is used at all three model sites, there are many cases where work is halted when equipment is needed because it is being used at another site.

Despite repeated instructions through the ToE to proceed with preparations for procurement of materials and equipment prior to construction work, no improvement was made. Since then, the procurement manager and the site manager have been replaced and the speed of procurement has increased, but not to the extent that there is not always a waiting time for field work.

3) Failure due to lack of maintenance of equipment

In many cases, equipment has been procured on site, but frequent breakdowns have halted work. In some cases, the equipment was moved to another site, and even after the replacement equipment was brought in, it was left at the site for almost a year due to

breakdowns, with work not progressing. The ToE has provided instructions to the contractor on this issue on numerous occasions, but there has been no drastic improvement has been made.

4) Rework due to construction without following work procedures

In conducting erosion control works, especially with regard to excavation work, it is necessary to be very careful about the timing and extent of the excavation work. Excavation work performed without following proper construction procedures can lead to unanticipated collapses and, depending on the time of year, erosion caused by surface water can change site conditions. The contractor prioritized the schedule for using the equipment and machinery and performed work using improper procedures at inappropriate times, which resulted in an unexpected collapse and a change in the topography of the construction area from the plan. In some cases, the excavation of the bed for a check dam was carried out before materials were procured, and the excavated area was eroded and buried by a large amount of surface water during the monsoon season, causing the work to have to be redone. This required the site to be redesigned for the new terrain, which led to delays in the process. The contractor was repeatedly instructed by the ToE to follow construction procedures, not to perform excavation work carelessly, and to always obtain the Field Engineer's approval before performing any work.

Due mainly to the above reasons, the work process has been significantly delayed and it is impossible to complete the construction of the model sites within the time frame of the Project. A list was prepared of what should be done and what should be noted at each site after completion of the Project, and this list was explained at each site in March 2024.

The construction progress for each model site construction as of January 2024 is shown below.

1) Nirgad

The table below shows construction progress in Nirgad as of March 2024.

Table 3.9 Construction Progress in Nirgad

Theme	Progress
Construction plan (date of approval)	Overall construction methodology (1/10/2020), construction methodology for temporary access road (22/12/2020), construction methodology for channel works 2-2 (5/1/2022), construction methodology for cut slope works (20/1/2022), construction plan for soil dumping site (18/5/2022), double-walled dam (DWD) construction plan (19/7/2022), amendment to worksheet (20/2/2023), revised version of the construction methodology for channel works 2-1 (13/10/2023) revised version of the construction methodology for channel works 2-1 (12/2/2024)
Health and safety plan	Approved with construction methodology
Startup survey	Implemented and approved
Construction materials (date of approval)	Steel wire for gabion (17/3/2020), erosion control mat (19/6/2020), gabion frame (5/11/2020), stones for filling gabion (10/2/2021), suction prevention material (4/3/2021), sandbags (8/3/2021), steel bars for fixing sandbags (12/3/2021), gabion frame (9/7/2021), stones for filling gabion (27/9/2021), concrete mixing test (7/10/2021), anchor bars and pins for erosion control mat (13/1/2022), anchor bars for erosion control mat (25/5/2022), DWD steel component (7/7/2022), HDPE pipe for DWD (7/7/2022), DWD filling material (6/8/2022)
Shop drawings (date of approval)	Startup survey drawings for ground sills and channel work 1-1 (15/12/2020), shop drawings for the construction of temporary road

	(22/12/2020), startup survey drawings for channel work 1-1 (22/12/2020), startup survey drawings for channel work 2-1 (23/12/2020), shop drawings for ground sill works No.1-5 (19/3/2021), shop drawings for channel work 2-2 (27/9/2021), shop drawing for channel work 1-1 (6/12/2021), shop drawing for cut slope work (20/1/2022), design document for DWD No .3, No. 2 and No. 1 (25/3/2022), DWD material manufacturing drafting (10/2/2023), shop drawing for channel work 2-1 (10/1/2024) (10/1/2024), shop drawing for gabion works for CD No.3 (5/2/2024), revised shop drawing for channel work 2-1 (12/2/2024)
Construction progress	Completion of temporary works on site such as temporary entrance road (31/3/2021), completion of ground sill No. 5 (27/8/2021), completion of ground sill No. 4 (10/10/2021), completion of ground sill No. 3 (28/11/2021), completion of ground sill No. 2 (16/12/2021), completion of ground sill No. 1 (7/1/2021), start of excavation for channel work 2-2 (17/1/2022), start of installation of rock fall protection fence against cut slope work (27/1/2022), cut slope work (4/2022~1/2024), excavation for DWD No.3 (10~11/2022), manufacturing of DWD No.3 material (4~10/2023), erection of DWD No.3(11~12/2023)
Monthly construction plan received	For the months of July, August, September, October, November and December 2021; January, February, March, April, May, June, July, August, September, October, November and December 2022; and January, February, March, April, May, June, July, August, November and December 2023; January and February 2024
Monthly health and safety plan received	For the months of July, August, September, October, November and December 2021; January, February, March, April, May, June, July, August, September, October, November and December 2022; and January, February, March, April, May, June, July August, November and December 2023; January and February 2024
Monthly progress reports received	For the months of July, August, September, October, November and December 2021; January, February, March, April, May, June, July, August, September, October and November 2022; and February, March, November and December 2023; and January and February 2024
Monthly safety report received	For the months of July, August, September, October, November and December 2021; January, February, March, April, May, June, July, August, September, October and November 2022; and February, March, November and December 2023; and January and February 2024
Progress meeting held with the contractor	General progress meetings: 27/7, 10/8, 28/9, and 16/12 in 2021; 14/1, 14/3, 2/5, 25/7, and 23/8 in 2022; and 7/7, 13/9 and, 31/10, and 17/11 in 2023; and 7/3 in 2024 Nirgad site meetings: 6/7, 23/7, 12/8, 25/9, 11/10, 23/10, 30/10, 13/11, 4/12, and 8/12 in 2021; and 22/1, 5/2, 19/2, 6/4, 13/7, 30/7, and 5/11 in 2022; and 18/11, 25/11, 8/12 and 22/12 in 2023; and 12/1, 19/1, and 9/2 in 2024
Design changes	Design change for the alignment of channel work 2-2 was completed. The design of check dam structure is completed so as to change from a steel frame dam to DWD.

2) Jawadi

The table below shows construction progress in Jawadi as of March 2024.

Table 3.10 Construction Progress in Jawadi

Theme	Progress
Construction plan (date of approval)	Overall construction methodology (18/10/2021), construction methodology for temporary access road for hillside works (11/2/2022), construction methodology for soil disposal area (No.1) (12/4/2022), construction methodology for soil disposal area (No.2) (12/4/2022), construction plan for section A of the hillside work (18/5/2022), construction plan for the crib works (22/11/2022), CV of the Japanese supervisor for crib works (30/1/2023), revised work schedule (20/2/2023), construction plan for the section B of the hillside work (5/1/2024)
Health and safety plan	Approved with construction plan
Startup survey	Implemented
Material (date of approval)	Material testing laboratory (10/12/2021), concrete mixing test (11/2/2022), gabion for temporary road (2/3/2022), RC pipe for temporary road (2/3/2022), gabion for dumping site (28/4/2022), suction prevention material for dumping site (28/4/2022), waterproof sheet for dumping site (30/4/2022), geotextile for dumping site (5/5/2022), cobble for dumping site retaining wall (29/6/2022), water PVC pipe for drainage (29/6/2022), cobblestone for culvert drainage at dumping site (29/6/2022), elastite for retaining wall joints (4/7/2022), concrete mix test (5/8/2022), logs for fence work (10/8/2022), gabion for temporary road (10/9/2022), logs for fence work (25/11/2022), logs for fence work (4/2/2023), material for formwork for crib works (tentatively approved on 10/2/2023), sprayed mortar mix for crib works (10/2/2023), wire mesh for formwork for crib works (20/2/2023), sprayed mortar core compressive strength test (20/6/2023), suction prevention material (14/8/2023)
Shop drawings (date of approval)	Startup survey drawings for hillside works, startup survey drawings for channel works, startup survey drawings for road retaining walls, shop drawing for the construction of soil disposal area, shop drawing for the construction of temporary access road (1/2/2022), construction drawing for soil disposal area (No.1) (15/3/2022), construction drawing for road retaining wall (25/3/2022), construction drawing for hillside works section A (25/3/2022), construction drawing for soil disposal area (No.2) (12/4/2022), crib work construction drawing (13/7/2022), construction drawing for hillside works section B (10/9/2022), falling rock protection fence (3/1/2023), temporary access road at the top of crib works (3/1/2023), crib work construction drawing (21/1/2023), crib work construction drawing (23/3/2023)
Construction progress	Access road to the hillside work area (April 2022~), disposal area (No. 2) (May 2022~), disposal area (No. 1) (September 2022~), retaining wall for existing road (September 2022~), hillside works (January 2023~), temporary access road at the top of crib works (3/1/2023), crib works (3/2023~)
Monthly construction plan received	For the months of December 2021; January, February, March, April, May, June, July, August, September, October, November and December 2022; and January, February, March, April, May, June, July, September, November and December 2023; and January, February and March 2024
Monthly health and safety plan received	For the months of December 2021; January, February, March, April, May, June, July, August, September, October, November and December 2022; and January, February, March, April, May, June, July, September, November and December 2023; and January, February and March 2024
Monthly progress reports received	For the months of October and November 2021; January, April, May, June, July, August September, October, November and December 2022; and February, March, April, May, June, July, August, September,

	October, November and December 2023; and February 2024
Monthly safety reports received	For the months of October and November 2021; January, April, May, June, July, August September, October, November and December 2022; and February, March, April, May, June, July, August, September, October, November and December 2023; and February 2024
Progress meeting held with the Contractor	General progress meetings: 27/7, 10/8, 28/9, and 16/12 in 2021; and 14/1, 14/3, 2/5, 25/7, and 23/8 in 2022; and 7/7, 13/9, 31/10, and 17/11 in 2023; and 7/3 in 2024 Jawadi site meetings: 9/10, 18/10, 26/10, 8/11, 20/11, 26/11, 10/12, and 18/12 in 2021; 11/1, 19/2, 28/5, 4/6, 10/6, 20/6, 25/6, 23/7, 13/8, 16/9, 15/10, 5/11, 19/11, 26/11, and 17/12 in 2022; and 7/1, 4/2 25/2, 4/3, 18/3, 25/3, 1/4, 15/4, 29/4, 12/5, 12/6, 19/6, 3/7, 19/8, 21/9, 13/10, 21/10, 6/11, 25/11, 8/12 and 23/12 in 2023; and 9/1, 20/1 and 18/2 in 2024

3) Padli

The table below shows construction progress in Padli as of March 2024.

Table 3.11 Construction Progress in Padli

Theme	Progress
Construction plan (date of approval)	Overall construction methodology (21/10/2021), construction methodology for NH road realignment works (18/3/2022), rockfall protection wall construction plan (10/6/2022), rock fall accident prevention plan (25/10/2022), crib works and rock bolt works plan (26/11/2022), revised work schedule (20/2/2023), the 2 nd revision of crib works and rock bolt works plan (5/2/2024), the 3 rd revision of crib works and rock bolt works plan (27/2/2024)
Health and safety plan	Approved with construction plan
Startup survey	Implemented
Material (date of approval)	Steel wire of gabion (21/12/2020), erosion control mat (21/12/2020), gabion frame sample (2020/12/21), material testing laboratory (10/12/2021), concrete mix test (13/1/2022), admixture (19/5/2022), coarse aggregate for foundation concrete (19/5/2022), PVC water stop plates (30/6/2022), joint sealing material (30/6/2022), gabion for rockfall protection wall (19/7/2022), rebar (10/8/2022), backfill material for reverse-T retaining wall (24/9/2022), cement (15/10/2022), erosion control mat (10/2/2023), gabion for rockfall protection wall (10/2/2023), steel works material for rockfall protection fence (10/2/2023), subgrade and, subbase and base course material for road pavement (10/2/2023), asphalt concrete mixing proportion (10/2/2023), sprayed mortar mixing proportion for crib works (10/2/2023), rock bolts material (12/4/2023), movable rockfall protection fences (7/6/2023), rock bolt material (8/1/2024), PVC sleeve pipe for crib work (10/1/2024) , wire rope 10mm dia. (26/2/2024), wire rope connector (1/3/2024)
Construction drawings (date of approval)	Design documents for reverse-T retaining walls for NH road realignment works (16/3/2022), construction plan for reverse-T retaining walls (6/5/2022), gabion protection wall (8/5/2022), crib works construction plan (13/7/2022), construction drawings for crib works (28/3/2023), final version of the national road realignment longitudinal and structure drawings (6/6/2023), movable rockfall protection fences (12/6/2023), fractured slope area treatment drawing for crib works (2/1/2024) , the revised version of fractured slope area treatment drawing for crib works (5/3/2024)
Construction progress	Construction of NH road realignment (April 2022~ May 2023), crib work No. 1 (December 2023 ~)
Monthly construction plan received	For the months of November and December 2021; January, February, March, April, May, June, July, August, September, October, November and December 2022; and January and February, April, May, June,

	October and December 2023; and January, February and March 2024
Monthly health and safety plan received	For the months of November and December 2021; January, February, March, April, May, June, July, August, September, October, November and December 2022; and January and February, April, May, June, October and December 2023; and January, February and March
Monthly progress reports received	For the months of October 2021; April, May, June, July, August September, October, November and December 2022; and February, March and April in 2023
Monthly safety report received	For the months of October 2021; April, May, June, July, August September, October, November and December 2022; and February, March and April in 2023
Progress meeting held with the Contractor	General progress meetings: 27/7, 10/8, 28/9, and 16/12 in 2021; and 14/1, 14/3, 2/5, 25/7, and 23/8 in 2022; and 7/7, 13/9/ and, 31/10, and 17/11 in 2023; and 7/3 in 2024 Padli site meetings: 9/10/, 23/11, 3/12, 18/12 in 2021; 4/1, 8/1, 17/1, 4/4, 23/5, 28/5, 4/6, 10/6, 20/6, 25/6, 30/7, 6/8, 17/10, and 24/12 in 2022; and 23/1, 1/2, 17/2, 25/2 and 29/12 in 2023; and 9/1 and 23/1 in 2024

Rainfall has a significant impact on safety management during construction. Monitoring rainfall is important during construction of erosion control works because slopes and streams may be more unstable during construction. A warning system was attached to rain gauges installed around the model sites during the survey phase. The warning threshold was set based on continuous hourly rainfall or effective rainfall, with the system sending out a warning when the designated threshold is observed on the rain gauge. When a warning was issued, emergency measures were taken, such as suspending construction, controlling traffic on roads, and evacuating residents if necessary. Warning thresholds were determined by analysing the relationship between disasters and rainfall based on past rainfall records. After the establishment of the system, the thresholds were reviewed based on new data. The following warning thresholds were set based on data from the 2023 rainy season.

Table 3.12 Warning Threshold for Each Model Site

Model Site	Warning Threshold	Remarks
Nirgad	20.0 mm/h	Hourly rainfall
Jawadi 1	31.2 mm	Effective rainfall (72 hours*)
Padli	71.6 mm	Effective rainfall (72 hours*)

*: Half-life period

The table below shows construction cost of each model site.

Table 3.13 Construction Cost of Each Model Site

Description	Nirgad	Jawadi	Padli	Total	Remarks	Page No
Original Value of Contract (Rs.)	81,430,509.00	206,937,356.58	142,863,543.00	431,231,408.58		
Cost escalation due to change in design resulting inclusion of extra items	2,854,586.18	14,155,707.00	6,603,921.90	23,614,215.08	Flag A (Note Sheet dated nil) and Flag B (Note Sheet dated nil)	6,7,8,9
Cost escalation due to COVID Lockdown (Change in cost of materials and labour as well as DSR/ SOR rate)	6,774,370.01	17,215,540.29	11,885,109.20	35,875,019.50	Flag C (Note Sheet dated 12. 04.2023) and Flag B (Note Sheet dated nil)	10
Idle Charge due to COVID	13,010,318.00	1,689,498.00	3,414,516.00	18,114,332.00 (Payment released on 15 th June 2023)	Flag D (note sheet dated nil)	11,12
Cost reduction due to change in check dam	-582,055.27			-582,055.27	Flag E (Work sheet of extra items)	13,14
Total Incremental cost	22,057,218.92	33,060,745.29	21,903,547.10	77,021,511.31		
Total Revised Cost (Without Taxes)	103,487,727.92	239,998,101.87	164,767,090.10	508,252,919.89		
% Incremental cost escalation	27.08%	15.97%	15.33%	17.86%		
Add: 18% GST	18,627,791.03	43,199,658.34	29,658,076.22	91,485,525.58		
Total Revised cost (With Taxes) Rs.	122,115,518.95	283,197,760.21	194,425,166.32	599,738,445.47		

3.2.2.7 Activity 1-7 Regular monitoring of facilities in model sites

A maintenance manual was prepared for the maintenance of the constructed facilities and for evaluating their effectiveness. This manual was prepared based on the maintenance and management of erosion control facilities in Japan. It is desirable to consider future maintenance management methods in India based on the types of work selected and constructed in the erosion control works being carried out at the model sites, taking into account their construction quality, ease of maintenance, workability, and maintenance targets. Study sessions were held in September 2023 for the ToE and the Task Teams based on this maintenance management manual to explain its contents and promote understanding.

In addition, monitoring sheets for maintenance and management were prepared for each model site, while explanations were given on how to use the monitoring sheets and what to look for during onsite inspections in March 2024.

3.2.2.8 Activity 1-8 Prepare guidelines for erosion control works

The Long-term Experts took the lead in conducting this activity, supported by the Japanese experts. The Japanese experts assessed the situation in Uttarakhand based on field visits to candidate model sites, while the Long-term Experts collected, reviewed, and gathered information from relevant documents (e.g., standards for erosion control technology) used in Japan. Based on the information collected, guidelines for the erosion control works were compiled by the Long-term Experts. The Japanese experts mainly conducted technical discussions in the field, provided materials and photos for use in the guidelines, and reviewed the drafts. In June 2018, the Long-term Experts submitted the completed version of the guideline to the UKFD and JICA India Office.

3.2.2.9 Activity 1-9 Prepare manual on design of erosion control works

The Long-term Experts led the preparation of the draft version of this manual, and the Japanese experts provided support by reviewing the draft version. An electronic version of the manual was shared with project stakeholders in September 2021, and Version 0.0 was

published for internal use in 2022. The manual was subsequently revised based on comments from stakeholders, and Version 1.0 of the design manual for the erosion control works was published in June 2023. In November 2023, Version 2 was issued with revised Indian version including tree species to be planted.

3.2.2.10 Activity 1-10 Develop standard operating procedures for erosion control works.

The construction types to be covered were based on the work to be performed at the model sites. The following 13 construction types were determined after discussions with the Long-term Experts. The contents of the SOP included the following work items.

【Type of work】	【Contents of description】
1. Start up survey	• Purpose of the work
2. Ground sill work	• Workflow of the construction
3. Double-wall check dam	• Explanation of the content of each operation related to construction and points to note
4. Channel work	• Safety measures
5. Cut slope work	• Supplementary points
6. Earth retaining work	
7. Concrete cribwork	
8. Rock bolting work	
9. Fence work	
10. Covering work (mat work)	
11. Foot protection work	
12. Temporary work	
13. Safety measures	
Appendix: Profile installation	

The SOP for each work type was developed by the Japanese experts, and study sessions were regularly held for the ToE from October 2021, when both Experts could not work in India due to the COVID-19 and the Task Teams based on the SOP to consolidate knowledge and promote understanding. In September 2023, Version 1 was completed based on the results of the study sessions.

3.2.2.11 Activity 1-11 Evaluate erosion control models constructed in model sites by UKFD staff.

This activity is to evaluate the activities and results related to erosion control works carried out at the model sites. The evaluation methodology and implementation policy were discussed with the Long-term Experts and the draft implementation policy was prepared as follows;

[Evaluation team]

- Deputy Project Director: Evaluation team representative
- Task Team members: 9 (3~4 x 3 teams)
- ToE: 2 persons (Chief Engineer and Deputy Chief Engineer)
- Japanese Experts: 2 (1 Long-term and 1 Short-term Expert)
- Japanese training participants: 1-2

[Evaluation details]

- Validity of work approach
- Comprehension of work objectives
- Technologies/methods that can be adapted in Uttarakhand
- Effectiveness as a future slope control measure

- Contribution to strengthening the technical capacity of the UKFD

[Subject of evaluation]

- Investigation (determination of countermeasure works): 3 model sites
- Design, construction and maintenance: Main hill control works carried out/being carried out as follows:
 - Double wall weir works
 - Concrete channel works
 - Covering works (mat works)
 - Concrete cribwork
 - Rock bolting works
 - Wooden fence works

[Evaluation method]

- Each assessor uses an evaluation sheet in written form.
- The evaluation items are rated on a five-point scale.
- A rating of four or more is considered high.
- Each evaluator gives an overall rating for each stage in five levels (average).
- An evaluation sheet is distributed to each evaluator in advance by email, and are basically collected at the time of evaluation.
- The JET compiles the evaluation results and analyzes them along with the evaluation team representative.

According to the R/D, the evaluation should be conducted by UKFD staff (including the UFRMP). However, since the erosion control works at the model sites have not been completed and will continue after the completion of the Project, it was decided after discussion with the Chief Project Director (CPD) that the evaluation to be conducted this time will be an interim evaluation and that a final evaluation will be conducted by the UKFD after the completion of the erosion control works at the model sites. At the request of the CPD, a JET member shall also join the evaluation team for the interim evaluation.

The evaluation of the erosion control works model was carried out by ToE and UKFD officials at the Padli on 29 December 2023, Nirgad on 30 December 2023 and Jawadi on 22 January 2024. The results showed that more than 80% of the evaluators rated 331 out of 336 assessment items highly.

3.2.3 Activity Related to Output 2

On 30 May 2018, four new Task Team members were nominated from each DFO office, for a total of 12 Task Team member nominees. By the end of June 2018, 10 of these 12 nominees were also assigned to the Task Teams. The other two were not assigned.

3.2.3.1 Activity 2-1 Carry out basic study for preparation of technology transfer plan

Many of the Task Team members have been transferred or reassigned and few of the initial members remain. Although the JET and ToE had often asked for personnel to fill in for them, this was not actually done. Only about two to three people were actively participating in the Task Teams. Some ToE turnover took place, with two ToE members leaving the Project in April 2023 and one in June 2023. Following this, one additional ToE member was brought on board in April 2023, two in June 2023 and one in February 2024, to manage the construction of the model sites and candidate sites. Baseline survey on the technology and knowledge of the Indian Task Teams and ToE. As of February 2024, there are 11 ToE members.

(a) Basic survey of the technology and knowledge of the Task Team and the ToE

A comprehension test on understanding of baseline survey positioning was conducted for the Task Team and ToE members who are C/Ps on the Indian side. Subsequently, a total of three tests of understanding have been conducted. For the test questions on the understanding test for the baseline survey, 31 multiple choice and descriptive questions were proposed for each category and compiled by the Long-term Experts, based on the materials used in the previous training courses on erosion control technology.

The implementation times for the comprehension tests are shown as follows:

Initial test for baseline survey: 3 June 2019

Interim comprehension test: 21 October 2021

Final comprehension test: 8 January 2024

The average percentage of correct answers in the interim comprehension test was 60%, while the average percentage of correct answers in the final comprehension test improved significantly to 80%.

(b) Baseline survey on the technology and knowledge of the Indian contractor

Research was conducted on suppliers of materials used in the construction of erosion control works, contractors involved in hydraulic works such as dams, canals, and weirs, and civil engineering firms involved in slope control works. Interview surveys were also conducted with several companies from 2017 November to February 2018 to obtain information on the track record of similar works, possible erosion control works, equipment that they have, and their capacity. The contractors had experience in general civil engineering work, shotcrete work, rock bolting, and retaining wall construction, and it was judged possible to implement these works with quality assurance under the guidance and supervision of the JET.

3.2.3.2 Activity 2-2 Prepare technology transfer plan, including basic concept for erosion control works, prepare plan on erosion control works, method of surveys for designing erosion control works, design and works for erosion control facilities, etc.

Daily technology transfer was conducted through the work from Activity 1-3 to Activity 1-7. The C/Ps were assigned to three Task Teams; basically, each Task Team was responsible respectively for model site 1, model site 2, and model site 3. Since repeated experience is important in acquiring technology, an attempt was made to involve the other Task Teams in charge of each model site as much as possible, but it was difficult to coordinate because the Task Team members were busy with their regular work, so this was not very feasible.

Table 3.14 Key Factors for Technology Transfer in Erosion Control Works

Stages of Erosion Control Works	Key Factors
Investigation	Method of investigation, soil thickness test using simple penetration test, sketches, illustration of investigation results
Designing	Selection of type of erosion control work based on the investigations, stability calculation, distribution of erosion control works by type, structural calculation, selection of tree species and method for planting vegetation
Procurement and Contract	Elaboration of contract, terms of reference and public announcement, evaluation of standard technical capacity of contractor, evaluation and examination of proposal submitted by the contractor, establishment of warranty against defects

Construction management	Construction as per the design, procurement, quality control management, construction period management, safety management
Safety Management	Establishment of reference values for safety management during monitoring and measures to be taken, safety management regarding inhabitants and road users during and after construction (establishment of reference values for safety management, traffic limitation and evacuation method for local inhabitants)

Assignment of staff will be formulated to satisfy the above factors successfully.

Through the results of the baseline study in Activity 2-1 and the work with the Task Team in Activity 2-2, a technology transfer plan was developed in consultation with the Long-term Experts. This technology transfer plan was submitted to the UFRMP.

3.2.3.3 Activity 2-3 Implement off-job-training (Off-JT) and on-job-training (OJT) based on technology transfer plan

OJT and Off-JT is carried out in accordance with the technology transfer plan prepared in Activity 2-2. Technology transfer to the Task Team, ToE. and DFO office staff at the three model sites is carried out and include aspects such as surveys, design, procurement and contracts, construction management, and monitoring. Of these, surveys, construction management, and monitoring are primarily technology transfer in the field, while design, procurement and contracts are mainly desk work. For onsite work, Task Teams, ToE and DFO office staff as C/Ps accompany the JET and as much as possible conduct technology transfer that can only be mastered onsite. For the desk work, the ToE shared their expertise with the Task Teams and Forest Division Officers with the help of the JET.

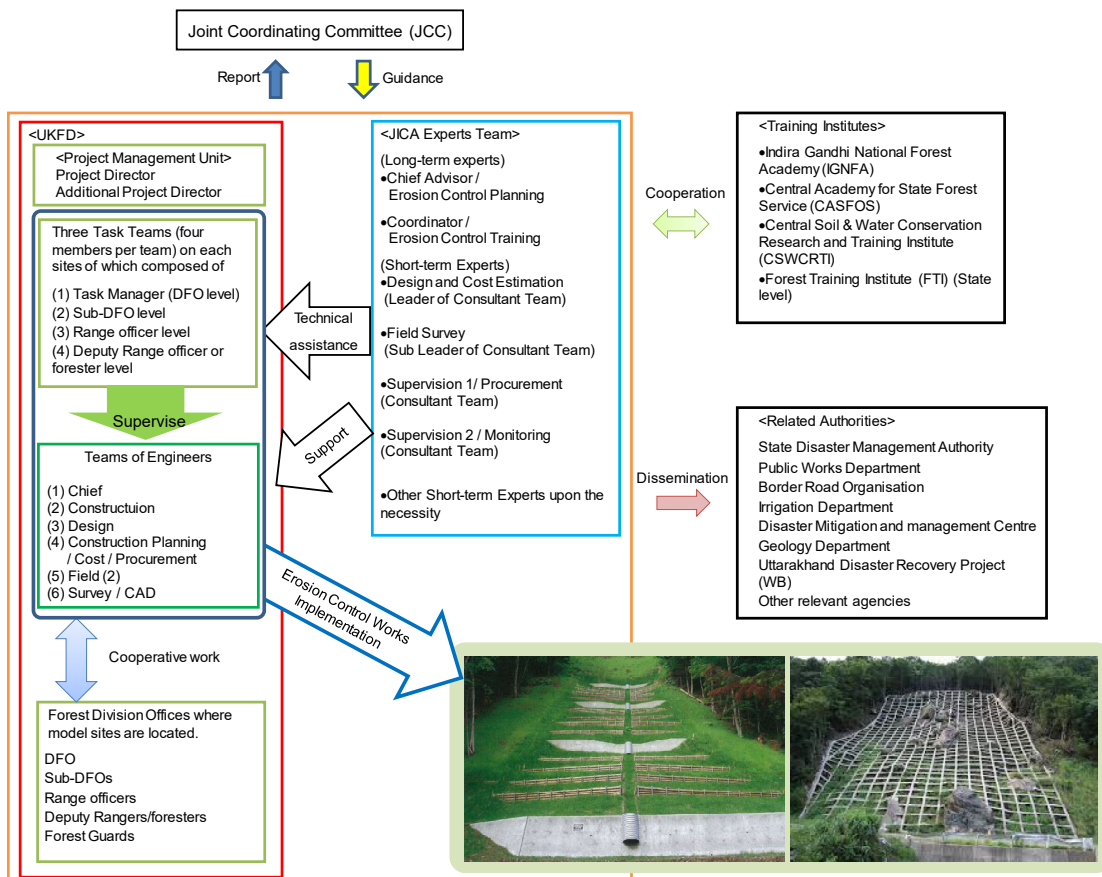


Figure 3.16 Organizational Structure for Technology Transfer

In addition to these OJT sessions, short technical workshops and study sessions were held at regular monthly meetings for technology transfer and on several other occasions. During the period when the JICA experts were unable to travel to India due to COVID-19 in 2020, study sessions for technology transfer were periodically held online.

Training in India as Off-JT

Prior to the second training in Japan, a training on “Design of Erosion Control Works” was held in Dehradun on 22-29 October 2018. The participants in the training included Task Team members and the ToE. Mr. Sakurai from Japan conducted a series of lectures on “Design of Erosion Control Works”, and Mr. Kitaura, who is a Long-term Expert, gave a lecture on the “Introduction of Erosion Control Works Japan and Safety Countermeasures in Work”. On the last day of the training in India, onsite training was conducted at a model site (Nirgad) to confirm the layout and purpose of structures using design drawings and other materials.

Training in Japan as Off-JT

This training course was conducted to deepen the understanding of the project staff, including C/Ps, on the Japanese system and technology of erosion control for the effective implementation of the Project.

■ First Training in Japan

The first training in Japan was held from 25 October to 9 November 2017 for UKFD staff and the ToE, who are C/Ps, as well as the Uttarakhand State Disaster Management Authority, Finance Department and the PWD, which are envisaged as relevant agencies for achieving the Project’s objectives, to deepen understanding of Japanese erosion control systems and technologies. Eleven trainees participated in the training. The training curriculum was developed in consideration of achieving the objectives of the training, and the actual training period was divided into three stages based on the content of the training.

- Stage 1: Lectures on basic knowledge related to erosion control
- Stage 2: Site observation of erosion control construction site
- Stage 3: Lectures on practical erosion control projects

■ Second Training in Japan

The second training in Japan was held from 12 to 22 November 2018. Task Team members, ToE, UKFD staff and the Chief secretary of the Uttarakhand Government participated in the training in order to understand erosion control technologies, disaster management and the legal system for erosion control, and forest conservation in Japan. The lectures on basic knowledge of erosion control were held at the headquarters of the Forest Agency, Forest Research and Management Organization, and at Nippon University. Visits were also conducted to erosion control work sites in the Oigawa area in Shizuoka Prefecture, the village of Ohshika in Nagano Prefecture, and the Norogawa area in Yamanashi Prefecture. On the last day of the training, all participants gave presentations about the training, talking about the knowledge they obtained and what could be applied in the field in India.

■ Third Training in Japan

The third training in Japan was held from 6 to 23 November 2019. Task Team members, ToE, UKFD staff and the Chief secretary of Uttarakhand Government participated in the training in order to understand erosion control technologies, disaster management, the legal system for erosion control, and forest conservation in Japan. The lectures on basic knowledge of erosion control were held at the headquarters of the Forest Agency and Forest Research and Management Organization. Visits were also conducted to erosion control work sites in

the Oigawa area in Shizuoka Prefecture, the village of Totsukawa-mura in Nara Prefecture, the Kii-tanabe area in Wakayama Prefecture, and the city of Kobe in Hyogo Prefecture. In addition, Mr. Masaaki Sakurai who has been a lecturer at the Forestry Agency of Japan for many years was invited to be the lecturer on the design of erosion control works. On the last day of the training, all participants gave presentations about the training, talking about the knowledge they obtained and what could be applied in the field in India.

Preparation of the materials for technology transfer

The following materials were prepared for C/Ps for the transfer of technology related to the survey and construction of the erosion control works.

(a) Geological Characteristics of Slope Disaster in Uttarakhand

The relationship between the geological characteristics of disaster sites identified in Uttarakhand and disaster type was studied. In addition, a report was prepared that summarizes the points to be noted when conducting a geological survey for each slope disaster type and the points to be noted regarding the selection of countermeasures. An outline of each item in the report is as follows.

■ Geological and Geomorphological Setting of Uttarakhand State

The geological and topographical conditions of Uttarakhand were summarized based on the collected geological and topographical literature of northern India and Uttarakhand. Many photographs were used to promote the understanding of non-specialist readers, particularly in the explanation of geology.

■ Classification of Slope Failure and Geological Characteristics

The characteristics of the slope disasters that occurred in Uttarakhand were analyzed from a geological point of view utilizing the slope disaster data from within the jurisdiction of the UKFD, collected in the slope disaster mapping survey conducted in the Project, and the slope disaster database in the Char Dham Yatra corridor provided by the National Disaster Management Authority (NDMA) in Uttarakhand.

■ Points in the Field Survey for Slope Disaster

When taking measures in consideration of each disaster characteristic explained in the previous section, the points to be noted in the preliminary field survey and how to confirm and estimate the mechanism of disaster occurrence were explained.

■ Points in the Selection of Countermeasure Works According to Type of Slope Disaster

The type of slope disaster countermeasure work differs depending on the type of disaster. In addition, when selecting the work, it is necessary to select the type of work that is most effective and safest for local conditions. In this section, the basic idea and points of interest when selecting countermeasures are described. The target types of slope disaster here are slope failures, rockfalls, debris flows, and landslides.

(b) Guidelines from the Survey, Planning and Design of Forest Conservation Works in Uttarakhand

Guidelines from the survey and measurement to the planning and design of forest conservation works in Uttarakhand basically follow the Manual on the design of erosion control works (Version-0) that was formulated in the Project before. These guidelines have been prepared in particular for the ToE, Task Team members and the engineers of construction companies to gain a grasp of the conditions of mountain disasters in Uttarakhand and discuss the concepts and procedures for planning and designing surveys for forest conservation works (or erosion control works) and the types of work used for disaster recovery according to local conditions in Uttarakhand. For these purposes, each work process is described step by step for the ToE to be able to adequately understand the order of each work.

In addition, in the future, when engineers deal with many disasters in Uttarakhand, they may be involved in more complicated situations or sites that may not accord with the work procedures/orders shown in the guidelines due to the complications of various site conditions, the variety of disaster types, or the necessity of combining multiple types of works. Therefore, when using these guidelines, adequate modifications should always be considered, and while the fundamental concepts of the guidelines and Manual on the design of erosion control works should be followed, it is expected that the contents of the guidelines will be revised by engineers in India to be more practical.

These guidelines are divided into two types of works: stream work and hillside work. In the guidelines, stream work is divided into three chapters: I. Surveying of Stream Work. II. Plan and Design of Check Dam Work. III. Plan and Design of Channel Work. With regard to the section on hillside work, it consists of two chapters: IV. Surveying of Hillside Work. V. Plan and Design of Hillside Work. The guidelines can be divided into five chapters as a whole.

(c) Manual on Management of Drilling and Monitoring Survey for Landslide

Drilling and monitoring surveys for landslides were conducted at Baliyanala, where a landslide occurred in 2018. Since there are no model sites or candidate sites in the Project for which landslides are the target disaster, technology transfer on the surveys, including a drilling survey for landslides, has not been carried out. However, since landslides are one of the major disaster types to be dealt with by erosion control works, it was decided to prepare a manual on landslide surveys. This manual is written from the perspective of an engineer who manages the surveys and analyzes the results of the surveys, rather than the engineers who actually carry out these surveys.

This manual is divided into three chapters: a drilling survey in landslide areas, a landslide monitoring survey, and an evaluation method for slip surfaces.

■ Drilling survey for landslides

This chapter describes planning and management of the drilling survey, in-situ geotechnical testing using boreholes, and how to prepare an observation borehole for monitoring. In-situ geotechnical tests describe what is commonly applied in landslide surveys. Specific examples, figures, and photographs of each item are posted to promote the understanding of the readers.

■ Landslide monitoring survey

There are many landslide monitoring methods in Japan. Some of the equipment for these are difficult to obtain in India, but the monitoring survey methods that can be applied or are common in India are described. In particular, monitoring devices including the borehole inclinometers that are installed at Baliyanala are described in more detail.

■ Determination of the slip surface of a landslide

One of the main purposes of conducting a geotechnical investigation, including a drilling survey and a landslide monitoring survey, is to know the depth of the slip surface of the target landslide. The method of interpreting the results of the surveys for understanding the depth of a slip surface is described.

(d) Training Curriculum for Surveying Technology Related to Forest Conservation Work Using UAV, RTK Receivers and Total Station

Survey instruments for unmanned aerial vehicles (UAV) or drones, real time kinematic (RTK) receivers, and a total station have been introduced to the Project for transferring and improving surveying skills for forest conservation construction work in the Project. In the training, survey methods for forest conservation work and how to handle instruments introduced for engineers to be able to perform surveying work, such as making a drawing of a plan view and a vertical cross section for designing forest conservation construction structure works. At the same time, a training curriculum has

been prepared in order to conduct the training.

The instruments that were introduced, for which training on handling was conducted, are shown as follows:

1. Drone 1 set: Asteria Aerospace A200-GEO Unmanned Aerial System with Reach M2 multiband RTK / PPK GNSS Receiver, and Reach RS2 multiband RTK / PPK GNSS Receiver as the base station
2. RTK GNSS Receiver 2 units: Reach RS2 multiband RTK / PPK GNSS Receiver
3. Drone Photogrammetry Software (Global Mapper, Agi soft Metashape Professional Edition)
4. Total station (Sokkia, Model-IM52, Accuracy -1", Least count -2")

The survey training shall be conducted twice. The two trainings have the same basic content, although the number of trainees will be limited to about five to eight participants. Further, by conducting the training twice, the content of the second training is expected to more refined. Because of this, even without the presence of Short-term Experts after the second training, the training curriculum is expected to be conducted only by engineers on the Indian side, in order to increase the number of engineers who can handle the instruments as much as possible and perform erosion control measurements.

The trainees are project engineers (ToE) and Task Team members of the UKFD. The training sites were the Project office, where there was a lecture-style training, and the candidate site in Raipur, where there was a practical training using instruments.

3.2.3.4 Activity 2-4 Evaluate improvement of the staff's knowledge and skill sets

The first understanding test for the baseline survey was conducted on 3 June 2019. A total of 14 participants from the Task Teams and ToE took the test. The second understanding test was conducted on 22 November 2021. A total of 12 participants took the test. Based on the results of the second test, efforts were made to further improve C/P knowledge during OJT and Off-JT opportunities. The final understanding test was conducted on 12 January 2024. At the time of this report, the test results have not yet been analysed as of the end of January 2024. 10 participants from the ToE took the test. Test questions were emailed to the task teams that were unable to participate on the day of the test, but their responses were not submitted by the deadline, so the task teams were unable to evaluate the results of the third test.

The passing score for the test was at 40, a common passing score in India. All of the ToE and task teams scored 40 or higher on each of the last three tests. The figure on the right shows the average score for the ToE and the task team for each test session, with the average score for the ToE improving significantly as the test was taken. On the other hand, the average score of the second test for the task team improved slightly compared to the first test. This is mainly due to the fact that the task team was not able to take full advantage of

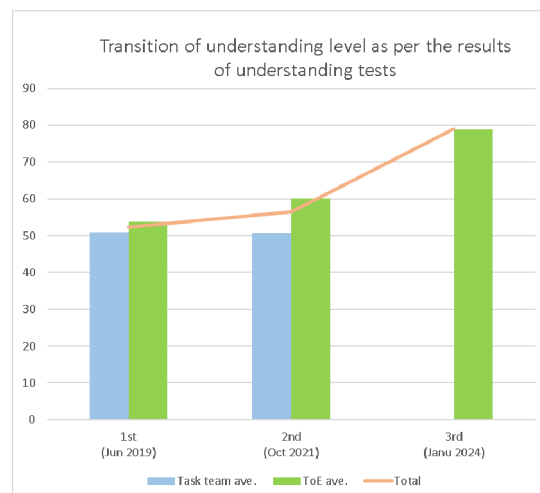


Figure 3.17 Transition of Test Results

the opportunity to improve their skills, since it was difficult for them to participate in the project after COVID-19 pandemic. The challenge is how the ToE, which has

increased its knowledge and capacity in erosion control through this project, will continue to contribute to the knowledge and capacity of the UKFD staff, including the task team.

3.2.4 Activity Related to Output 3

3.2.4.1 Activity 3-1 Prepare a plan for sharing of information on erosion control works

The issuance of a brochure to introduce erosion control works and regular updating of the Project's Facebook page were carried out from June 2018 onwards to share information regarding erosion control technology in and out of Uttarakhand. The brochures consist of eight topics related to erosion control and were prepared by a Long-term Expert. Short-term Experts provided technical advice for the preparation of these brochures. During this period, the brochures were compiled to make a booklet. The booklet was prepared in three languages — Hindi, English and Japanese — for better understanding of erosion control works among a larger number of stakeholders.

3.2.4.2 Activity 3-2 Organize seminars and workshops for stakeholders within Uttarakhand

Short-term Experts lent support to the operation and preparation of a workshop for stakeholders within Uttarakhand, which was held on 27 February 2019. Stakeholders concerned with disaster prevention in Uttarakhand were also invited to the workshop. Experts were invited from Japan to give presentations on the following topics on erosion control technology, which took place after a briefing about the UFRMP by Ms. Neethu Lakshmi, Deputy Project Director, UFRMP.

- Available erosion control technology in India (by Mr. Asano, Forest Research and Management Organization, Japan)
- Technology on forestry and erosion control in Japan (by Mr. Goseki, Forestry Agency, Japan)
- Important points in the implementation of erosion control construction (by Mr. Miura, Forestry Agency, Japan)
- Capacity development on highway construction in mountainous areas and early warning systems (by Mr. Moriyama and Mr. Kitagawa, JICA Experts)

Several queries regarding the possibility of adapting the technology to India came from participants. Each Task Team leader and ToE gave presentations on the use of knowledge and technology acquired through training in Japan in 2018, so as to share the output of the training with the participants. After the presentations, Mr. Goseki, Mr. Anup Malik (UFRMP), Mr. S K Birla (PWD) and Mr. Kitaura (the Project) held a panel discussion, which was facilitated by Mr. Asano.

3.2.4.3 Activity 3-3 Organize seminars and workshops for stakeholders in other Himalayan states in collaboration with Ministry of Environment, Forests and Climate Change

The workshop on erosion control works on hillsides regarding construction control and safety management was to be held on 16-17 March 2020. Short-term Experts were to support Long-term Experts in organizing the workshop and preparing the material for the same. However, the workshop was not conducted and was postponed due to COVID-19.

A two-day technical workshop held on 15-16 December 2023, with Short-term Experts providing administrative support on the day of the workshop. The participants were widely welcomed by engineers involved in disaster management in Uttarakhand. Emphasis was placed on sharing the technical challenges of implementing erosion control works, relevant to

the stakeholders of various agencies in Uttarakhand. On the first day, an indoor session was held with presentations by the ToE and Long-term Experts on the concept and application of erosion control works, safety considerations, and project deliverables. On the second day, field visits were made to Nirgad, one of the model sites, and Raipur, one of the candidate sites, to provide briefs on the local application of the erosion control technology. During the visits especially, site conditions and countermeasures were explained and more active discussions were held; further, for the project members, the results of the Project so far were presented and feedback was obtained.

A National Seminar was then held on 1-2 February 2024 to present Eco-DRR mountain control measures (the results of project activities). In addition to the three Himalayan states, the Seminar also invited officials from the Western Ghats area and northeast states. Invitation requests were made to each State Secretary in charge of JICA's forest project implementation states and disaster departments in these states. A summary of the questionnaires distributed after the seminar showed that attendees were very satisfied and made many positive comments, while others commented on budgetary issues and that they would not be able to judge whether this technology had been applied until the model and candidate sites had been completed.

A National Workshop, organised by the UFRMP and JICA, was held on 11-13 April 2018. Members of the Project supported the preparation of the workshop and undertook public relations, as described below.

1. Preparation and exhibition of the model: Countermeasure works (hillside and torrent works) for erosion control (prepared mainly by the UFRMP and ToE)
2. Preparation of video: An introduction of the Project's activities has been prepared in a video clip. It was introduced in the workshop (prepared by the UFRMP). The video is available on the Facebook page of the UFRMP.
3. Pamphlet and other materials: A pamphlet, collage, and other materials were introduced along with the model. Training materials and newsletters were distributed to the participants (prepared by long-term experts).

3.2.4.4 Activity 3-4 Prepare policy recommendations for mainstreaming erosion control works for slope disaster management into forest and other key development sectors

The draft basic policy recommendations for mainstreaming erosion control works for slope disaster management into the forest and other key development sectors were prepared in January 2022 and discussed within the Project from May to June 2023. The final consultation was held with the C/P in March 2024 and the following policy recommendations were prepared as the basis for the policy recommendations

- 1) Continue the work on a small scale or in a direct-managed way
- 2) Develop skills for technical staff and other related organizations
- 3) Utilize the Project's outputs
- 4) Strengthen collaboration with related organizations
- 5) Promote awareness among local society

3.2.4.5 Activity 3-5 Set up a policy-level council in UKFD and other related organizations for erosion control works

No specific work has been done by the Short-term Experts with respect to this activity.

3.2.4.6 Activity 3-6 Organize periodic meeting of policy-level council for erosion control works

No specific work has been done by the Short-term Experts with respect to this activity.

3.2.4.7 Activity 3-7 Study the status of sharing of information

No specific work has been done by the Short-term Experts with respect to this activity.

3.2.5 Activity Related to Output 4

3.2.5.1 Activity 4-1 Identify and prioritize candidate sites for erosion control works under UFRMP based on 1.1.

This activity was scheduled after the completion of Activity 1-1. However, the UFRMP has decided to move up the schedule, as the three model sites were scheduled to be constructed by 2022. The UFRMP requested that each DFO submit candidate sites. The surveys of the candidate sites were undertaken by ToE. Japanese experts accordingly accompanied ToE members for the surveys and supported their work on the selection of the candidate sites.

The ToE and the JET members carried out the surveys at fourteen (14) sites as follows. The Project has recommended one site in the Chakrata DFO as a candidate site to construct the erosion control works under the UFRMP. Recommendations were made considering the points below:

- Site in which the knowledge and technology at the model sites can be diverted or applied.
- Assumed budget and construction period is within the schedule of the UFRMP
- Benefits and effects of the countermeasure can be expected.
- Disaster area will not expand during or after the implementation of countermeasure works due to heavy rainfall (the surroundings are stable)

In the past, Jokla, Company Garden, Malla, and Lakhanpur were initially selected as candidate sites in this activity, but Company Garden was eliminated as a target site due to a lack of agreement with the landowner. Raipur was selected as an alternative site.

Table 3.15 Erosion Control Candidate Sites

DFO office	Site	Type of Disaster
Chakrata	Jokla	Debris flow
Dehradun	Raipur	Debris flow
Uttarkashi	Malla	Slope failure + debris flow
Pithoragarh	Lakhanpur	Slope failure + debris flow

3.2.5.2 Activity 4-2 Enhance capacity of engineers through Off-JT and OJT in model sites

Technology transfer and enhancement of the capacity of the ToE was planned and implemented remotely through the following activities. Not only model site activities, but other activities related to technology transfer for candidate sites are also described.

- Construction supervision for model site;
- Documents submitted by the contractor for model sites included the construction plan, temporary road construction plan, result of the start-up survey, material approval application, drawing approval application, and health and safety management review;

- Inspection for each stage of progress in model site construction;
- Site survey, site investigation, and detailed design for candidate sites;
- General construction supervision of candidate site construction;
- Site survey, site investigation, and basic design for the Baliyanala site.

3.2.5.3 Activity 4-3 Provide support for field surveys, designs and supervision of erosion control works in candidate sites under UFRMP

【Support for Survey and Design】

(a) Jokla (Chakrata District)

Collapsed slopes are in the upper stream, which has a width of about 1500 m and a height difference of about 500 m. The collapsed slope flows into the lower stream and accumulates. In order to stabilize the accumulated debris, hillside works, 12 check dams and channel work (about 400 m long) were designed and will be constructed in the upper stream of the collapsed slope.

Basic design was completed in March 2020, when the Short-term Experts were in India. In June 2020, the ToE restarted its activity with remote instructions from the Short-term Experts and placed an order for a site survey with the local surveying company. As a result, the cross-section design was completed in September 2020. In October 2020, the ToE started designing the 12 check dams with instructions from the Short-term Experts.

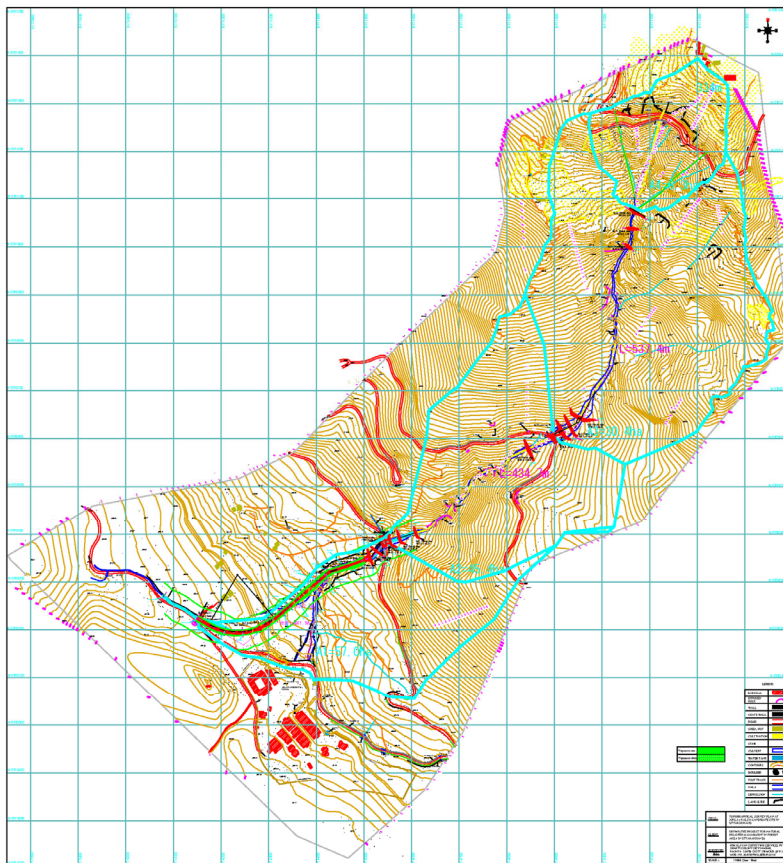


Figure 3.18 Plan View of the Site in Jokla
(Countermeasure work: hillside work in the upper area, 12 check dams in the stream, 400 m of channel work)

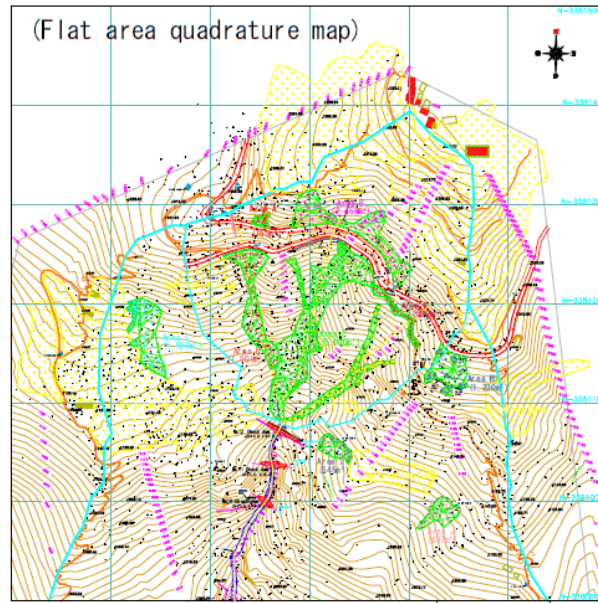


Figure 3.19 Plan View of the Upper Slope
(Countermeasure work: Steel wire netting work, hydroseeding work, total area 21,575 m²)

(b) Malla (Uttarkashi District)

The target area in Malla faces NH 34 along the Bhagirathi River. There is a sloped section in the catchment area where debris flow often occurs from the stream during the rainy season, adversely affecting traffic on the NH. Countermeasure works have not been carried out in this area.

The ToE conducted field reconnaissance to investigate site deformation and identify dangerous points. Deformed parts were identified and the mechanism of the occurrence of disaster was estimated through an online meeting with Short-term experts based on the ToE survey results.

Based on the geological map and the site deformation situation of the previous period, the countermeasure work plan was examined. The plan described four areas based on the site situation, and basic measures for each area were determined. These countermeasure plans were discussed and decided upon during the web conference and implemented by the ToE. In response to the countermeasure plans for each area requiring urgent construction orders, a basic design for countermeasures for the slope was prepared and, based on this result, quantities were calculated and used for estimating costs for orders.

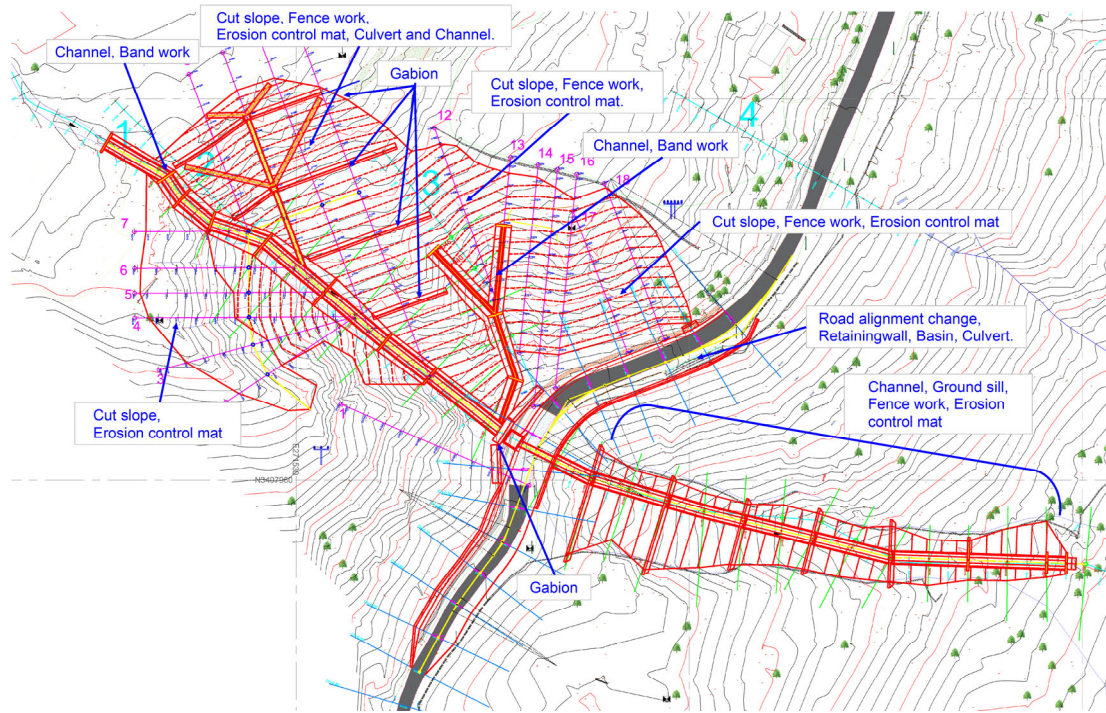


Figure 3.20 Arrangement Plan of Countermeasure Works on the Slope in Malla

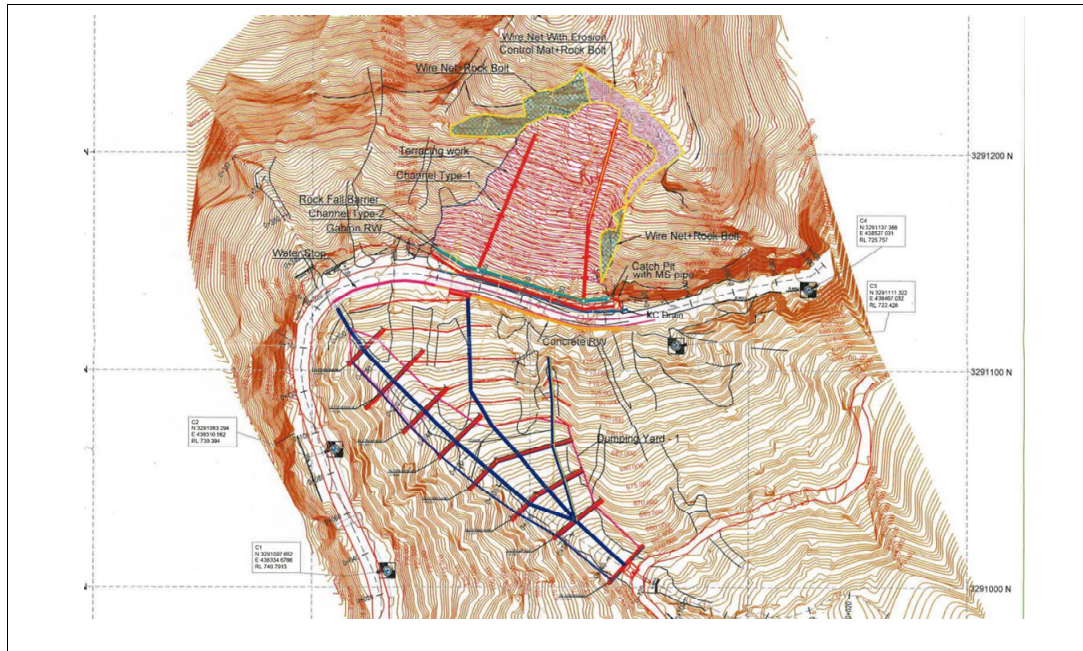
This countermeasure works includes the repair of the border road that crosses the target slope. The road will be renovated to the standards of the NH, under instructions by the Border Roads Organization (BRO), which manages the road. This means the road needs to be widened and, therefore, road alignment needs to be changed as well. The ToE is in charge of the new road design and is in the process of implementing it. Based on the road design, it is necessary to adjust both the canal on the mountain side of the road and the canal on the slope on the valley side of the road.

(c) Lakhanpur (Pithoragarh District)

Lakhanpur is located along the Nepalese border, which is the farthest from Dehradun of the model sites (three sites) and candidate sites (four sites).

A preliminary survey was conducted once in 2018 for the collapsed slope that occurred in Lakhanpur. In response to the site being selected as a candidate site for erosion control work construction, the ToE and Japanese experts conducted a field survey in October 2021 and prepared a basic policy of countermeasures works.

The following is a plan for countermeasure works prepared by the ToE with the assistance of the Japanese experts. The study was conducted to determine the availability of rockfall prevention nets in India.



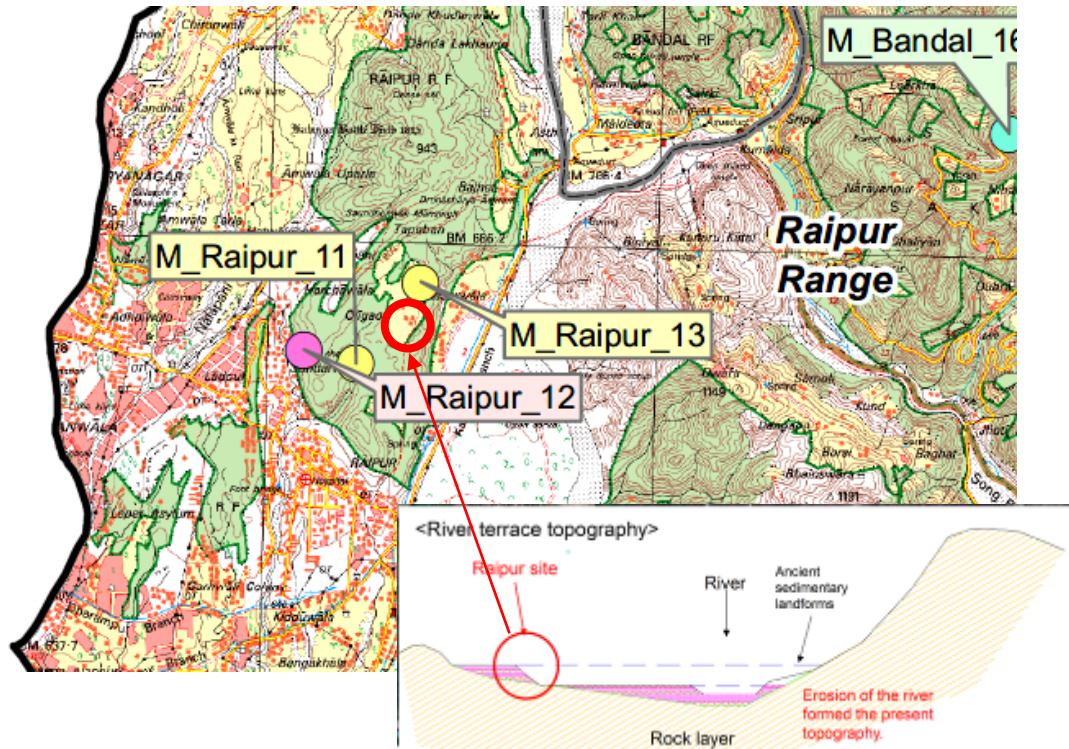


Figure 3.22 Topography Outline of Raipur

Streams flowing down the terrace cliffs are meandering and stream bank collapses are frequent due to erosion of the stream banks on the undercut slopes. Collapsed soil masses are flowing down the stream and causing damage to downstream houses and cultivated land.

The countermeasure plan based on the field survey is as follows:

- Fixing of unstable soil masses deposited on the stream bed: Check dam, ground sill;
- To reduce erosion by easing the gradient of the stream bed: Check dam, ground sill;
- Prevention of streambank erosion: Revetment;
- Fixing the water way at the end of a stream: Channel works; and
- Stabilization of collapsed slopes: Cutting slope and erosion control mat.

Based on this policy, the basic design was carried out under the leadership of the ToE and detailed design and the preparation of bidding documents for the order were carried out.

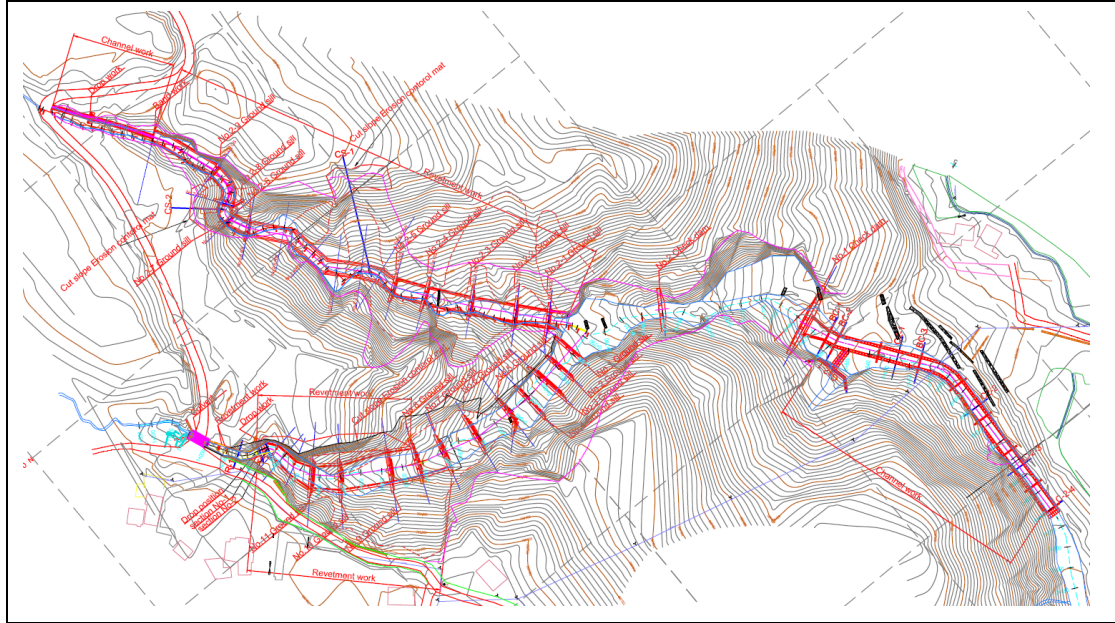


Figure 3.23 Plan of Countermeasure Works in Raipur Area (Basic Design)

The following countermeasure works were designed:

- Valley stanchions: Fixing of unstable soil in the stream bed, fixing of the foot of the mountain (2 units);
- Bedding works: Fixing of unstable soil on the stream bed (20 units);
- Channel works and revetment works: Fixing the flow channel and preventing erosion at the foot of the mountain (3 units);
- Hillside construction: Stabilization of previously collapsed slopes and restoration of vegetation (3 units); and
- Ancillary works: Roadway connection (1 set).

Experience with the model site and candidate site (Malla and Jokla) design work that has been carried out to date has been utilized and a steady increase in capacity has been confirmed, with work being executed under the leadership of the ToE. The Short-term Experts conducted workshops for the ToE from 4-18 March 2024 to explain and provide guidance on design changes and construction management considerations at the four Candidate Sites

【Support for Bidding】

As a result of publicly announcing four sites (Jokla, Malla, Lakhanpur, and Raipur) as one-lot bids, three bidders responded. A bid evaluation committee was set up on 17 November 2022 and bid opening held on 18 November 2022, with a technical bid evaluation meeting held on 19 November. Since it was determined that there were no problems, price bidding was opened on 21 November. Hindustan Builders & Developers was the successful bidder (first negotiating party).

Hindustan Builders & Developers proposed a construction period in excess of that specified in the RFP, but after contract negotiations, the UFRMP accepted the company's proposal. Accordingly, the contracted construction period is 30 months for Jokla, 24 months for Malla, 27 months for Lakhanpur, and 24 months for Raipur.

The JET provided assistance especially technical evaluation stage in the bidding process, as the ToE took the lead in conducting the bidding process.

【Support for supervision of the construction】

(a) Malla

A start-up survey is currently being carried out and the work will commence after design verification. Detailed design of the overburden disposal area is also being carried out at the same time.

(b) Jokla

Design modifications based on the start-up survey and revised design due to changes in conditions caused by heavy rainfall during the rainy season have been carried out, while two check dams are under construction, with quality management by the ToE. The clearance of 13 trees on the section between Check dam No. 1 and No. 5 has been done. Excavation work for Check dam No. 4 is being conducted. For the three dams upstream from Check dam No. 9, the ToE decided to change the design to a wet masonry dam from the reinforced concrete because the dams are 120 m away from the road and concrete cannot be pumped. Layout diagrams were prepared by a Short-term Expert. Delays in permit applications for clearance of other trees have caused construction delays. The current work areas are shown in the drawing below.

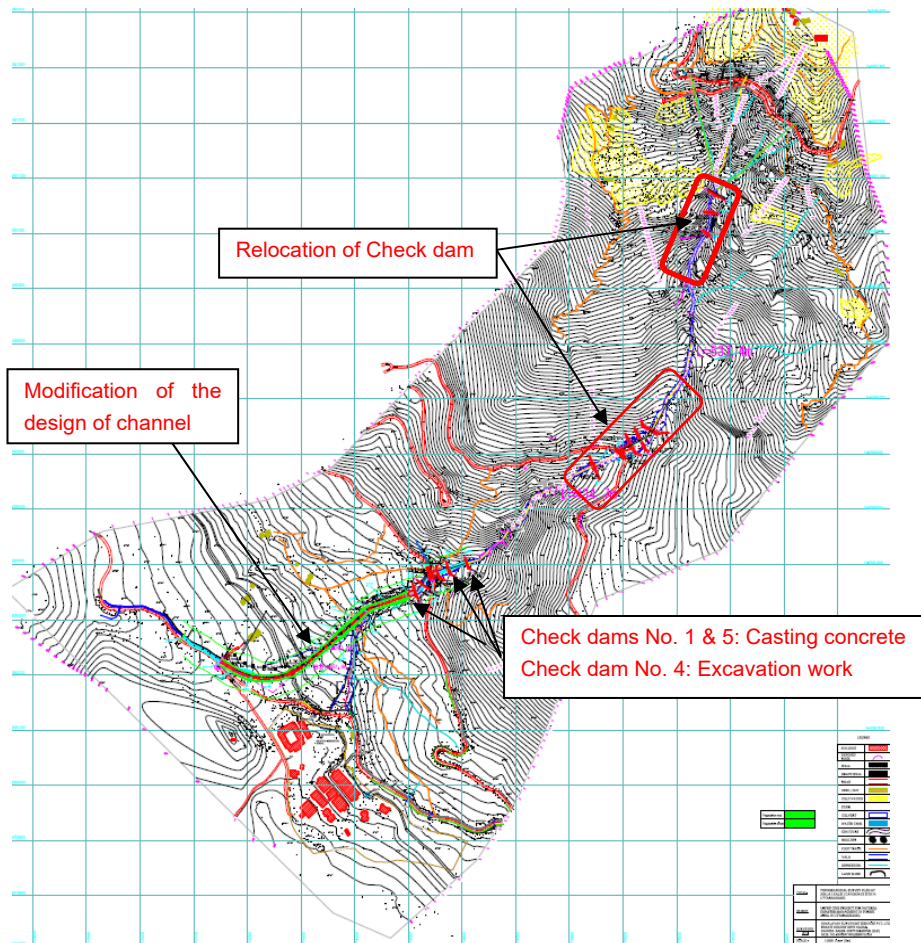


Figure 3.24 Construction Work in Jokla

(c) Lakhanpur

Road widening was carried out within the target area (without notification or consultation with the UFRMP), which significantly changed the slope conditions. This has necessitated a

design review, which is currently underway. In addition, concrete placement work has begun on the road retaining wall, for which the design has been completed. Although this site is remote from Dehradun, Short-term Experts provided guidance on the importance of quality control, since the construction work is primarily concrete work. A soil dumping site has been selected, but the decision has been postponed.

(d) Raipur

By mid-May 2023, the ToE and the JET were working together to complete most of the implementation design. At the same time, design instructions were provided to the ToE. Construction progress has been slow due to the limited number of areas in which there can be construction, which is a result of the significant delay in the procedures for cutting trees and restrictions on work during the rainy season. The current work areas are shown in the following diagram.

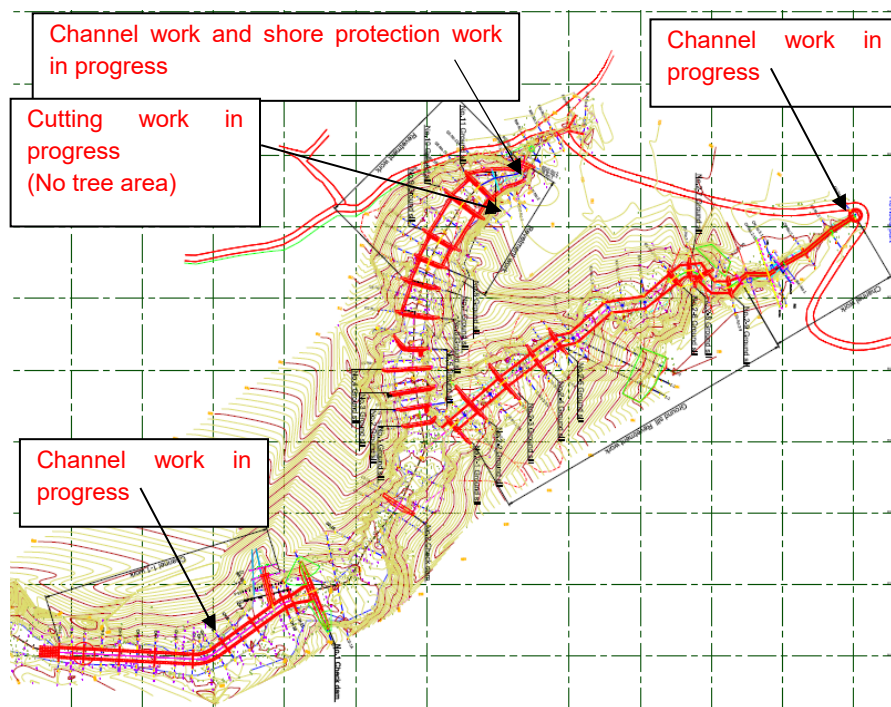


Figure 3.25 Construction Conditions in Raipur

【Summary of the work at the four candidate sites】

The contract was completed and construction was originally scheduled to start. However, work could not start due to incomplete implementation design at some sites, restrictions on the felling of standing trees and significant delays in felling procedures, the departure of three members of the ToE who had gained knowledge through previous instruction, and inadequate management from ToE personnel and the Task Teams/UFRMP. Under these conditions, the contractor, Hindustan Builders & Developers, also found it difficult to carry out work under a proper process plan, and the company submitted a request to the UFRMP to improve the situation. Meanwhile, all of the sites continue to be re-surveyed, with the submission of some start-up survey deliverables that do not match the current situation.

The stance of the JET is that the contract for these four sites is solely a ToE-led contract and, unlike the JET-led model sites, the intention here is for the JET to work at the support level. However, there were concerns that if this situation continued, the work would not progress at all, leading to contractual problems with the contractor. Further, despite repeated

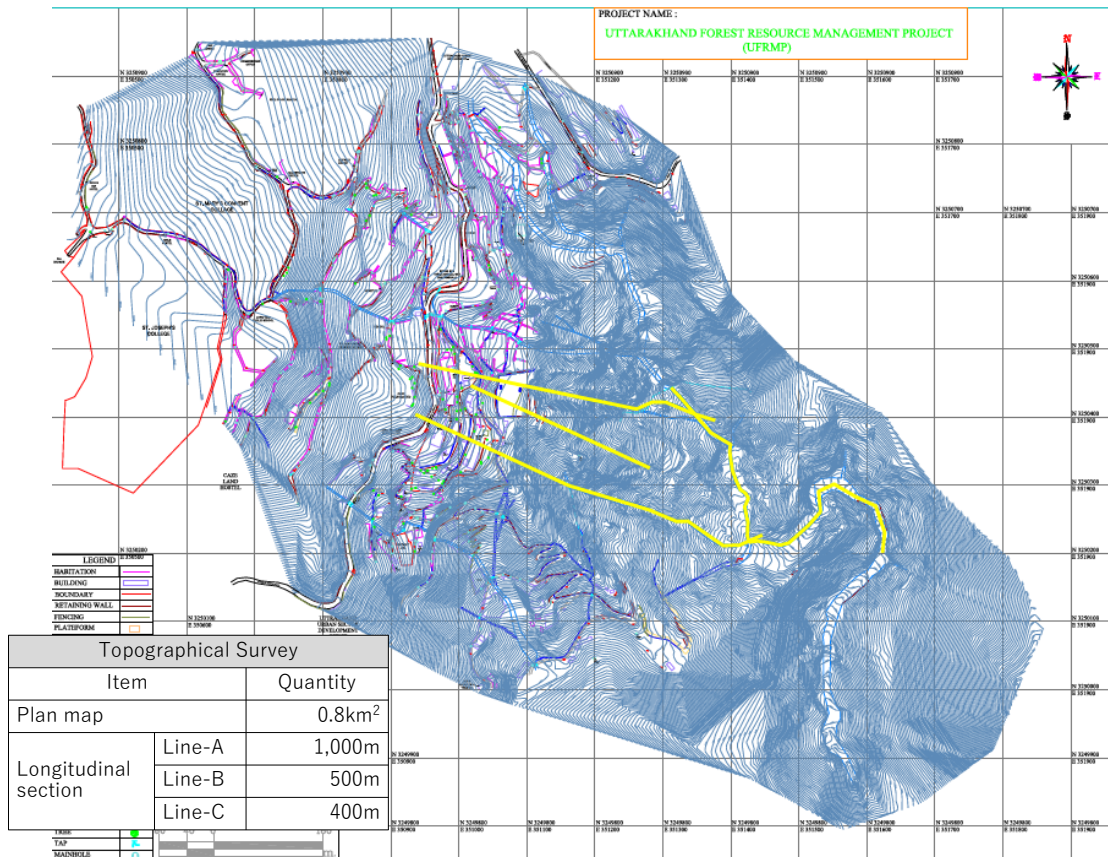
attempts to provide instructions to ToE management personnel, no improvement was expected. Design instructions were also provided to the new contact person.

Another reason for the delay in progress is the low capacity of Indian surveying firms and the fact that the contractor does not verify the survey results, forcing a review of the design. Improvement in this case has also been guided to the ToE as Short-term Experts. There is an urgent need to secure a quality surveying firm that will continue to be utilized in the future.

3.2.5.4 Activity 4-4 Support for the field surveys and designs and supervisions of countermeasure works at the landslide site in Baliyanala, Nainital District, which collapsed in September 2018.

According to the revision of the R/D, it was decided that technical assistance for a site survey, design and supervision in the Baliyanala area, where a large collapse occurred in September 2018, would be included in the Project. The Japanese experts supported the UFRMP in site investigation and in drafting countermeasure plans, since the UFRMP requested support from the Project. Technical assistance for the collapse in Baliyanala was discussed at the third JCC meeting, which was conducted in February 2019, and the same was agreed upon.

A drilling survey and site investigation was conducted by the UFRMP for countermeasure works at Baliyanala. The content of the survey is as follows.



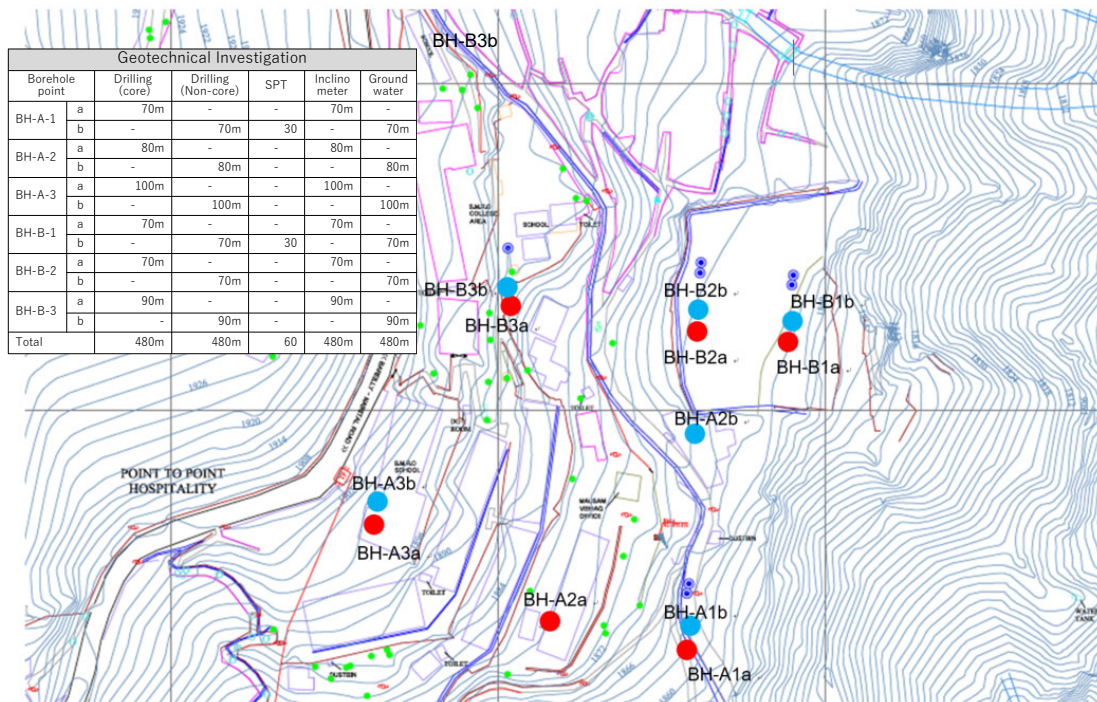


Figure 3.26 Plan of Topographical and Drilling Survey

A topographical survey, boring survey, monitoring survey of the groundwater level and inclinometer observations were conducted in Baliyanala in 2019. Three proposed plans for countermeasure works were submitted through the UFRMP to the Baliyanala High Power Committee (HPC).

Technical assistance was given to the ToE for the implementation of a detailed geological survey using plain view, cross-section view, geotechnical analysis for countermeasure work designs, and countermeasure work design, since the HPC requested geological evidence and pointed out the lack of a comparison study of the three plans. Based on the result for a geological survey under instruction of the Japanese experts, which was conducted 24-27 December 2019, soil geological contents, including soil parameters, stability analysis and collapse mechanism, were considered. In addition, revisions to the three plans for countermeasure works and technical assistance for the lower reaches design, not related to the aforementioned three plans, were assessed. The revised plans were submitted through the UFRMP to the HPC on 12 March 2020. The HPC then met in July 2020 and decided on Plan 1 of the three countermeasure plans.

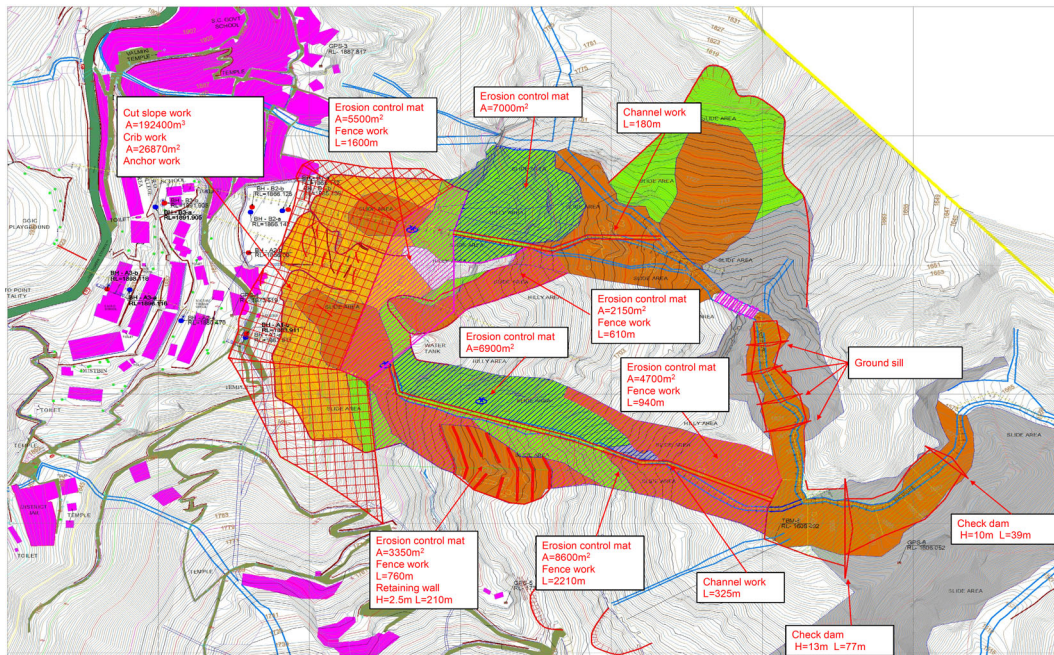


Figure 3.27 Comparison Study for Three Plans (Above) and the Selected Countermeasure Plan for Baliyanala (Below)

Through the UFRMP, the HPC requested that the JET prepare a Detailed Project Report (DPR) for slope disaster countermeasure works selected in the committee. However, due to the impacts of the COVID-19 pandemic, the JET was unable to travel to India for a long time. Under these circumstances, the HPC decided to procure an Indian consultant company to prepare the DPR for countermeasures. The HPC issued an expression of interest (EOI) to several companies and then sent an RFP to five short-listed companies to procure as consultants for the work. The deadline for the proposal was September 2021. In November, the HPC reported that GENSTRU Consultants was selected. The DPR of the countermeasure works in Baliyanala will be prepared by GENSTRU Consultants and the UFRMP will provide the firm with the geological survey results, monitoring results, and basic design of the countermeasures. The Chief Project Director of the UFRMP has communicated that the Project does not need to be further involved in Baliyanala slope disaster countermeasures.

The geological survey report and basic design materials for countermeasures for the Baliyanala slope disaster have already been prepared by the Short-term Experts. The landslide monitoring has been conducted regularly by the ToE and Task Team, and a report summarizing the monitoring data so far was prepared, including the data obtained, with January 2022 as the final measurement date.

In March 2022, the Short-term Experts submitted to the ToE a geological investigation report and basic design documents, a landslide monitoring results report, and monitoring data in the Baliyanala slope disaster.

The following is a summary of activities related to the Baliyanala slope disaster. Since the JET was not involved in these activities, the information is based on the reports of the Indian side.

- | | |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6 May 2022 | At the HPC meeting, the UFRMP submitted the geotechnical investigation reports, monitoring reports, and basic design documents prepared to date. These materials will be handed over to the Irrigation Bureau. The monitoring and measurement instruments are currently being kept at the UFRMP office, since the Irrigation Bureau declined to receive them. |
| 31 May 2022 | The consultancy firm hired by the state of Uttarakhand, GENSTRU Consultants, has submitted a proposal to address the Baliyanala slope |

disaster.

- Mid-July 2022 At the HPC meeting, GENSTRU Consultants submitted a DPR. Discussions were held within the HPC in response to the DPR.
- 5 August 2022 The DPR was discussed again at the HPC meeting, and the content and suggestions of the discussion were incorporated into the slope disaster countermeasure plan.

3.3 Record of Training (Field, Period, Number of Participants, Outline)

The following is a list of the trainings conducted for the Project. This list of trainings does not include courses conducted during OJT or study sessions for a short period of time such as less than half a day.

Table 3.16 Main Technical Training Conducted in the Project

Field of Training	Period	Attendant	Summary of Training
Creation and updating of slope disaster location maps	22 January 2019	15	<ul style="list-style-type: none"> Utilization of paid GIS software for creation and updating of slope disaster location maps
	13 to 16 February 2023	21	<ul style="list-style-type: none"> Utilization of free GIS software for creation and updating of slope disaster location maps Extraction method for slope hazard area
Basic knowledge of erosion control works	22 to 29 October 2018	13	<ul style="list-style-type: none"> Design of erosion control works Introduction to erosion control works in Japan Work safety countermeasures
Survey and design of erosion control works	6 and 7 October 2020	All ToE, Task Team members	<p>Online training</p> <ul style="list-style-type: none"> Procedure of design, cost estimation, supervision of the works, practice of survey and design
Invitation to Japan for high level officials	4 to 14 September 2017	5	<ul style="list-style-type: none"> Disaster management of forest area in Japan Site tour of erosion control works in Japan
First Training in Japan (Short program)	25 October to 9 November 2017	6	<ul style="list-style-type: none"> Basic knowledge of erosion control and conditions in Japan Site tour of erosion control work construction
First Training in Japan (Full program)	25 October to 22 November 2017	5	<ul style="list-style-type: none"> Basic knowledge of erosion control and conditions in Japan Site tour of erosion control work construction Practical training on supervising works
Second Training in Japan	12 to 22 November 2018	11	<ul style="list-style-type: none"> Legal system for erosion control Basic knowledge of erosion control works Site tour of erosion control works under and after construction.
Third Training in Japan	6 to 23 November 2019	10	<ul style="list-style-type: none"> Legal system for erosion control Basic knowledge of erosion control

			<ul style="list-style-type: none"> • Site tour of erosion control work under and after construction. • Practical training on design
Survey training using UAV (1)	4 to 11 January 2022 (6 days)	7	Basic knowledge of surveying UAV and survey equipment
Survey training using UAV (2)	18 to 23 April 2022 (6 days)	6	Practical training on operation of UAV Data analysis of survey data Contour map and cross section diagram

4 Inputs

4.1 Inputs from Japanese Side

4.1.1 Dispatch of Experts (Name, Field, Period, Outline)

The following shows the Japanese experts engaged in the Project.

Table 4.1 List of Japanese Experts

Expert Type	Duties/Assignment	Expert	Period
Long-term Experts	Chief Advisor/ Erosion control works planning	Shingo Kitaura	from July 2017 to March 2020
		Yasuo Iijima	from March 2020 to March 2024
	Coordinator/ Erosion control training	Saori Miyajima	from July 2017 to May 2019
		Atsuko Godo	from May 2019 to March 2024
Short-term Experts	Team leader/ Erosion control works design and cost estimation 1	Fumihiko Yoko	from July 2017 to March 2019
	Team leader/ Erosion control works design and cost estimation 1	Tomoyuki Ueda	from March 2019 to July 2022
	Team leader	Satoshi Ishida	from July 2022 to March 2024
	Deputy team leader/ Erosion control works design and cost estimation 2	Hideo Sato	from April 2019 to March 2024
	Deputy team leader/ Erosion control works investigation	Takashi Hara	from July 2017 to March 2024
	Construction management of erosion control works/ Procurement and contract	Tomoyuki Ueda	from July 2017 to November 2018
		Satoshi Ishida	from November 2018 to March 2024
Construction management of erosion control works/ Monitoring	Hotaka Aoki	from July 2017 to March 2024	

	Erosion control works investigation/ Design 2		
	Erosion control works investigation/ Design 3	Kei Kishimoto	from December 2019 to March 2024
	Erosion control works investigation/ Design 4	Keiji Someya	from December 2019 to March 2024
	Construction management of erosion control works	Kentaro Seya	from July 2022 to March 2024
	Training supervision	Makoto Tokuda	from July 2017 to July 2018
		Yumika Yoshinaga	from July 2018 to May 2021
		Miwako Araki	from May 2021 to March 2024

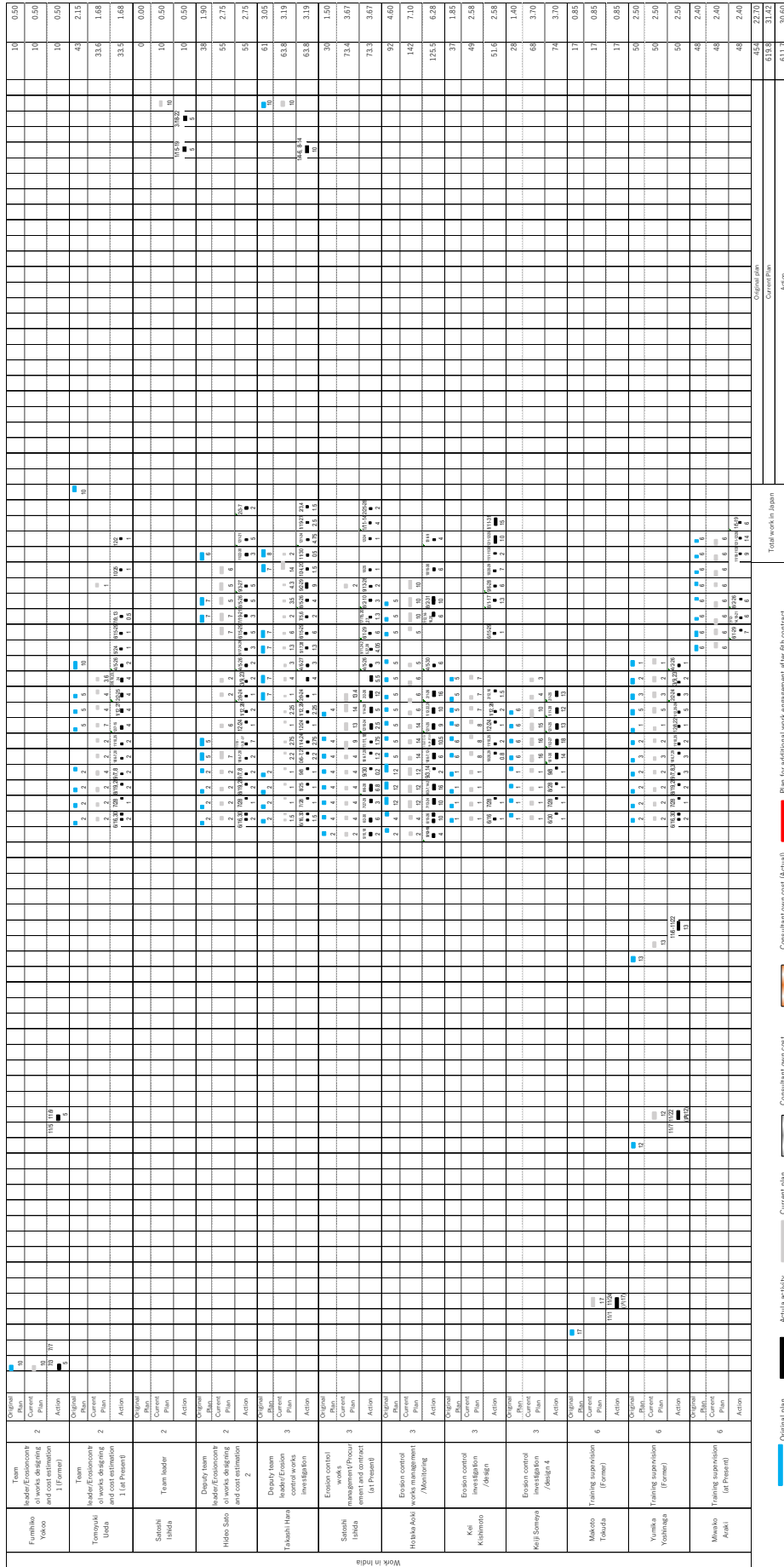


Figure 4.1 Short-term Experts Assignment Schedule: Plan and Action (3 / 3)

4.1.2 Procurement of Equipment to Be Taken

The following table shows the procurement of equipment to be taken.

Table 4.2 List of Procured Equipment to Be Taken

No	Equipment	Use	Quantity (Unit)	Achieved Quantity (Units)	Date of Procurement
1	Laser range finders	Simple measurement survey (distance confirmation)	3	3	July 2017
2	Pocket compass	Simple measurement survey	3	3	July 2017
3	Laptop	Analysis of CAD, GIS and data management	1	1	August 2017
4	Soil hardness meter	Site survey	3	3	September 2017
5	Soil moisture meter	Site survey	3	3	September 2017
6	GPS	Location confirmation	3	3	October 2017
7	Rain gauge (with alarm)	Collection of rainfall data, safety measures during construction	3	2 1	December 2017 August 2018
8	Soil strength test stick	Site survey	1	2 1	December 2017 August 2018
9	GIS software	Digitization of landslide location map and measurements, database	1	1	August 2018
10	CAD software	Designing and drawing	3	3	December 2017
11	Drone	Site Survey	1	1	November 2022
12	Total Station	Site Survey	1	1	November 2022
13	Base for drone	Site Survey	3	2	December 2021
14	Software for drone	Site Survey	1	2	January 2022

4.2 Inputs from Indian side

In order to ensure effective and smooth implementation, the Project made requests for offices, equipment, and land at model sites as shown in tables below. The current status of the provision from the UKFD for expediciencies is as indicated below.

4.2.1 Project Offices and Equipment

The inputs from the UKFD for the Project office and equipment are as follows.

Table 4.3 Project Offices and Equipment Provided by the UKFD

Request	Achievement	Remarks
Project office and required equipment at UKFD headquarters	Provided	Already provided.
Project offices and required equipment at DFOs where model sites are located	Provided	Already provided
Land for forest conservation operations at model sites	Provided	Prior to construction at model sites, land possession and utilization permissions have been provided.

4.2.2 Human Resources

The inputs from the UKFD for human resources are as follows.

Table 4.4 Human Resources Provided by the UKFD

Request	Achievement	Remarks
Project Director	Assigned	Dr. Vijay Kumar (2023.6.19~) Mr. Anup Malik (~2023.6)
Vice Project Director	Assigned	Dr. Koko Rose (2022.10~2024.03.12) Mr. B.P. Martolia (2022.7~2022.10) Mr. Amit Kanwar (2021.12~2022.7) Ms. Neethu Lakshmi (2017.7~2020.12)
Three Task Teams	Assigned	1) Task Team 1 (Nirgad) Mr. Mahipal Singh Sirohi (Team Leader) (2022.1~), successor to Mr. Dharm Singh Meena Mr. Rohit Srivastava (DRO) Mr. Babu Singh (Forester) Mr. Rakesh Kumar (Forest Guard 2) 2) Task Team 2 (Jawadi) Mr. Mahipal Singh Sirohi (Team Leader) Mr. Subhash Chandra Nautiyal (FRO) Mr. Ganesh Bahuguna (Forester) Mr. Prakash Singh Kandari (Forest Guard 3) 3) Task Team 3 (Padli) Mr. Umesh Joshi (Team Leader) Mr. Mahesh Chandra Joshi (DRO) Mr. Kundan Singh Bisht (Forester) Mr. Kishore Chandra (Forest Guard)
Staff DFO office where model sites are located	Assigned	Since the Task Team members are DFO office staff at their respective model sites, the Task Teams will also serve as the relevant staff.
Team of Engineers	Assigned	Mr. Jay Kumar Sharma (Chief Engineer) (2017.9~) Mr. Jagraj Singh Mehra (Construction

		Planning/ Cost/ Procurement Engineer) (2017.9~) Mr. Prem Singh Negi (Field Engineer) (2017.9~2023.4) Mr. Vinod Jhinkwan (Field Engineer) (2017.8 ~2019.6) Mr. Kuldeep Singh Pundir (Field Engineer) 2018.7~) Mr. Tribhuvan Singh Rana (Field Engineer) (2018.7~2023.6) Mr. Aman Raizada (Construction Planning/ Cost/ Procurement Engineer) (2019.1~) Mr. Deepak Bhatt (CAD/ Survey Engineer) (2019.1~2023.4) Mr. Sandeep Singh (Assistant Site Engineer) (2020.8~) Mr. Abhishek Panwar (Assistant Engineer) (2019.9~) Mr. Vipin Chandra Benjwar (Assistant Site Engineer) (2022.11~2023.2) Mr. Himanshu Maithani (Assistant Site Engineer) (2023.1~) Mr. Praffull Lingwal (Assistant Site Engineer) (2023.6~) Mr. Gaurav Joshi (Assistant Site Engineer) (2023.6~) Mr. Anish Kumar (Assistant Site Engineer) (2023.5~) Mr. Vikash Singh (Assistant Site Engineer) (2024.2~)
Project support staff (administrators, secretaries, drivers)	Assigned	Ms. Anita Panwar (2017.4~2018.12) Ms. Amita Sharma (2017.11~2020.3.31) Ms. Neetu (typist) (2022.4~)

4.2.3 Other

The inputs from the UKFD for the budget of the Project are as follows.

Table 4.5 Budget of Project Provided by UKFD

Request	Achievement	Remarks
Construction costs for forest conservation operations at model sites (Project operation costs)	Provided	Estimated contract price was agreed upon by the contractor on 12 December, 2019.
Project implementation and administrative costs by UKFD	Provided	At present, there are no issues. May be reviewed for future needs.
Travel expense of C/Ps (Travel allowance / accommodation costs)	Provided	At present, there are no issues. May be reviewed for future needs.
Consumption costs	Provided	At present, there are no issues. May be reviewed for future needs.
Communication costs	Provided	At present, there are no issues. May be reviewed for future needs.

Utility costs	Provided	At present, there are no issues. May be reviewed for future needs.
Fuel costs for project vehicles	Provided	At present, there are no issues. May be reviewed for future needs.
Maintenance costs for Project vehicles	Provided	At present, there are no issues. May be reviewed for future needs.

5 Ingenuities and Lessons Learned in Project Implementation

5.1 General Project Matters

(1) Implementation structure of the Project

Task Team members, consisting of staff from the UKFD, the target organization for technology transfer were assigned as the C/Ps of the Project. However, since UKFD staff members are not specialists in civil engineering fields such as erosion control, it was anticipated that it would take time for the transferred technology to be understood and disseminated. In order to support the activities of the UKFD staff assigned to the Task Teams, a ToE was established, consisting of engineers with civil engineering skills in the field of erosion control hired for the Project, and a project implementation structure was designed around the Task Teams, ToE, and the JET. The ToE was expected to serve as a liaison between the JET and the Task Teams and to provide technical support to the Task Teams through the activities of the Project.

The Task Team members, who are the main targets for technology transfer, are assigned from the District Forest Officer (DFO) office staff with jurisdiction over the pilot sites. Although these staff members have received the aforementioned training in Japan and have been eager to participate, they each have other regular duties that they are responsible for, and personnel transfers are customary after two-year period. Adjustments to additional workload and customary transfers have not been considered, due to transfer to a distant location, therefore, a practical problem was that their participation rate in the Project was not high due to their normal work schedules. In addition, the fact that the ToE that participate in the Project as technical assistants to Task Team members are also subject to technology transfer that may have contributed to less participation by the Task Team members in the Project. On the other hand, the Task Team members, consisting of Nainital DFO office staff in charge of the Padli pilot site, were actively involved in the Project while performing their regular duties, so it can be also inferred that the participation rate was partly a matter of workplace understanding of their status after the transfer. In addition, training programs in Japan were a motivating factor for each staff member, but were completed by 2019, in the first half of the project, then subsequent personnel changes and retirements caused structural problems.

(2) Technology transfer by OJT and Off-JT

■ On-the-Job Training

The purpose of the Project is to provide technology transfer and technical assistance to the C/Ps. An important part of technical cooperation for capacity building in relation to erosion control works is on-the-job training (OJT), in which participants go to the actual sites and do the work themselves, such as design and cost estimation. For this reason, requests were made to the Task Teams and ToE to accompany the JET whenever they conducted field work, whether it was surveying, investigation, design, or construction supervision. The situation allowed things to be explained to and discussed

with the participating C/Ps while seeing these same things at the sites, which facilitated understanding of the Project.

On the other hand, information obtained and found in the activities was shared with C/Ps who were unable to participate in the reports on the activities conducted. It was also desirable to increase the number of OJT sessions so that the C/Ps who were unable to participate in onsite activities could do so on other occasions, and to increase opportunities to be involved in actual work as much as possible.

■ Off-the-Job Training

Off-the-job (Off-JT) training sessions were planned for the C/Ps to consolidate their basic knowledge and to promote understanding of the work content through hands-on works. Study sessions using the manuals and guidelines developed in the Project and workshops with lecturers from Japan were also held. While the JET were unable to travel to India due to COVID-19, technical training sessions were held using online communication tools, and discussions and guidance were provided on the results of the field work conducted by the C/Ps. For online training sessions, the participation rate of C/Ps was high because of the relatively flexible time schedule. However, it was also felt that online instruction had limitations, as it was often difficult to express and communicate in detail during online instruction and discussions. Depending on the content, especially for onsite work, it is suggested that face-to-face instruction would be more efficient and ensure mutual understanding.

A total of three training courses were held in Japan. Through these trainings, not only Task Team and ToE members, who are CPs, but also trainees from the National Highway Authority and disaster management agencies participated as trainees, thereby improving the knowledge and capacity on the erosion control works of not only UKFD but also related agencies for slope disaster project within the state of Uttarakhand.

C/Ps actively participated in technical seminars and workshops and were given opportunities to present to the ToE. By preparing presentation materials and presenting at these events, they were able to review the techniques they had learned, which helped them to further consolidate their knowledge.

(3) Regular progress meeting and information sharing

During the survey, investigation and design phase, the ToE stationed at the Project's offices, as well as Task Team members from the three DFOs, were called to office headquarters in Dehradun. There, each Task Team provided regular progress reports on project activities, shared information with project stakeholders, and discussed problems. When construction supervision work started, the teams were connected online to the field offices at each model site, and the ToE Field Engineer stationed at each site reported on the progress of each site. Information on the reports was shared and problems were discussed for resolution. The attendance of the UFRMP Chief Project Director (CPD) or Deputy Project Director (DPD) at the meetings enabled prompt decision-making and direction on actions to be taken to solve problems.

(4) Preparation of Manuals

The activities of the Project have resulted in the creation of many technical support tools, including technical manuals, guidelines, and SOP for erosion control works. In addition, study sessions using these tools were held during the process of creating these tools and after they were completed. These tools were revised to reflect the results of questions and answers and discussions during these study sessions. Study sessions were held again using the revised tools to consolidate the knowledge of the C/Ps.

5.2 Survey and Investigation

(1) Planning of survey and investigation

In order to develop a plan for surveying and investigation for the model sites, a site visit is first conducted to confirm the topographical and geological conditions and identify the affected areas to determine the scope of the erosion control works and the scope of surveying and investigation items to be conducted. During the site visit, the JET surveyed the slopes with Task Team members and ToE members to confirm the target areas of the erosion control works, such as slopes and streams, explain and exchange opinions on the problematic geology and topography, and to determine the scope of surveying and survey items. In conducting the activities, the survey and investigation plan was prepared after gathering information on investigation methods available in India with the C/Ps in advance. In India, neither the contractors nor the C/Ps have much experience in surveying and investigation for construction work on slopes, so the technical specifications for contractor procurement included detailed descriptions of the objectives of the work and precautions to be taken when surveying and investigating, and face-to-face explanations were provided at the office before the actual work to ensure the accuracy and quality of the survey and investigation.

However, discrepancies were found between the locations of survey stakes and the locations on the drawings, or flaws were identified in the results, such as the accuracy of the geophysical survey analysis. As a result, in some cases, the work had to be redone or required action on the part of the JET and the C/Ps.

(2) Practical training on simplified survey method

The C/Ps also had some knowledge of surveying. Based on this situation, the JET instructed the Task Teams and ToE to actually survey for the analysis and detailed design using the surveying equipment provided for the Project. For the cross-sectional survey for detailed design, the JET also instructed them on how to conduct a simple survey using a surveying pole without using surveying instruments, as well as how to compile the survey results and prepare design drawings using the cross-sectional drawings.

In addition, the C/Ps were instructed in surveying using drones, which have been utilized in recent years in erosion control projects and drafting techniques, so that they will be able to conduct onsite surveying and drafting techniques on their own. In surveying work, the ToE was instructed to conduct surveys for minor areas and surveys for detail design at model sites such as Nirgad and Jawadi as much as possible, since gaining more experience in actual work will enable them to work more efficiently and accurately.

(3) Understanding of geology

Geological reconnaissance in erosion control works is conducted to understand the local geology and geological structure, and the geological information is important for verifying the predisposing factors of the mechanism of disaster. The data should also be referred to in designing more effective countermeasure works. In order to collect geological information, the JET instructed the C/Ps to carefully observe geological outcrops and estimate the geological structure of the area.

On the other hand, geological reconnaissance inevitably requires observation of local conditions based on geological knowledge. However, since there were no engineers with enough geological knowledge on the Task Teams or ToE, it was necessary to explain the situation from a basic knowledge of geology. The C/Ps often asked questions about geology and geological structures that could be identified in the field. As much as possible, explanations were provided with schematic drawings to make things easy to understand for the C/Ps, even for those without sufficient technical knowledge in geology. Although the JET have often held study sessions and field presentations on geology, it would have been desirable to have more opportunities to observe more examples of geology at various sites in order for the C/Ps to fully understand geology.

(4) Promote understanding of mechanism of disaster occurring

In erosion control works, analyzing the mechanisms of disasters occurring on the target slopes is of utmost importance in selecting appropriate and effective countermeasure works. The mechanism of disaster occurrence is to identify the predisposing and triggering factors that caused the disaster occurrence and to estimate the process of disaster. To perform these tasks, it is necessary to comprehensively analyse topographical, geological, and meteorological data acquired through surveys and investigations.

Therefore, the JET provided guidance on how to acquire these data and how to determine the usefulness of the acquired data, both in the field and at study sessions. In addition, the same approach and summary format were used at the three model sites to explain the mechanism of disaster occurrence and to promote understanding of how disasters occur. Time was also spent on explanations in the field and at office study sessions based on examples of various predisposing factors and triggers of common slope disasters. It is believed that the most effective way to improve the ability to analyse the mechanisms of disasters in erosion control works, where topographical, geological, and environmental conditions differ for each target slope, is to learn from as many case studies as possible and gain experience. For this reason, the JET took as many opportunities as possible to observe the local conditions and discuss the mechanisms of disaster occurrence, not only at the sites covered by the Project, but also at slope disaster sites which observed on the way to the site, as case studies.

5.3 Design

(1) Selection and design of sustainable countermeasure works in India

One of the main objectives of the Project is to introduce Japanese erosion control technology. It is an important selection criterion that the construction method to be introduced in the Project should be sustainable in India in the future. Therefore, in selecting the work method using Japanese technology to be introduced, it was necessary to consider the procurement of materials necessary for the construction of the works and the guidance of contractors who had no experience in the construction of structures. In particular, India's national policy requests the UKFD that all items used and utilized in India be made in India. Considering these conditions, a work method was selected that was relatively uncomplicated and did not require special techniques or materials for the manufacture of the components. At the design stage, it was assumed that Japanese engineers with sufficient experience in the construction of the selected work method would be dispatched at the time of construction, and the condition was clearly stated in the specifications for the procurement document of the contractor. The design of the erosion control works using Japanese technology was led by a Japanese expert, as it was anticipated that the design would take a significant amount of time relative to the overall schedule if the design was implemented while providing guidance to the ToE. The concept and workflow of the design were explained and taught in study sessions and workshops at a later date.

In addition to erosion control works using Japanese technology, construction methods commonly used in India were also applied at the three model sites. The design for those works was also led by a Japanese expert, taking into consideration the overall schedule. The concepts and flow of design work were explained and guided at a later date during study sessions and training sessions in India conducted by invited lecturers from Japan.

(2) OJT for design work

While the JET led the design work at the three model sites, the ToE, with the support of the JET, carried out the design work at the candidate sites. The ToE and the JET discussed matters onsite and decided on the policy for erosion control works and the type and layout of works to be installed. Based on the results of the discussions, the JET prepared layout drawings of the works, which were then used by the ToE to complete the design drawings and quantity survey.

Since the long-term suspension of construction at the three model sites due to COVID-19, the topography at the time of design had changed by the time construction resumed, and the design had to be revised. For these revisions, the ToE, with the assistance of the JET, prepared the design drawings, calculated quantities, and performed other tasks. In this way, OJT for design work was provided to the C/Ps.

5.4 Project Supervision

(1) Adoption of Japanese advanced technology for erosion control

In the construction of the model site, as Japanese advanced erosion control technology, a double-wall dam method was adopted for the erosion control dam at Nirgad site, and a crib work method was adopted for the hillside works at the Jawadi and Padli sites. In order to introduce these technologies, the contractor was obliged to dispatch a Japanese technical supervisor to the Project as part of the contract. Dispatch contracts were concluded with two Japanese companies for the double-wall dam construction method and the crib work construction method. Further, Japanese supervisors were dispatched from both companies, which have Japanese technology for each method, to provide on-site construction supervision.

The construction method for a double-wall dam is a one in which steel sheet piles about one meter high are fabricated, placed on the upstream and downstream walls, and then filled with suitable material and compacted, with the process repeated to the top of the dam. In the method for crib works, reinforced concrete is placed on the slope in a grid pattern to fix the ground of slope in place.

Both construction methods are new to Uttarakhand. The double-wall dam was completed in about one month, excluding excavation and material fabrication time, which caused some impact on the Indian stakeholders. It is expected that both construction methods will be widely used in Uttarakhand in future.

(2) Preparation of Construction Supervision Plan

Before contracting for the construction of the model site, a Construction Supervision Plan was prepared and attached to the contract, and the construction was supervised according to this plan. The detailed stipulation of construction supervision procedures, including the format of documents related to submittals, approvals, and instructions concerning construction plans, construction drawings, construction materials, safety management, and quality control, as well as the management method of construction supervision documents, regular meeting schedules, and agendas, has enabled the standardization of the construction supervision work.

Currently, the Construction Supervision Plan is being used for construction supervision at the model site, followed by the candidate site. It is desirable to continue to utilize and improve the Construction Supervision Plan and establish a standard document for the Construction Supervision Plan of the UKFD.

(3) Creation of a Manual for Preparation of Construction Plans

As far as could be seen of the contractors at the model site, they were not proficient in preparing the construction plan. In addition, due to insufficient understanding of erosion control works, they submitted construction plans that lacked specificity in content, and repeated instructions were given to revise and resubmit the plan, resulting in considerable time spent before approval.

Therefore, a Manual for Preparation of Construction Plans was prepared, showing items that should be included in the construction plan and how to include them. In addition, an SOP describing the construction procedures for each type of work for erosion control works was

prepared with the Long-term Experts; this has been made an appendix to the construction plan preparation manual.

In the future, it is expected that this manual will be used as an attachment to bidding documents and contracts in order to ensure that construction plans are prepared efficiently and to improve the capacity of contractors.

(4) Guidance for installing profiles for cut slope work

In many cases, road slope cuttings in Uttarakhand are excavated almost vertically, without ensuring a stable slope. If stable slopes are not secured, the risk of landslides and rock falls increases. In order to ensure a stable slope, it is necessary to install profiles to clearly indicate the excavation slope, but since neither the ToE nor the contractor knew how to install them, they were given hands-on guidance on how to do so.

As a result, the installation of profiles has been established in the slope excavation at the model site and the candidate site. It is desirable to continue to install slope profiles as an SOP of the UKFD.

(5) Risk of the Project not progressing as planned due to construction progress

The construction period was significantly delayed due to the suspension of construction work with the onset of the COVID-19 pandemic. This occurred immediately after contracting with the contractor for the model site work, and the work is still not complete. Therefore, the post-completion monitoring activities planned for the Project could not be carried out.

The delay was largely due to the contractor's technical and financial capacity and a lack of awareness of the need to adhere to the construction schedule, rather than COVID-19. Therefore, the contractor was instructed to submit a revised construction schedule after the delay, and after verifying the rationale for the construction plan, was provided to revise the plan and to manage the progress based on the revised schedule. As a result, the Jawadi hillside work is progressing relatively smoothly, due to appropriate progress supervision by the resident ToE. Since Japanese standards were applied in introducing Japanese technology, it took longer than usual for the contractor to understand these standards.

However, for other items of work, the contractor repeatedly delayed further from the revised schedule and had to submit a new revised process schedule, because the JET were not a party to the contract, it was not possible to improve the progress of construction significantly by the contractor during the Project.

It was realized that there was a significant risk that the Project would not proceed as planned due to the progress of construction by the contractor. It is necessary to develop measures to avoid these risks when implementing projects similar to the Project in the future.

(6) Length of travel time to the target site

Travel to the target sites is by vehicle on mountain roads, and while the straight-line distances to the sites are short, the travel distances on these roads are long. Therefore, of the eight target sites, only three sites (Nirgad, Raipur, and Jokla) can be reached by day trip from Dehradun, where the Project's office is located. Travel to Jawadi, Padli, and Baliyanala, where road construction was previously conducted, took a full day, requiring a minimum of two nights to provide technical guidance. The current Lakhanpur site requires a minimum of two nights as well. The remaining site, Malla, also requires a minimum of one night. The target sites are widely dispersed throughout Uttarakhand, and similar time would be required to travel between target sites, with the exception of Padli-Baliyanala.

While dispersing the target sites is effective in disseminating the Project widely throughout the state, it is inefficient for the Project because of the large amount of time spent traveling between sites. Construction management is also less efficient for contractors, and they have less incentive to participate in bidding.

It is thought that there is room to consider concentrating the target sites in one district for efficient project implementation and reduction of construction costs.

(7) Necessity of resident experts for construction supervision support

In erosion control works, design changes are often required due to changes in topography caused by rainfall and other factors. Therefore, it is desirable to have at least one resident expert in charge of construction supervision support, rather than only a shuttle bus-type dispatch.

6 Recommendations for the Future Implementation of Erosion Control Works in India

6.1 Planning of Erosion Control Works

Slope conditions will deteriorate and the devastated area will expand without some erosion control works. This will result in a decrease in forest area. Therefore, for forest conservation, the implementation of erosion control works is essential for the UKFD to manage the forests in Uttarakhand. However, it is not difficult to implement the erosion control works on all of the degraded lands in the forest area. Moreover, it is necessary to plan the total amount of forests and develop an efficient and effective plan for the erosion control works for more effective forest conservation, taking into consideration the economic and human resources that the UKFD has. To this end, information on slope disasters in forests must be collected and updated. The slope disaster location maps created in the Project need to be updated regularly, while the latest data should be used to determine the total amount of forests subject to erosion control projects, develop short-, mid- and long-term plans for the erosion control works, and to apply for budgets for execution of the works by the DFO office according to the plan.

6.2 Establishment of Cell in Department for Erosion Control and Education of Engineers

In order to carry out the erosion control works necessary to conserve forests, it is necessary to establish a State level cell in Forest department. The major task of the department shall be to identify the areas where slope failures occur every year, to update the status of past failures, and to manage the implementation of erosion control projects. In addition, there is an urgent need to assign and train specialized engineers to manage the erosion control works. The practical work of the erosion control works themselves do not need to be carried out by a specialized cell in department that manages the erosion control works, and surveying, design, and construction can be handled by outsourcing. However, knowledge and ability to judge the appropriateness of the content of the deliverables from the outsourced contractors are required. In addition, monitoring and maintenance of the constructed structures will be carried out by this specialized department, and conservation of the target forests will also be in the scope of work of the specialized department. The specialized department at UKFD headquarters alone to collect information on disasters in the forests of Uttarakhand and to implement and maintain the erosion control works. In addition of current system, it is recommended that an information sharing network be established with DFO office in the province and that a system to be set up where local information is collected by the specialized department at the headquarters as appropriate, and information from the headquarters is transmitted to the DFO office. Task Team members within UKFD and/or those who have Civil Engineering background may form the core group of the Cell.

In order to further improve the capacity of ToE and Task Team members who have acquired knowledge and skills in erosion control works through the Project, and to train

future professional engineers in erosion control works, the establishment of a training course on erosion control management at the Uttarakhand Forestry Research Institute (Forest Training Institute) is proposed.

The following is a proposed training course for erosion control works management.

- Duration: 1 week/ year
- Contents
 - How to utilize GIS software using SDLM update (desk-based learning)
 - Surveying techniques using drones and total stations (desk-based learning and practical training)
 - Surveying and designing for erosion control works (desk-based learning)
 - Standards for construction of erosion control works (desk-based learning)
 - Maintenance and management methods for erosion control works facilities (desk-based learning)
 - Monitoring of existing erosion control works facilities (practical training)
 - Field inspection of any slope disaster site and study of countermeasure works (practical training)

6.3 Continuation of Promotion and Introduction of Japanese Advanced Erosion Control Technology

During the construction of the model sites, the construction of the double-wall dam introduced at the Nirgad site and the crib works introduced at the Jawadi and Padli sites is conducted as advanced Japanese technologies for erosion control works. It is expected that the Indian side continue construction and conduct monitoring after completion to confirm the effectiveness of the technology, and then these technologies will be introduced to the entire state of Uttarakhand as well as to other states in the future to disseminate the technologies.

Construction quality was improved during Japanese engineers from two Japanese companies which have technical capabilities in Japan, provided direct onsite technical guidance during the construction of the double-wall dam and the crib works introduced at the model sites. It is expected to promote the same type of works in Uttarakhand and encourage collaboration with operators using advanced construction techniques and other erosion control technologies that can be utilised in India.

6.4 Thorough Examination of Financial Status in Prequalification for Bidding

As mentioned above, the major delay in the construction of the model site was partly due to COVID-19 and the contractor's insufficient technical capacity, but it is thought that it was also largely due to delays in procuring materials and bringing in machinery because of the contractor's lack of financial resources. For this reason, a prequalification screening process should be implemented prior to bidding to verify the financial status of bidders.

6.5 Utilization and Dissemination of Construction Supervision Plan and a Manual for Preparation of Construction Plans

Although the Project has been completed and there will no longer be any JET, construction work will continue. It is desirable that construction and safety supervision be thoroughly carried out and continued until the completion of the model sites and the candidate sites in accordance with the Construction Supervision Plan as described above.

In addition, as mentioned above, it is desirable to make efforts to utilize, establish, and disseminate the Construction Supervision Plan and the Manual for Preparation of Construction Plans, and to improve the capabilities of the stakeholders involved in the erosion control works in the state of Uttarakhand.