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Global Facility for Disaster Reduction and Recovery

ASSESSMENT OF ECONOMIC IMPACTS FROM DISASTERS ALONG KEY CORRIDORS

Final Report

MAY 2021
WORLD BANK

IN ASSOCIATION WITH:

iMC worldwide

SRD Group
SILK ROAD DESING ENGINEERING GROUP, LLC

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RESEARCH & CONSULTING

Within this study, the locations of sites with existing hazards have been determined based upon extensive site visits. These made use of official measures of the length of each road where possible. Efforts have been made to ensure that these are correct at the time of the site visit. In light of possible reconstructions or rehabilitations of the automobile roads, there is a likelihood of changes to the kilometrages of the identified hazard prone locations. During the site visit, the location of each site was also recorded using a geo-reference (latitude and longitude) using handheld devices. Where there is any uncertainty regarding a location, these geo-references should be used (in consultation with the specialists of the Ministry of Transport) to ensure that the correct location is being referred to, so as to avoid any inaccuracies inherent in measuring distance using vehicle odometers. It should be noted that the information provided herein is intended to be an inventory of hazard sites and is not intended to provide a definitive indication of each and every site identified. Data showing the precise location of each site will need to be collected as part of any future design studies needed to develop and implement any investment programme, with engagement of representatives of relevant departments of the Ministry of Transport.

This assessment was developed with support from the Japan-World Bank Program for Mainstreaming DRM in Developing Countries, which is financed by the Government of Japan and managed by the Global Facility for Disaster Reduction and Recovery (GFDRR) through the Tokyo Disaster Risk Management Hub.

CONTENTS

1 INTRODUCTION 1
1.1 The Study 1
1.2 Impact of COVID19 1
1.3 This Report 1
1.4 Workshops and Stakeholder Engagement 2
1.5 Ackowledgements 2
2 Disasters in Tajikistan 3
2.1 National Socio-Economic Profile 3
National Economy 3
Population 4
Livelihoods in Tajikistan 5
Industry 6
Agriculture 7
2.2 Historic Patterns of Disasters 8
2.3 Costs of Disasters 10
2.4 Disasters Affecting the Road Network 11
3 ASSESSING MITIGATION INTERVENTIONS 15
3.1 Overview 15
3.2 Road Inspections 15
3.3 Description of Main Hazards Assessed 18
3.4 Selection of Typical Mitigation Interventions 21
Scale of Impact and Types of Mitigation Measures 21
3.5 Costs of Disaster Mitigation Measures 24
Avalanche Galleries 24
Snow Barriers SPIDER® Avalanche 32
Gabion Retaining Walls 37
Flexible Rock Fall Protection Barriers 43
Rock Fall Drapes, Nail Grid System TECCO / SPIDER 46
Debris Flow Barrier UX/VX 50
Culverts 57
Bridges 63
Road Realignment 65

Replacement of Soft/Swamp Material 67
Raising of Roadbed 68
Construction of a Surface Water Drain 71
3.6 Overall Costs of Mitigation 73
Costs of Mitigating Investments 73
4 The Impact of Climate Change 74
4.1 How Climate Change May Affect Road Infrastructure 74
4.2 Impact of Climate Change in Tajikistan 74
4.3 Climate Change Impacts on Different Regions 75
4.4 Impact on Future Disasters 76
4.5 Key Climatic Parameters for Climate-resilient Road Design 77
4.6 Impact on the Number and Type of Disasters 77
5 Estimating the Economic Costs of Disasters 79
5.1 Cost Categories 79
Assessment of Economic Costs of Disasters 79
5.2 Effect of Growth in Traffic and Population 79
Population Growth 79
Growth in Traffic Intensity 80
5.3 Damage and Repair to Road Infrastructure 80
Costs of Damage to Infrastructure 80
5.4 Search and Rescue Costs 81
5.5 Loss of Life 82
Estimating the Resource Value of a Life Lost 83
5.6 Disruption to Traffic 85
Number of Disasters by Road Section 86
Number of Vehicles Affected 87
Average Length of Closure 89
Value of Time 90
Value of Cargo 90
Calculation of Overall Costs of Traffic Disruption 91
5.7 Costs of Severance of Communities 92
Using the Results of the Socio-Economic Surveys 93
Impact on Typical Incomes 93
Permanent Impact of a Loss of Access 96
Temporary Impact due to Temporary Loss of Access 96
Total Costs of Loss of Employment and Income 97

5.8 Total Economic Costs ... 98
6 Assessing the Viability of Mitigation ... 100
6.1 Methodology ... 100
COST BENEFIT ANALYSIS OF MITIGATION MEASURES ... 100
Appraisal Length ... 100
Discount Rate ... 100
6.2 Cost Benefit Analysis Inputs ... 101
Expenditure Profile of Costs ... 101
Benefits Profile ... 101
6.3 Cost Benefit Analysis Results ... 101
Whole Programme ... 101
Individual Road Sections ... 103
7 Conclusions ... 105
7.1 Overall Study ... 105
7.2 Road Hazard Sites ... 105
7.3 Socio-Economic Surveys ... 105
7.4 Assessment of Total Costs ... 106
7.5 Cost Benefit Analysis ... 106
Annex A List of Emergencies from CoESCD 2018 and 2019 ... 107
Annex B Selection of Mitigating Measures for Inspection Sites ... 112
Annex C Calculation of Total Traffic Disruption Costs ... 125
Annex D Calculation of Inflation ... 134

LIST OF FIGURES

Figure 2-1 Age Structure of Urban Population, by gender, 2019 5
Figure 2-2 Age Structure of Rural Population, by gender, 2019 5
Figure 2-3 Livelihood Zones in Tajikistan 6
Figure 2-4 Disasters in Tajikistan by Month 2019 10
Figure 2-5 Avalanche Risk Map 12
Figure 2-6 Mudflow Risk Map 12
Figure 2-7 Comparison between Total Cost of Damage and Repairs and the Number of Casualties 14
Figure 3-1 Locations of Inspection Sites 17
Figure 3-2 Cross-Section of the Avalanche Gallery 26
Figure 3-3 Illustration of Proposed Avalanche Gallery 27
Figure 3-4 Components of the SPIDER® AVALANCHE system 33
Figure 3-5 Illustration of Proposed Snow Barriers 34
Figure 3-6 Illustration of a proposed Gabion Wall 38
Figure 3-7 Components of the GBE-1000A barrier 43
Figure 3-8 Illustration of Rock Fall Protection Barrier 44
Figure 3-9 Slope stabilization with the TECCO® or the SPIDER® system 47
Figure 3-10 Illustration of Nail Grid Active System 47
Figure 3-11 Components of a UX debris flow barrier 51
Figure 3-12 Illustration of Debris Flow Barrier 52
Figure 3-13 Box Culvert Diagram 58
Figure 3-14 Pipe Culvert Diagram 59
Figure 3-15 Illustration of a Pipe Culvert 60
Figure 3-16 Bridge Centre Section Diagram 64
Figure 3-17 Illustration of Road Bed Raising 68
Figure 5-1 Average Daily Traffic Intensity - Republican Road Network 89
Figure 5-2 Vulnerability to Climate Change and Natural Disasters 93
Figure 6-1 Summary of CBA Results by Road Section 104

LIST OF TABLES

Table 2-1 Population Changes 2018 - 2019 4
Table 2-2 Industry in Tajikistan 7
Table 2-3 Agricultural Sector in Tajikistan 7
Table 2-4 Agricultural Production 2020 8
Table 2-5 Patterns of Disasters 2017 – 2019 8
Table 2-6 Disasters Recorded by Region 9
Table 2-7 Numbers Killed by Disasters 10
Table 2-8 Estimated Costs of Disasters (million somoni) 11
Table 2-9 Summary of Disasters Recorded by CoESCD 11
Table 2-10 Estimated Number of People Killed in Disasters Affecting the Road Network 13
Table 2-11 Damage and Repair Costs (million somoni) 14
Table 3-1 Roads Included in Road Inspections 15
Table 3-2 Scale and Type of Mitigation 21
Table 3-3 Summary of Measures Selected by Road Section 23
Table 3-4 Items included in the cost of Avalanche Galleries 28
Table 3-5 Avalanche Galleries Quantities and cost 28
Table 3-6 Items included in the cost of snow barriers 33
Table 3-7 Snow Barriers Quantities and cost 35
Table 3-8 Gabion Wall dimensions 39
Table 3-9 Items included in the cost of Gabions 39
Table 3-10 Gabion Walls Cost of works 40
Table 3-11 Items included in the cost of Rock Fall Protection Barriers 44
Table 3-12 Flexible Rock Fall Barriers Quantities and cost 45
Table 3-13 Items included in the cost of Rock Fall Protection Measures 49
Table 3-14 Nail Grid Active Systems Quantities and cost 49
Table 3-15 Items included in the cost of Debris Flow Barriers 51
Table 3-16 Debris Flow Barrier Quantities and cost 53
Table 3-17 Items included in the cost 61
Table 3-18 Culvert Construction Quantities and cost 61
Table 3-19 Items included in the cost of Bridges 64
Table 3-20 Bridges Quantities and cost 65
Table 3-21 Items included in the cost of road realignment 66
Table 3-22 Road Realignment Quantities and cost 66
Table 3-23 Items included in the cost of removal of soft material 67
Table 3-24 Replacement of Soft Material Quantities and cost 67
Table 3-25 Items included in the cost of road bed raising 69
Table 3-26 Road Bed Raising Quantities and cost` 69
Table 3-27 Items included in the cost of surface water drainage 71
Table 3-28 Surface Water Drainage Quantities and cost 71
Table 3-29 Total costs of Mitigation Measures 73
Table 4-1 Projected impacts of climate change on extreme events 75
Table 4-2 The regional impacts of Climate Change in Tajikistan 75
Table 4-3 Future Number of Disasters by Type 78
Table 5-1 Growth in National Population 79
Table 5-2 Total Vehicle Kilometers 80
Table 5-3 Estimates of Future Damage and Repair Costs (million somoni) 81
Table 5-4 Total Future Search and Rescue Costs (somoni) 82
Table 5-5 Future Casualties as a Result of Disasters 82
Table 5-6 Tajikistan Population Profile 2019 83
Table 5-7 Calculation of the Average Cost of Casualties by Age Range 85
Table 5-8 Calculation of Total Cost of Casualties (somoni) 85
Table 5-9 Breakdown of Disasters 2018/19 86
Table 5-10 Traffic Survey Results 87
Table 5-11 Traffic Intensity Data from Strengthening Implementation of Road Maintenance Financing System Project 88
Table 5-12 Typical Lengths of Road Closures by Hazard Type 89

Table 5-13 Calculation of Value of Time per hour (somoni) ... 90
Table 5-14 Summary of Calculation of Traffic Disruption Costs (somoni) ... 91
Table 5-15 Estimated Total Costs of Traffic Disruption (somoni) ... 92
Table 5-16 Multi-Dimensional Poverty Index ... 94
Table 5-17 Average Monthly Incomes from Socio-Economic Surveys (somoni) ... 94
Table 5-18 Calculation of Average Income Impact Per Person Per Disaster (somoni) ... 95
Table 5-19 Estimation of the Number of Disasters Affecting each District ... 95
Table 5-20 Calculation of Average Temporary Income Loss ... 97
Table 5-21 Calculation of Income Losses 2020 (somoni) ... 98
Table 5-22 Summary of Total Economic Costs (somoni) ... 99
Table 6-1 Cost Benefit Analysis Results – All road sections ... 102
Table 6-2 CBA Results by Road Section ... 103

ACRONYMS & ABBREVIATIONS

ACTED	Agency for Technical Cooperation and Development
ADB	Asian Development Bank
ADRC	Asian Disaster Reduction Centre
AKAH	Aga Khan Agency for Habitat
CEP	Committee for Environmental Protection
CMIP	Coupled Model Inter-comparison Project
CoESCD	Committee for Emergency Situations and Civil Defence
CRM	Climate Risk Management
DFID	Department for International Development
DRR	Disaster Risk Reduction
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EOS	Earth Observation System
GAI	Traffic Police
GBAO	Gorno-Badakshan Autonomous Oblast
GCM	General Circulation Model
GERICS	Climate Service Center Germany
GIZ	Gesellschaft für Internationale Zusammenarbeit
GLOF	Glacier Lake Outburst Flood
GOT	Government of Tajikistan
Hydromet	Agency for Hydrometeorology of the Committee of Environmental Protection
IMC	IMC Worldwide Ltd
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
KNMI	Royal Netherlands Meteorological Institute
LST	Land Surface Temperature
MODIS	Moderate Resolution Imaging Spectroradiometer
MoT	Ministry of Transport
NASA	National Aeronautics and Space Administration
OSCE	Organisation for Security in Europe
OXFAM	Oxford Committee for Famine Relief
PDNA	Post Disaster Needs Assessment
RCP	Representative Concentration Pathways

SDC	Swiss Development Cooperation Office
SRD	Silk Road Design Company
TL	Team Leader
ToR	Terms of Reference
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework for Climate Change Convention
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WB	World Bank
WFP	World Food Programme

EXCHANGE RATES

(source: xe.com 27th November 2020)

1	somoni =	0.088
1	USD =	11.3

EXECUTIVE SUMMARY

This Study

This Final Report forms the third deliverable for the World Bank funded study to assess the economic costs incurred by Tajikistan, due to the impact of disasters affecting the road network. This report details the overall findings of the study, building upon previous reports. This Report details the work done to identify the potential costs of mitigating disasters across the road network, the socio-economic costs incurred by Tajikistan as a result of disasters that affect the road network, and the economic viability of investing to increase resilience across the network.

As part of this study, engineering inspections of at risk sections of the republican road network have been completed. These inspections identified the locations within target sections that require the implementation of mitigation measures. At each location an assessment was undertaken to identify the source of a problem, the potential impact and appropriate mitigation measures. 331 individual locations were identified and inspected across more than 2,000 km of the road network, highlighting hazards including flooding, landslides, avalanches, rockfalls and mudflows. As part of the inspections pro formas were completed, ensuring that all relevant information was collected. In addition, a range of photographs were taken to ensure it is possible to identify the particular location being considered. From this work, appropriate mitigating measures were identified for each site. These were costed, based upon high level standardised costs, to produce a total cost for a programme of mitigation. It should be noted that in order to implement this programme, further detailed inspections and design work must be completed, to ensure that proposed measures are adequate.

To inform the study at a detailed household level, a series of socio-economic surveys were undertaken. The locations of these matched, as far as possible, the locations of the road inspections, ensuring that the results of the surveys and road inspections could be used in combination. The socio-economic surveys included a wide range of questions aimed at detailing the situation of surveyed households, as well as the impact of disasters on a range of socio-economic factors. These surveys were backed up by a series of key informant interviews. In total, 400 surveys and 15 key informant interviews were completed, giving a broad based view of the areas affected by disasters.

The basis for the study were existing, published statistics on past disasters that have affected Tajikistan. This data includes records of all disasters for the past 3 years from CoESCD and records of disasters affecting the road network from MoT for the past 7 years. Together these were used to build a picture of historic patterns of recent disasters.

Whilst there are reasonable records of past disasters in Tajikistan, it is important to assess how the patterns of disasters may change over time, particularly as a result of the effects of climate change. A detailed analysis of secondary data sources has been undertaken as part of this study, to assess future patterns of the factors that lead to disasters. The aim of this was to highlight where factors may change over time, particularly highlighting differences in different parts of the country. This has resulted in a clear understanding of how climate change will affect different parts of Tajikistan and the disasters that affect different parts of the road network. Whilst in some ways Tajikistan will benefit as a result of climate change, issues such as increased glacial melt, changes to snow and rainfall patterns and a quicker transition into spring will result in gradually increasing numbers of disasters.

Road Inspections

Based upon the results of the road inspections, proposals for appropriate mitigating measures have been developed for each of the 331 sites. In eight locations more than one measure has been proposed, to deal with multiple hazards. Where appropriate, a range of innovative solutions have been suggested for hazard sites. Whilst some of these solutions will be new to Central Asia and Tajikistan, and some may not yet be included within relevant design standards, it is considered appropriate to include these within this analysis, as these new solutions represent the best options for dealing with identified hazards. Based upon outlines of the requirements for each measure, an assessment of the likely costs has been made. Where the solution from a particular manufacturer is proposed, costs have been estimated based upon data from the relevant manufacturer. Where solutions have been implemented in Tajikistan in the recent past, we have utilised information from recent construction contracts to estimate costs. The overall estimated cost of the proposed programme of measures for all 331 sites is 4.6 billion somoni (USD404 million). It should be noted that this total cost is significantly increased by a relatively small number of more expensive measures, mainly avalanche galleries, which represent almost 65% of the total cost, for 65 of the 331 sites.

Economic Cost of Disasters

The economic costs of disasters affecting the road network includes a range of costs such as damage to infrastructure and the costs of repair, search and rescue costs and the costs associated with the loss of life. In addition, other less tangible costs, such as the costs to delayed traffic and the costs endured by communities that are often regularly cut off by disasters, are key elements in the total costs of disasters that affect the road network. These latter two cost items will generally represent around 95% of total costs, according to the assessment undertaken for this study.

The costs of damage and repair have been assessed based upon existing data provided by the Ministry of Transport, which reflect the costs incurred each year since 2014. The estimate of the costs of search and rescue has been informed by data provided by the Aga Khan Agency for Humanity, which often leads these operations in Tajikistan. The costs associated with loss of life have been estimated based upon statistics on the numbers killed since 2009. The cost of each individual casualty has been estimated based upon published income data and assumptions regarding the profile of casualties. In total, over the period 2022 – 2032, these costs are expected to total around 355 million somoni.

The costs incurred by traffic that is delayed by disasters which block road sections have been estimated based upon traffic intensity data provided by the Ministry of Transport. Data sourced by the consultants relating to the breakdown of traffic by type and journey purpose, has been used to supplement traffic intensity data. Data since 2011 has been used to estimate past growth patterns for traffic, which have informed predictions for how traffic will grow in the future. The costs incurred by delayed traffic have been predicted based upon estimates of the value of time for travellers, for different regions within Tajikistan. Over the period 2022 – 2032, these costs are expected to total around 4 billion somoni.

The long term costs incurred by remote communities that are regularly cut off by disasters are more difficult to estimate. The impacts that regular disasters have are many and varied, including loss of economic opportunity, reduced education, shorter life expectancy, reduced short term income, and loss of household assets. The socio-economic surveys carried out under this study, provide a useful guide to some of these effects, although some are difficult to quantify. For this study, estimates have been developed of the short term loss of income that may occur immediately after a disaster, and the long term effects of repeated disasters that affect a particular area.

Short term loss of income has been assessed based upon published income statistics, the results of the socio-economic surveys and secondary sources. Estimates of how many days income are likely to be lost each year have been developed based upon assumptions regarding the impact of each individual disaster, with the number of disasters being predicted based upon past trends and the predicted impact of climate change.

The long term impact of repeated disasters has been related to average income in each area. Based upon published statistics and the results of the socio-economic surveys, it was possible to estimate how much income is lost in affected areas. By estimating the proportion of people affected by repeated disasters, based upon the socio-economic surveys, it was possible to estimate the overall impact for each of the areas affected.

Over the period 2022 – 2032, these costs are expected to total around 2.2 billion somoni.

The total economic costs of disasters affecting the road network has been estimated at 445 million somoni in 2022, rising to 787 million in 2032. This represents around 0.5% of national GDP for Tajikistan.

Cost Benefit Analysis

This study has completed a cost benefit analysis of the proposed programme of mitigation measures for identified hazard sites. The results of the CBA show that as it is currently proposed, the full national programme of mitigation measures is not considered to be economically viable. This is in part due to the large costs attached to some of the measures on roads with limited traffic and only a small number of disasters.

To better inform the analysis, appraisals of each road section have been completed separately. This highlights that there are a number of road sections where the proposed programme of measures would be economically viable. These include Labijar – Kalaikumb, Murgab - Karakul – Kizilart, Guliston - Pyanj and Dehmoy – Kanibodom.

1 INTRODUCTION

1.1 THE STUDY

IMC Worldwide was appointed on 6th January 2020 by the World Bank, on behalf of the Ministry of Transport of the Republic of Tajikistan (MoT), to conduct a study entitled "Consultancy Assignment for Assessment of Economic Impacts from Disasters Along Key Corridors" in Tajikistan. For this assignment IMC Worldwide has sub-contracted two local firms: M-Vector - to undertake socio-economic surveys, and Silk Road Design Company (SRD) - to undertake road network inspections and provide support on the identification and costing of mitigating measures.

The objective of this assignment is to quantitatively assess the economic impacts of hazards such as landslides, rock falls mudflows, debris flows, flash flood and avalanches on key corridors in the Republic of Tajikistan. The assignment has a number of key activities, including:

- A review of existing hazard and incident data;
- A review of the road network to identify target sections;
- Visual inspections of relevant sections of the road network;
- Collection of road design information;
- Socio-economic surveys in selected case study areas;
- Assessment of direct costs of incidents;
- Quantitative assessment of indirect impact costs of incidents and
- Cost benefit analysis of potential interventions, where possible.

The geographical scope of the assignment comprises selected key corridors including republican roads across Tajikistan (approximately 2,000 km), focussing on national and international trade corridors and links with neighbouring countries. At the same time, the assessment is focussing on areas of the country with greater risks from natural hazards.

1.2 IMPACT OF COVID19

The progress and conduct of the study has been significantly affected by COVID19 related restrictions. Key impacts include:

- The inability of international consultants to visit Tajikistan;
- COVID related illness affecting the local inspections team;
- Internal travel restrictions delaying the socio-economic surveys;
- Additional pressures on Government ministries leading to slower than normal response times; and
- Overall delays to the project schedule.

These issues have been partially mitigated by additional involvement of local consultants in data collection, working remotely via voice over internet protocols and use of remote survey techniques.

1.3 THIS REPORT

This Draft Final Report, describes the overall findings of the study, including the assessment of the costs of improving resilience across the road network, the identification of the costs incurred in recent years as a result of disasters and cost benefit analysis to assess the viability of the proposed mitigation measures. This report builds upon previous reports which have set out the results of the road inspections and socio-economic surveys and work undertaken to assess the effect of climate change on the frequency and magnitude of future disasters.

Section 2 of this report provides a summary of recent patterns of disasters in Tajikistan. Section 3 details the work done to identify potential mitigation measures and the overall costs of improving resilience across the road network. Section 4 summarises the effect of climate change on future disasters. Section 5 sets out the methodology for assessing past and future costs of disasters. Section 6 summarises the assessment of the viability of mitigation measures for the road network.

1.4 WORKSHOPS AND STAKEHOLDER ENGAGEMENT

As part of this study, a number of stakeholder workshops have been organised. These workshops had a dual role, or presenting progress on key aspects of the study, and to collect comments and insights in relation to key results. The following workshops have been completed:

- An inception workshop with Government stakeholders during the inception period, during February 2020;
- A virtual workshop to discuss the methodology and findings of the road inspections, with Ministry of Transport officials, held in December 2020;
- A virtual workshop to discuss the wider study, focusing on the socio-economic surveys and climate change assessment, with Government and development partner stakeholders, held in February 2021;
- A final virtual workshop to discuss the findings and recommendations resulting from the whole study, with all stakeholders, in April 2021.

1.5 ACKOWLEDGEMENTS

This assessment was made possible with support from the Japan-World Bank Program for Mainstreaming DRM in Developing Countries, which is financed by the Government of Japan and managed by the Global Facility for Disaster Reduction and Recovery (GFDRR) through the Tokyo Disaster Risk Management Hub.

We would like to acknowledge the support of the officials of the Ministry of Transport, and the other Government agencies that have thus far collaborated with the study team.

We would also like to thank the World Bank resident mission in Dushanbe for their assistance and support to set up meetings for the study team.

2 DISASTERS IN TAJIKISTAN

2.1 NATIONAL SOCIO-ECONOMIC PROFILE

NATIONAL ECONOMY

Tajikistan is a lower middle-income country in the centre of Central Asia. The country is largely mountainous, with 93% of the country being covered by mountains. The population of around 9.3 million people is 75% rural. In 2017, Gross Domestic Product (GDP) was estimated at USD 7.2 billion[1], with GDP per capita at USD 801. Real GDP growth has averaged around 7% in recent years, prior to the COVID19 restrictions.

The country's economic outcome reflects: (i) the legacy of the 1992–97 civil war; (ii) a centralized, state-led approach to economic management; (iii) low domestic productivity, with wages at levels that leave most households exposed to (seasonal) poverty (risks); and (iv) an economy reliant on remittances and imports, with a limited tax base and a nascent private sector.

The main drivers of Tajikistan's economy are remittance inflows (one-third of GDP), cotton and export of metallic minerals, including aluminium, and substantial levels of public investment mostly funded by official development assistance (ODA) inflows. Structural economic challenges include a persistent trade deficit, heavy reliance on remittances, a small and fragile financial sector, and limited internal labour mobility, slow pace of job creation and scarce employment opportunities[2].

Tajikistan remains one of the poorest countries in Central Asia, with a large share of its population dependent on remittances and low-productivity sectors. Extreme poverty, measured by the international poverty line of US$1.90 per day, fell markedly - from 54% in 1999 to 5% in 2015. According to the GoT's own calculations, using a national poverty line, poverty declined, from 82% in 1999 to 29% in 2017.

Rural areas remain significantly poorer than urban areas[3]; with poverty and income insecurity significantly higher during winter and spring months. Non-monetary aspects of poverty remain important contributing factors to Tajik's hardship and lack of opportunity.

Natural disasters and climate change threaten Tajikistan's economic and social development[4]. The country's varied geological, climatologic, and topographic features exacerbate its vulnerability and make it highly susceptible to many natural hazards, including earthquakes, floods, landslides, and avalanches. Between 1992 and 2016, economic losses from natural hazards in Tajikistan exceeded $1.8 billion and affected almost 7 million people[5]. Estimated average annual losses in Tajikistan could reach 1.4% of GDP in the case of floods and 5% of GDP in the case of earthquakes[6].

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[1] The World Bank, Data: Tajikistan https://data.worldbank.org/country/tajikistan
[2] Tajikistan Socio-Economic Resilience Strengthening Program Project Appraisal Document, May 30, 2019
[3] According to the official poverty estimates for 2015, Dushanbe has the lowest poverty rate in Tajikistan (20.4%) followed by Sughd (22.3%). In other regions, the share of the poor population is much higher—35.8% in Khatlon, 37.3% in the Districts of Republican Subordination (DRS), and 39.4% in the Gorno-Badakhshan Autonomous Oblast (GBAO).
[4] World Bank, Reducing Multi-Hazard Risks Across Tajikistan: Protecting Communities Through Quality Infrastructure (Washington, DC: World Bank, 2017)
[5] Centre for Research on the Epidemiology of Disasters, International Disaster Database: http://www.emdat.be
[6] World Bank. 2017. Press Release – Tajikistan. Washington, DC: http://www.worldbank.org/en/news/press-release/2017/07/10/tajikistan-aims-to-better-protect-people-and-property-from-natural-disasters-and-climate-change

POPULATION

Tajikistan's population continues to grow rapidly with 9.314 million residents recorded in 2019[7]. This had grown from 8.352 million in 2014. However, this growth has not been uniform across the country, with the rural population (12%) growing more quickly than urban population (10%). The number of women (14.4%) has also grown significantly more quickly than the number of men (8.6%). This is significant, as rural populations are much more vulnerable to the impacts of disasters, and women often find it more difficult to recover from these impacts.

Table 2-1 below shows the reported change in population by region, for urban and rural populations. This shows significantly lower growth in GBAO, whilst population in Sughd, Khatlon and the Regions of Republican Subordination have grown much more quickly. Whilst there are no doubt many reasons for these patterns, it is notable that the region with the highest risk in terms of natural disasters also has the lowest population growth.

Table 2-1 Population Changes 2018 - 2019[8]

Region	Category	2018	2019	Change
GBAO	Total	223,600	226,900	1.48%
	Urban	29,900	30,300	1.34%
	Rural	193,700	196,600	1.50%
Sughd	Total	2,608,500	2,658,400	1.91%
	Urban	646,200	657,700	1.78%
	Rural	1,962,400	2,000,700	1.95%
Khatlon	Total	3,198,500	3,274,900	2.39%
	Urban	580,600	591,000	1.79%
	Rural	2,617,900	2,683,900	2.52%
Dushanbe	Urban	831,400	846,400	1.80%
RRS	Total	2,069,200	2,120,000	2.46%
	Rural	266,200	271,400	1.95%
	Urban	1,803,000	1,848,600	2.53%

Figure 2-1 and Figure 2-2 below compare the structure of urban and rural populations, by gender. As would be expected, the urban population has a greater proportion of people in the 15 – 40 years categories, with more men than women. In rural areas, women predominate in this age range, reflecting the high degree of domestic and international migration of young men in search of work.

[7] Tajikistan in Figures 2020
[8] Tajikistan in Figures 2020

Figure 2-1 Age Structure of Urban Population, by gender, 2019[9]

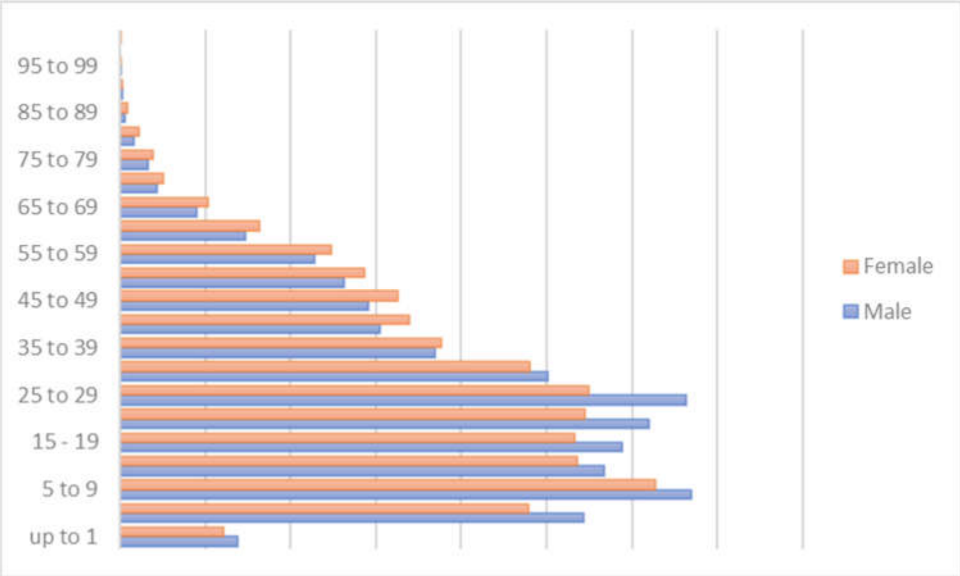
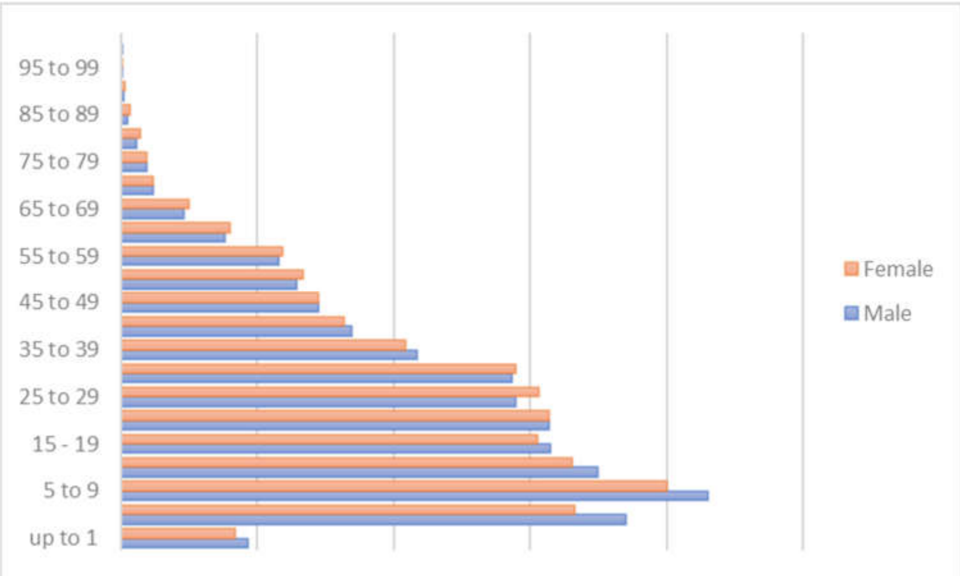


Figure 2-2 Age Structure of Rural Population, by gender, 2019[10]



LIVELIHOODS IN TAJIKISTAN

Work undertaken by USAID and others has identified the predominant types of economic and livelihoods activities across Tajikistan. This has identified 13 broad geographic definitions based around five broad categories, as shown in :

- Agro-industrial (Central and Eastern Tajikistan, Central Khatlon and North Sughd);
- Irrigated agriculture (Western Pamir, Rasht Valley, Southern Khatlon, Penjakent);
- Rainfed agriculture (Southern Khatlon, Gonchi and Istaravshan);
- Livestock based (Eastern Pamir, Eastern and Central Zeravshan, Khatlon Mountains);

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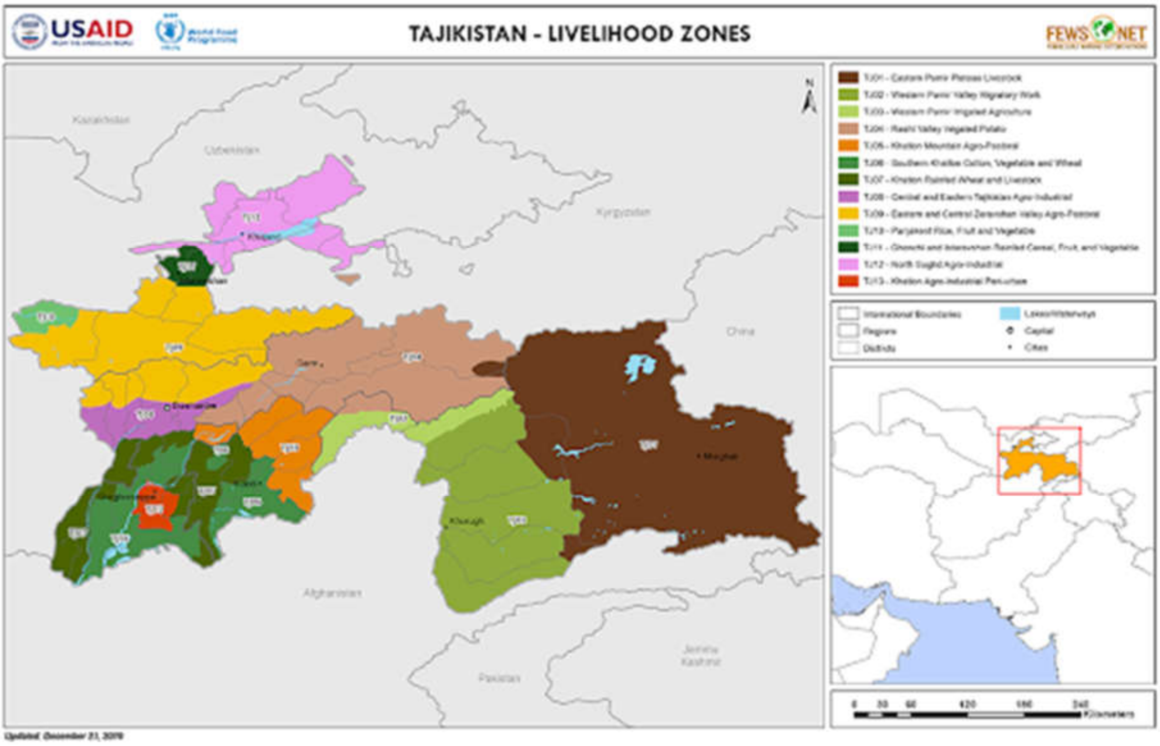
[9] Tajikistan in Figures 2020
[10] Tajikistan in Figures 2020

- Remittances based (Western Pamir).

Figure 2-3 Livelihood Zones in Tajikistan[11]



This work also identifies the key risk factors for livelihoods in each of these areas. In many areas, natural hazards are identified as a key factor determining seasonal and annual poverty. Examples of this include in the Eastern Pamir where "*From October to May, market access is hampered by heavy snow, avalanches and rock falls. If roads are not passable, households reduce their weekly market trips to monthly*". Similarly in the Penjakent area "*Market access within the zone is good, but becomes isolated from major regional markets in the winter due to road blockages. Flooding, mudslides, and hail are the major common shocks faced in the zone*".

INDUSTRY

The industrial sector in Tajikistan is limited both in scope and contribution to the national economy. In common with most of central Asia, the output of most industries declined sharply during the mid-1990s. Despite widespread privatization, in the early 2000s industry rallied very slowly. In 2006, an estimated one-third of Tajikistan's 700 major industrial enterprises were completely idle, and the remainder were operating at 20 or 25% of capacity[12]. As shown in Table 2-2 the industrial sector in Tajikistan has been growing in recent years, particularly in terms of the value of industrial output, although the number of people employed has grown much less quickly.

[11] Livelihoods Zoning 'Plus' Activity in Tajikistan: A Special Report by the Famine Early Warning Systems Network (FEWS NET), January 2011
[12] Tajikistan Institute of Economic Studies

Table 2-2 Industry in Tajikistan[13]

	2014	2015	2016	2017	2018	2019
Number of Industrial Enterprises	2,164	2,310	2,043	1,999	2,161	2,164
Industrial Output (2019 prices) thousand somoni	14,083	15,674	18,182	22,055	24,393	27,613
Annual Growth in Industrial Output	5.0%	11.3%	16.0%	21.3%	10.6%	13.2%

Tajikistan's only major heavy industries are aluminium processing and chemical production. The former, which provided 40% of industrial production in 2005, is centred at the Tursunzoda processing plant, the latter in Dushanbe, Kurgonteppa, and Yavan. Some small light industrial plants produce textiles and processed foods, using mainly domestic agricultural products. The textile industry processes about 20% of domestically grown cotton. Recent investment from China is developing the cotton processing industry[14].

The construction industry, about half of which is state-owned, has suffered from low investment in capital projects and from poor workmanship that has discouraged international contracts. However, new infrastructure projects and increased housing construction has helped this sector to expand. As of 2009, one third of industrial plants and factories were inactive.

The Vakhsh River valley in southern Tajikistan has become a centre of extensive industrial development. The river was dammed at several points to provide water for agriculture and cheap hydroelectric power, which stimulated construction of factories in the area. Many of the plants in the valley process agricultural products or provide agricultural materials such as fertilizer. A large chemical plant also uses power from the Vakhsh[15].

AGRICULTURE

Only 28% of Tajikistan's territory of 14.3 million hectares is agricultural land. Of the total area of agricultural land 21% is arable land, 3% is under perennial crops (orchards and vineyards), and 76% is pastures and hay meadows[16].

Table 2-3 Agricultural Sector in Tajikistan

	2014	2015	2016	2017	2018	2019
Gross Agricultural Output (million somoni)	21,490	22,160	23,321	24,912	25,899	27,750
Plant Cultivation (million somoni)	15,123	15,335	16,117	17,303	17,884	19,280
Animal Husbandry (million somoni)	6,367	6,826	7,204	7,609	8,015	8,471

[13] Tajikistan in Figures 2020
[14] http://www.xinhuanet.com/english/2019-06/13/c_138138259.htm
[15] US Library of Congress, Country Studies
[16] Agriculture in Tajikistan, Statistical Yearbook

Total Sown Area of Agricultural Crops (thousand ha)	828	831	837	837	827	847
Grains and Legumes (thousand ha)	413	423	424	412	375	384
Industrial crops (thousand ha)	208	189	191	203	215	216
Cotton (thousand ha)	178	160	163	174	186	186

Agricultural activity across Tajikistan is not uniform in nature, with different patterns of production in different regions. This reflects the type of land available in each region. Little official information is available regarding production statistics in each region. However, the data included in Table 2-4 shows these differences, in terms of the production of eggs, milk and meat. This shows the relatively low level of organised agriculture in GBAO.

Table 2-4 Agricultural Production 2020[17]

	Eggs (million)	Milk thousand tonnes	Meat thousand tonnes
RRS	206.4	212.7	49.1
Khatlon	85.3	500.9	155.9
Sughd	429.9	269.2	58.6
GBAO	4.1	17.8	8.9

2.2 HISTORIC PATTERNS OF DISASTERS

Tajikistan regularly suffers from a range of natural disasters including avalanches, floods, mudflows and earthquake induced landslides. However, whilst disasters occur every year, the number and severity of disasters varies, apparently randomly, year on year. This is true of both all disasters and those that specifically affect roads. Data from the Committee on Emergency Situations and Civil Defence highlights this issue. Table 2-5, Table 2-6 and Table 2-7 summarise data for the past 3 available years from CoESCD[18].

Table 2-5 Patterns of Disasters 2017 – 2019

Type	2017	2018	2019
Mudflows	19 (20%)	48 (28%)	80 (12%)
Earthquakes	19 (20%)	30 (18%)	25 (4%)
Rockfalls	18 (19%)	44 (26%)	37 (5%)
Avalanches	15 (16%)	8 (5%)	445 (65%)[19]
Floods	8 (9%)	11 (7%)	32 (5%)

[17] Food Security and Poverty No 4 2019, TAJSTAT
[18] Committee on Emergency Situations and Civil Defence, Annual Reviews 2018 and 2019
[19] The reason for this large increase is unclear

Landslides	4 (4%)	8 (5%)	13 (2%)
Strong Winds	5 (6%)	7 (4%)	18 (3%)
Heavy Snowfall	3 (3%)	1 (0.5%)	8 (1%)
Humidity	3 (3%)		
Thunder and Lightning		2 (1%)	1 (0.1%)
Drought		1 (0.5%)	
Mass Poisoning		1 (0.5%)	
Heavy Rains		1 (0.5%)	17 (3%)
Fog		2 (1%)	
Wildfire		1 (0.5%)	
Glacier Movement		1 (0.5%)	4 (0.6%)
Total	94	169	680

There are a large number of locations where disasters have occurred or are likely in the future. A study by OSCE[20] in 2016 identified between 30,000 and 40,000 sites where avalanches may occur across the country. The same study identified 573 mudflow sites, of which 194 were considered to be hazardous.

Disasters of different types occur across Tajikistan, with different types affecting each region. For example, the GBAO region tends to suffer more mudflows, whilst Sughd is more afflicted by avalanches. The number of events affecting each region is affected by many factors, including climate, the occurrence of earthquakes and human activity. Table 2-6 below summarises data from CoESCD.

Table 2-6 Disasters Recorded by Region

Region	2017	2018	2019
Sughd	8%	30%	8%
Khatlon	3%	39%	5%
GBAO	30%	9%	51%
RRS	40%	22%	33%
Dushanbe	19%		4%

Disasters are a well known cause of fatalities across Tajikistan. The number of fatalities that result from disasters vary depending upon the type of disaster. Data suggests that typically more people are killed by avalanches and mudflows and less so by landslides and floods. As with other aspects of

[20] Natural Hazards in Tajikistan, OSCE Technical Report, 2016

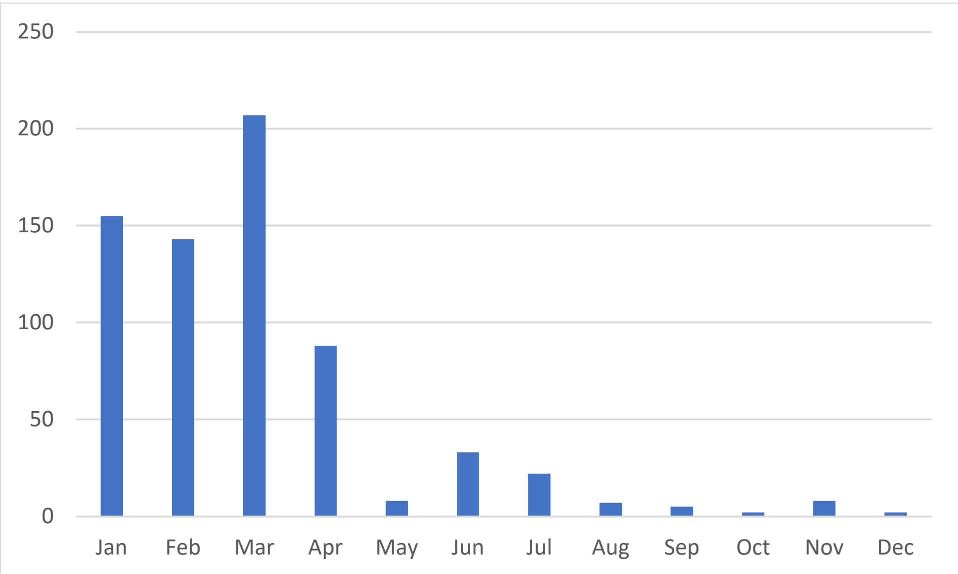
disasters, the number of people killed each year follows no clear pattern, as shown in Table 2-7. No official estimate of the numbers of people injured in disasters is available.

Table 2-7 Numbers Killed by Disasters

Region	2017	2018	2019
Sughd	3	6	7
Khatlon	0	7	2
GBAO	6	0	6
RRS	22	4	6
Dushanbe	0	0	6
Total	31	17	27

Figure 2-4 below shows the pattern of disasters in Tajikistan by month, in 2019. As can be seen, there is a strong concentration of disasters in the winter months, reflecting that the greatest number of disasters were avalanches.

Figure 2-4 Disasters in Tajikistan by Month 2019[21]



2.3 COSTS OF DISASTERS

There are widely varying estimates of the costs of disasters in Tajikistan from a number of different sources. As part of the justification for their ongoing Disaster Risk Management technical assistance project, Asian Development Bank estimated the total economic losses per annum at USD 111 million (Somoni 1.25 billion)[22].

[21] 2019 Overview of Emergency Situations in the Republic of Tajikistan, Committee for Emergency Situations and Civil Defence
[22] National Disaster Risk Management Project: Report and Recommendation of the President, September 2018, Asian Development Bank

Each year the CoESCD also assesses the cost of disasters that affect Tajikistan. These estimates include the costs of damage to infrastructure and a broad estimate of the economic costs of each disaster. These estimates are shown in Table 2-8 below. Whilst no direct measurement is made, CoESCD does estimate that the indirect costs of disasters are likely to be ten times the direct costs.

Table 2-8 Estimated Costs of Disasters (million somoni)

Region	2017	2018	2019
Sughd	4.00 (13%)	13.01 (38%)	11.28 (36%)
Khatlon	4.73 (15%)	19.54 (57%)	13.04 (42%)
GBAO	14.30 (47%)	0.00 (0.1%)	0.84 (3%)
RRS	7.53 (25%)	1.68 (4.9%)	5.93 (19%)
Dushanbe	0	0	0.27 (1%)
Total	30.54	34.35	31.36

2.4 DISASTERS AFFECTING THE ROAD NETWORK

Details of the past disasters that have affected the road network have been drawn from a number of sources, but primarily from unpublished data provided by the Ministry of Transport and the Committee on Emergency Situations and Civil Defence. The MoT records a range of data regarding disasters, which has been used to determine recent trends. CoESCD data has provided an understanding of the disasters reported, and to which it responded, in 2018 and 2019. Table 2-9 summarises the data provided by CoESCD. Annex A details the disasters reported including details of the event and the road affected[23].

Table 2-9 Summary of Disasters Recorded by CoESCD

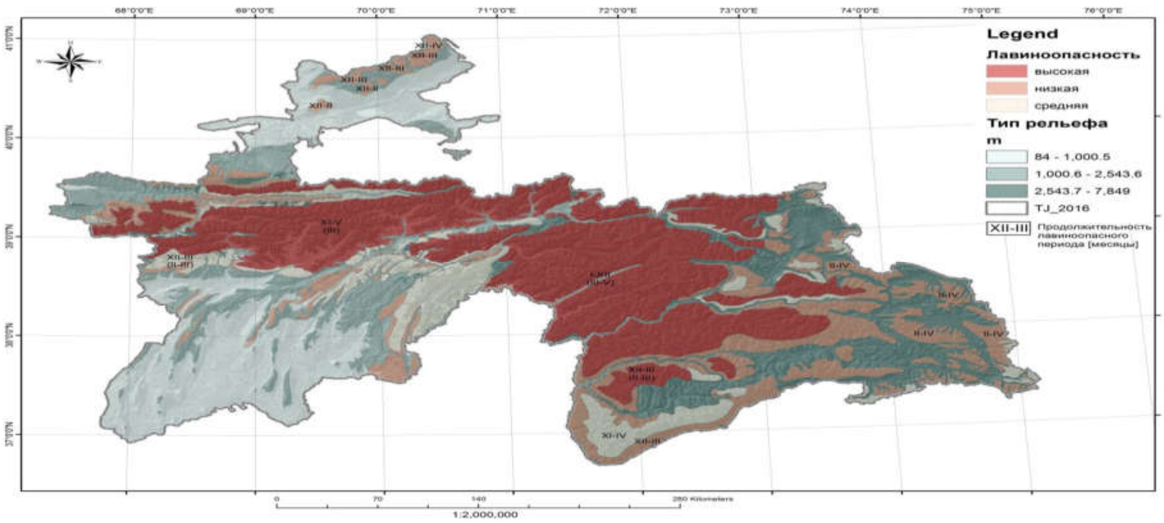
Type	2018	2019
Avalanche	16	44
Rockfall	7	4
Mudflow	5	7
Landslide	4	5
Flooding	0	3
Slope failure	0	1
Total	32	64

It should be noted that disasters affecting the road network are concentrated in certain locations, particularly:

[23] It should be noted that the descriptions provided do not always provide a precise location, making it difficult to identify exactly which road section is involved.

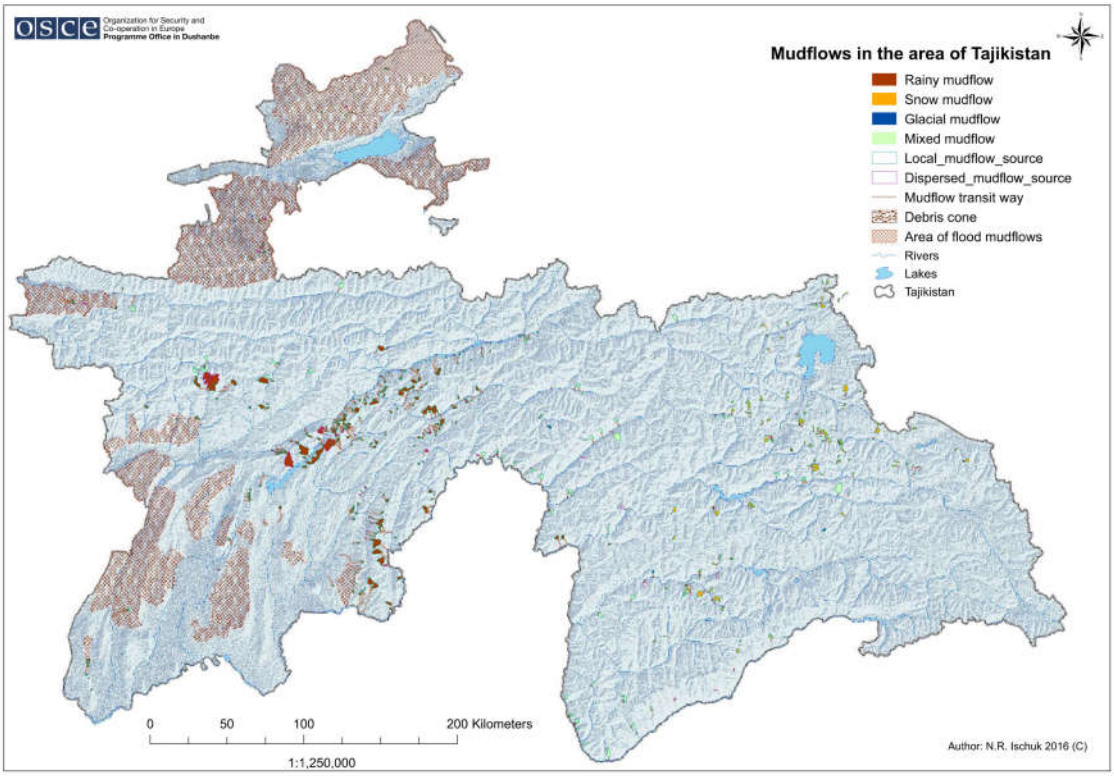
- For avalanches, the northern and western parts of GBAO, most of RRS and the southern parts of Sughd region, as shown in Figure 2-5;

Figure 2-5 Avalanche Risk Map[24]



- For mudflows, the northern parts of Sughd, western and central parts of Khatlon, Rasht Valley and glacier related points in GBAO, as shown in Figure 2-6;

Figure 2-6 Mudflow Risk Map



[24] Natural Hazards in Tajikistan, OSCE Technical Report, 2016

- For flooding, the lower lying parts of Khatlon; and
- For rockfalls and slope failures, across the mountainous parts of the country.

In response to this, a number of organisations have undertaken assessments of hazard risk and monitoring of events. These studies have resulted in a number of feasibility studies and databases, although these are not coordinated, leading to potential definitional issues. However, each of these have been reviewed as part of this study and key lessons integrated into the assessment.

- The Aga Khan Agency for Humanity has been monitoring avalanches in GBAO since 2009. This has been combined with detailed mapping and assessment of avalanche sites across the region;
- The Design Institute has completed assessments of the road sections between Dushanbe and Ayni, and between Labijar and Kalaikumb. These have assessed hazard risks on these road sections to identify the requirements for mitigation;
- Feasibility studies undertaken by a private consultancy highlighting disaster hazards between Ayni and Penjakent. These have identified some mitigation measures and outline costs; and
- Studies completed by the Design Institute of a number of bridge replacement projects in Khatlon region.

No official record of the numbers killed in disasters affecting the road network was made available. However, data collected by the consultancy team suggests that the number of people killed is as shown in Table 2-10 below. As can be seen, the numbers killed vary widely, with no apparent relationship between the number of disasters and the number of fatalities. The figures shown below include road workers killed during their emergency response and repair duties. No estimate of the number of people injured in disasters affecting the road network is available.

Table 2-10 Estimated Number of People Killed in Disasters Affecting the Road Network

Year	Number of fatalities
2009	6
2010	9
2011	0
2012	9
2013	1
2014	1
2015	6
2016	0
2017	16
2018	0
2019	2

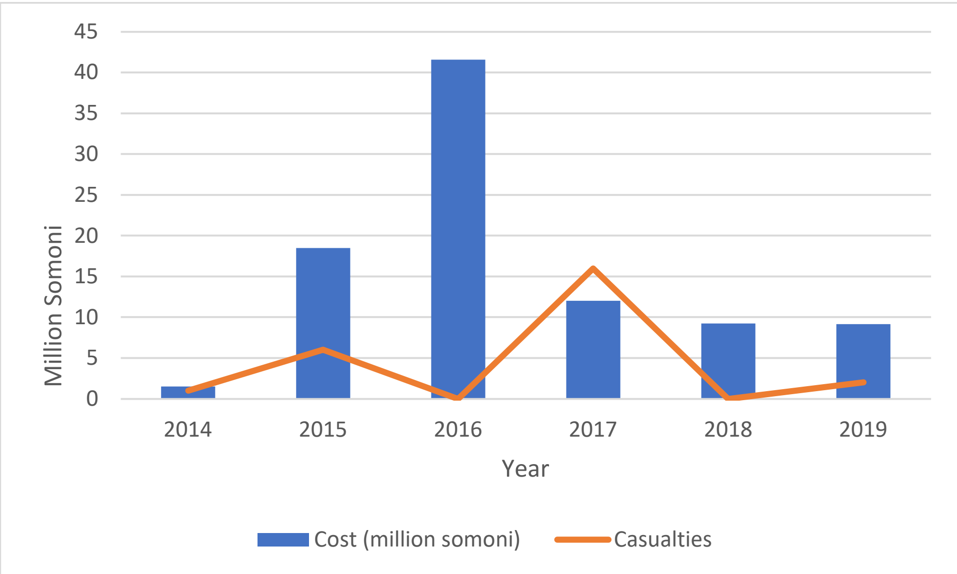
Source: Consultants Estimates

Data provided by the Ministry of Transport can be used to estimate the cost of damage to road infrastructure resulting from disasters. Data for the period 2014 to 2019 (the last complete year available) is shown in Table 2-11 below. These costs vary considerably annually, depending upon the pattern of disasters, although as can be seen in Figure 2-7, there is no direct link between the number of people killed and the costs of repairs.

Table 2-11 Damage and Repair Costs (million somoni)[25]

Total costs	Damage			Repairs			Total	Total
	Roads	Bridges	Pipes	Roads	Bridges	Pipes	Damage	Repair cost
2014	0.941	0.094	0.000	0.460	0.033	0.000	1.035	0.493
2015	3.044	6.300	3.132	0.897	5.080	0.027	12.476	6.004
2016	16.356	23.686	0.016	1.277	0.221	0.020	40.058	1.518
2017	6.080	2.908	0.041	2.957	0.012	0.001	9.029	2.970
2018	6.842	1.452	0.157	0.745	0.003	0.019	8.451	0.767
2019	4.454	1.863	0.698	1.412	0.713	0.022	7.015	2.147

Figure 2-7 Comparison between Total Cost of Damage and Repairs and the Number of Casualties[26]



[25] Unpublished data provided by Ministry of Transport
[26] See Table 2-10 and Table 2-11

3 ASSESSING MITIGATION INTERVENTIONS

3.1 OVERVIEW

A key element of the work undertaken during this study was a series of inspections at hazard sites across Tajikistan's road network. The purpose of the inspections was to identify at risk sites on key roads, assess conditions at each site, and identify potential mitigating measures. Following identification of potential mitigation measures, outline costs were identified to enable the assessment of the overall costs of improving resilience on the road network. The following sections summarise the work undertaken.

3.2 ROAD INSPECTIONS

To provide the data required to assess the overall need for the implementation of mitigation measures a programme of road inspections was completed. This involved visual surveys along a series of agreed road sections. These road sections were selected on the basis of recent patterns of disasters – mudslides, avalanches, flooding and landslides. For each location where it was identified that mitigation interventions may be required, a visual survey was completed, requiring the completion a pro forma describing the topography, infrastructure, environment and land use surrounding each location.

Preparations and completion of the road inspection, collecting the necessary data on natural disasters involved, among other things, the following approach methods:

- Interviews with all local stakeholders, ministries, departments, regional road maintenance organizations, etc ;
- Collection and review of available data, maps, reports and statistics on various natural disasters and hazards;
- Visual inspection and recording of data of natural disaster sites during field trips on selected transport corridors;
- Low-cost Earth observation data (eg satellite imagery, photographs from natural disasters).

The roads inspected are listed in Table 3-1 below and shown in Figure 3-1. This list was agreed with Ministry of Transport in advance of the inspections.

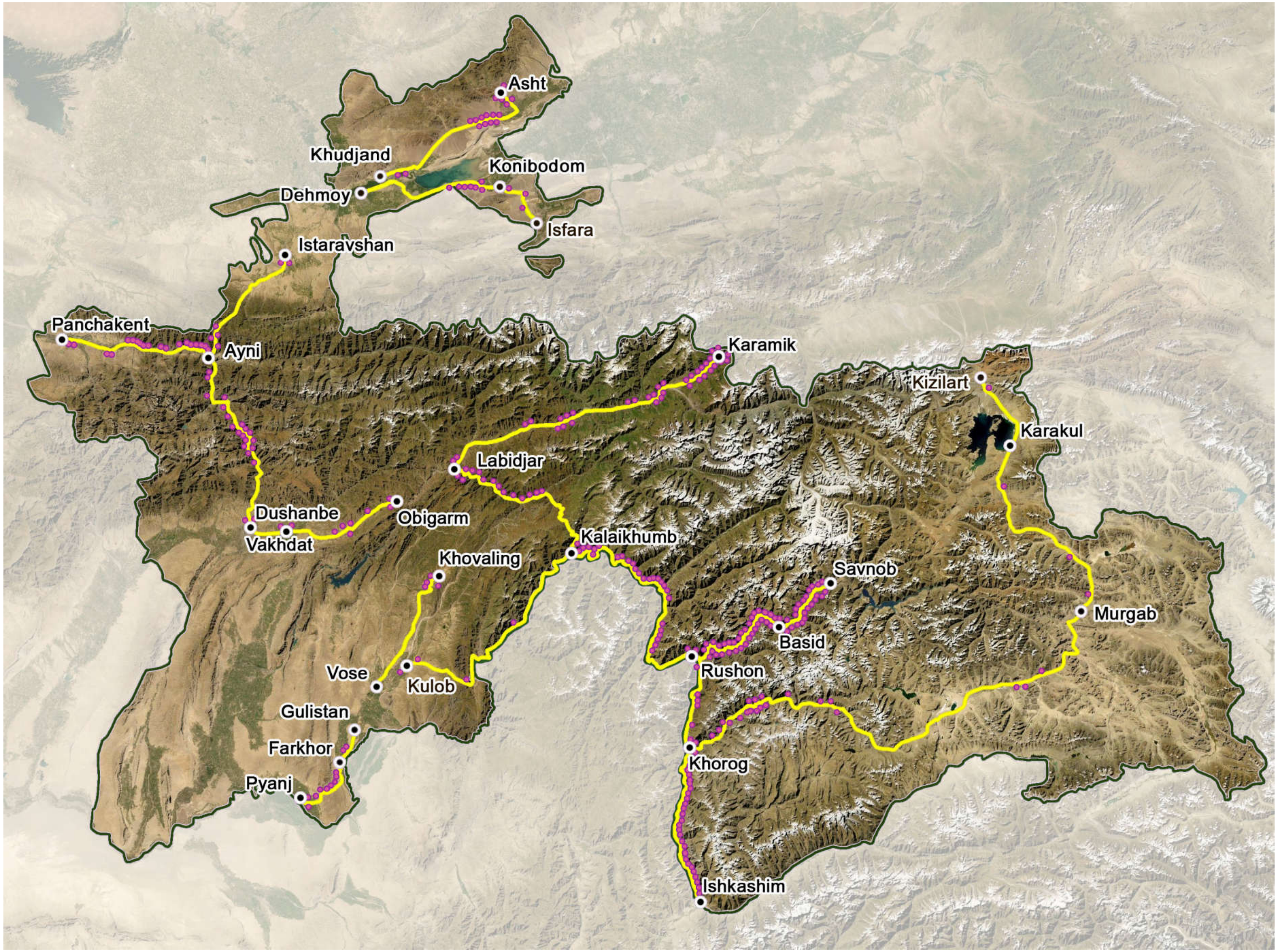
Table 3-1 Roads Included in Road Inspections

Roads Inspected	Number of Individual Sites Inspected
GBAO	
Kalaikumb - Khorog	35
Rushan – Basid – Savnob	80
Khorog - Ishkashim	34
Khorog – Murgab	22
Murgab – Karakul - Kizilart	4
Regions of Republican Subordination	
Labijar - Kalaikumb	20
Vakdat – Obigarm	5
Labijar - Karamik	49

Dushanbe – Ayni[27]	23
Sughd	
Ayni - Penjakent	16
Ayni - Istaravshan	4
Khujand - Asht	13
Dehmoy - Konibodom	8
Konibodom - Isfara	3
Khatlon	
Khovaling – Vose	4
Gulistan - Pyanj	11
Kulob - Kalaikumb	2

[27] The slightly greater part of this road section is located within the Region of Republican Subordination. Hence, for the purposes of this study, this section has been classified under RRS

Figure 3-1 **Locations of Inspection Sites**



3.3 DESCRIPTION OF MAIN HAZARDS ASSESSED

The types of natural disasters assessed have different characteristics and exogenous geological processes, which needed to be taken into account, when drawing up the pro formas. The six main types of hazard are described below.

Earthquake

Tremors and vibrations of the Earth's surface caused by natural causes (mainly tectonic processes) or artificial processes (explosions, filling of reservoirs, collapse of underground cavities of mine workings).

An earthquake is also usually called any vibration of the earth's surface and subsoil, no matter its causes - endogenous or anthropogenic, and whatever its intensity.

Tajikistan is a country with a long history of devastating earthquakes. According to the Database of Large Earthquakes of the Geophysical Service of the Academy of Sciences of the Republic of Tajikistan, the list of the most powerful, destructive earthquakes with large human casualties in the last century includes:

- the 1907 Karatag earthquake with a magnitude of 7.2 on the Richter scale, with a death toll from 12,000 to 15,000;
- the 1949 Hait earthquake with a magnitude of 7.5 on the Richter scale, which destroyed several settlements and killed more than 7,200 people;
- the 1989 Hissar earthquake, which, although it had a magnitude of 5.3 on the Richter scale, caused large landslides that covered the village of Sharora and killed 274 local residents.

The entire territory of the country is subject to earthquake shocks. Zones with the highest seismicity are located in the central and eastern parts of the country. Therefore, seismic loads must be taken into account when designing all infrastructure facilities.

At present, earthquake-resistant design in Tajikistan is based on the ISS design standard ChT 22-07-2007 “Earthquake-resistant construction. Design standards ". The current regulatory document presents requirements for the design of buildings and structures exposed to seismic effects. The manual describes recommendations for measures that will allow buildings or structures to withstand certain damage to individual structural elements, while ensuring the safety of life.

Seismic hazard levels should be considered in the design of both bridge structures and supports to ensure the reliability and stability of these structures in the event of an earthquake. Design of earthquake-resistant structures must be carried out in accordance with local regulations. It is also recommended that controls are carried out in the design of earthquake-resistant structures in accordance with international guidelines such as the Eurocodes, and that both local and international best practices are taken into account in design and construction.

When designing seismic-resistant structures, the following potential seismic hazards should be considered:

- Seismic tremors, including amplification of tremors due to site ground conditions;
- Susceptibility of soil to liquefaction and decrease in its strength;
- Susceptibility of soil to subsidence due to seismic tremors;

- Exposure to slope instability due to seismic tremors; and
- The likelihood of rupture in the plane of the fault and permanent displacement / deformation along the alignment of pre-existing active geologic faults in the area.

A detailed seismic hazard assessment is outside the scope of this study.

Rockfall

Rockfall is a phenomenon that refers to rocks, boulders and large stone masses falling freely from steep mountain slopes and cliffs. During rockfalls, rocks proceed down slopes through combinations of bouncing, flying and rolling. Rockfall is one of the most serious and common hazards in the mountains.

Rockfalls are caused by two primary mechanisms – geology and climate. These include how intact the rock mass is, discontinuities within the rock mass, weathering susceptibility, ground and surface water presence, freeze-thaw action, root-wedging, and external stresses (including human-caused).

Rockfalls occur both on natural as well as artificial slopes such as in mining excavations.

When compiling the risk assessment sheet for Rockfall, the height and shape of the slope, topographic factors and geological conditions were taken into account. The condition of the structure and the presence of anomalies where also considered.

Landslide

The term landslide or less frequently, landslip, refers to several forms of mass wasting that may include a wide range of ground movements, such as rockfalls, deep-seated slope failures, mudflows, and debris flows. However, influential narrower definitions restrict landslides to slumps and translational slides in rock and regolith, not involving fluidisation. This excludes falls, topples, lateral spreads, and mass flows from the definition.

Landslides occur in a variety of environments, characterized by either steep or gentle slope gradients, from mountain ranges to coastal cliffs. Gravity is the primary driving force for a landslide to occur, but there are other factors affecting slope stability that produce specific conditions that make a slope prone to failure. In many cases, the landslide is triggered by a specific event (such as a heavy rainfall, an earthquake, a slope cut to build a road, and many others), although this is not always identifiable.

Mudflow

A mudflow is a form of mass wasting involving very rapid to extremely rapid surging flow of debris that has become partially or fully liquified by the addition of significant amounts of water to the source material.

Mudflows contain a significant proportion of clay, which makes them more fluid than debris flows; thus, they are able to travel farther and across lower slope angles.

Mudflows can occur as a result of intense and prolonged rainfall, rapid melting of glaciers or seasonal snow cover, or high levels of groundwater flowing through cracked bedrock. The point where a muddy material begins to flow depends on its grain size, the water content, and the slope of the topography. Fine grained material can be mobilized by shallower flows than a coarse sediment or a debris flow. Higher water content (higher precipitation/overland flow) also increases the potential to initiate a mudflow. Areas where wildfires or human modification of the land have destroyed vegetation, are at increased risk of mudflows.

When compiling the risk assessment sheet for Mudflow, the properties of the slope, the presence of previous slides, the percentage of vegetated area within the watershed and obvious lines of weakness on the slopes were taken into account. The size of the watershed area was also taken into account.

Avalanches

An avalanche (also called a snowslide) is an event that occurs when a cohesive slab of snow lying upon a weaker layer of snow, fractures and slides down a steep slope. Avalanches are typically triggered in a starting zone from a mechanical failure in the snowpack when the forces of the snow exceed its strength. Avalanches can also be triggered by other loading conditions such as human or biologically related activities. Seismic activity (activities in the earth's crust relating to plate movements) may also trigger the failure in the snowpack and avalanches.

After initiation, avalanches usually accelerate rapidly and grow in mass and volume as they entrain more snow. Although primarily composed of flowing snow and air, large avalanches have the capability to entrain ice, rocks, trees, and other surficial material.

When compiling a risk assessment sheet for Avalanches, factors such as slope property, slope exposure, avalanche type, potential avalanche cone size and potential avalanche characteristics were taken into account. It is worth noting that since the inspections took place in the summer (when snow masses are at a minimum), we were guided mainly by the testimony of eyewitnesses, namely local residents and representatives of road maintenance enterprises of the UAH in each region. In the future, it is necessary to study this natural phenomenon in more detail, to compile and update a summary sheet of avalanches (avalanche passport) for each region.

Flooding

A flood is an overflow of water that submerges land that is usually dry. Flooding may occur as an overflow of water from water bodies, such as a river, lake, or ocean, in which the water overtops or breaks levees, resulting in some of that water escaping its usual boundaries. Alternatively, it may occur due to an accumulation of rainwater on saturated ground in an areal flood. This usually happens either during rainy seasons or in spring due to melting snow.

With regards to rivers, floods occur when the flow rate exceeds the capacity of the river channel. In Tajikistan, melting snow in the mountains in Spring is a huge contributary factor to river flows and hence, flooding. Since the mountains of Tajikistan occupy 93% of the country's territory and accumulate significant volumes of snow during the winter months, river flooding as a result of melting snow during the Spring is a significant risk. .

When compiling the risk assessment sheet for flooding, the following factors were taken into account: the location of the road in relation to the alignment of the river; the height difference between the road level and the average height of the river level (annual); the condition of the road surface, including the shape of the longitudinal and transverse road profile, road surface and anomalies.

Erosion

Erosion is the action of surface processes (such as water flow or wind) that removes soil, rock, or dissolved material from one location on the Earth's crust, before transporting it to another location.

Agents of erosion include rainfall, bedrock wear in rivers, coastal erosion by the sea and waves, as well as glacial plucking, abrasion, and scour.

When compiling the risk assessment sheet for erosion, factors such as soil material, effects on river flow, groundwater, foundations, surface anomalies and others were taken into account.

3.4 SELECTION OF TYPICAL MITIGATION INTERVENTIONS

SCALE OF IMPACT AND TYPES OF MITIGATION MEASURES

As a result of the field trips, natural disasters have been grouped by type as well as by scale of impact on road infrastructure in each case. The scale of impact has been divided into three groups, and measures to mitigate disaster impact have been assigned to each group. Table 3-2 below shows the results of this exercise.

Table 3-2 Scale and Type of Mitigation

Disaster type	Scale of impact and types of mitigation measures		
	Low — 3	Medium — 2	High — 1
Avalanche	Only small-scale measures required: • Install snow retaining barriers	Extensive snow control required: • Install snow retaining barriers	Snow sheltering required: • Construct an anti-avalanche gallery
Erosion	Some bank protection required: • Stabilize slopes with bushes and trees	River training works required: • Construct surface water drain pathways: curbs, trench drains	Road realignment required: • Replace soft/swamp material
Flooding	Drainage works require maintenance: ✓ Clear the existing drainage works, culvert/bridge • Clear the river bed / streams from rock debris	A new cross-drainage required: • Stabilize slopes with gabions and rock paving	The road must be raised: ✓ The road must be raised by 3-4-5 m
Landslide	Soil stabilization required: • Plants along the upside of slopes and landslide-prone slopes	Upside stabilization required: • Install drain pathways to prevent water accumulation in the upper part of the slope	Downside stabilization required: • Construct a gabion retaining wall

Mudflow	Drainage works require maintenance: • Rehabilitate the existing mudflow protection works/structures	New protection structures required: • Construct a large-diameter culvert or a bridge	New protection structures required: ✓ Road realignment; • Construct mudflow protection works
Rockfall	The existing structures require maintenance: • Rehabilitate the existing structures, retaining walls	New protection structures required: • Construct a new retaining wall	Slope stabilization required: ✓ Flexible rock fall protection barriers • Nail grid active system, such as TECCO / SPIDER

Source: Consultants' Research

The final selection of mitigating measure at each location is shown in Annex B of this report.

Table 3-3 below summarises the selections, by road section and type of hazard.

Table 3-3 Summary of Measures Selected by Road Section

Road Section	Avalanche Fences	Avalanche Galleries	Debris Control	Culvert	Road Realignment	Rockfall Barriers	Nail grid	Gabion Wall	Remove Wet Material	Surface Drain	Raise Roadbed	Bridge	Total
Kalaikumb - Khorog	7	9	10	0	0	0	1	6	0	1	0	0	34
Rushan – Basid - Savnob	18	9	10	1	1	4	3	7	0	4	23	0	80
Khorog - Ishkashim	9	6	12	0	0	1	3	5	0	0	0	0	36
Khorog - Murgab	2	9	9	2	0	0	0		0	0	0	1	23
Murgab – Karakul - Kizilart	0	0	2	1	0	0	0		0	1	0	0	4
Labijar - Kalaikumb	0	0	7	7	1	1	0	2	3	0	0	0	21
Vakdat - Obigarm	0	0	2	0	0	0	0	3	0	0	0	0	5
Labijar - Karamik	3	15	8	3	0	5	3	12	0	1	0	0	50
Dushanbe - Ayni	1	14	1	0	0	2	1	3	0	0	0	1	23
Ayni - Penjakent	0	0	3	9	0	2	3	1	0	0	0	0	18
Ayni - Istaravshan	0	3	0	0	0	0	0	1	0	0	0	0	4
Khujand - Asht	0	0	4	8	0	0	0		0	0	0	1	13
Dehmoy - Konibodom	0	0	8	0	0	0	0		0	0	0	0	8
Konibodom - Isfara	0	0	0	3	0	0	0		0	0	0	0	3
Khovaling - Vose	0	0	1	1	0	0	0		1	1	0	0	4
Gulistan - Pyanj	0	0	1	5	0	0	0	2	0	1	1	1	11
Kulob - Kalaikumb	0	0	1	0	0	0	0		0	0	0	0	1
Total	40	65	79	40	2	15	14	42	4	9	24	4	

3.5 COSTS OF DISASTER MITIGATION MEASURES

AVALANCHE GALLERIES

Avalanches inflicting huge financial damage and claiming human lives occur during quite a long period of a year, with varying intensity in different years (in some years, avalanches release in some avalanche catchments several times in a season).

Avalanches are among the most complicated and least studied hazards.

The combination of terrain, climatic, and weather conditions determine the degree of avalanche hazard in any mountainous region.

In Tajikistan, the avalanche hazard period lasts around five months in a year, spanning from December through April, when stable snow cover is formed.

At the same time, the avalanche hazard period ends in March on most road sections. Small erosion channels and trenches get first released from snow. High release frequency is their salient feature. Avalanches release along them during intense snowfalls. Frequent and intense snowfalls are the factor that determines the avalanche frequency. Some small cone volumes may reach tens of thousands of cubic meters by the end of the avalanche hazard period.

Major avalanche catchments release snow much less often (1 to 2 times per season)—some of them do not even release snow every year—but the released volumes may reach hundreds and even millions of cubic meters.

By type of snow, there are wet snow avalanches and very wet snow avalanches since they, as a rule, occur in the midst of thawing.

The following are road sections where the road inspections identified avalanche sites:

- Kalaikumb—Khorog
- Rushan—Basid—Savnob
- Khorog—Ishkashim
- Khorog—Murgab
- Dushanbe—Ayni
- Ayni—Istaravshan
- Labijar—Karamyk

All identified road sections are located in rugged mountain terrain with steep long straight slopes and gorges.

All roads traverse mountain areas, at elevation of 950 to more than 7,000 m, characterized by substantial terrain ruggedness, substantial precipitation in spring and summer, and thick snow cover in winter.

In such a terrain, avalanches release even with little snowfall. When surveying these sections, we identified 103 cases of avalanches of varying thickness even though the inspections took place in summer and autumn (we relied on information provided by the local population as well as representatives of road maintenance enterprises in each region).

These road sections, as well as other areas, witness a big number of avalanches every year which cause road closure.

The past road reconstruction projects in Tajikistan had made their decisions on location, type, and length of avalanche galleries. More than 23 avalanche galleries totalling 3,560.0 linear meters in length have been constructed to date. The practice of operating the constructed avalanche galleries suggests that their insufficient length and incompleteness (no portal walls or cushion backfill) are among their key shortcomings.

The survey of roads undertaken from August through November 2020 by a team composed of the SRD and IMC specialists resulted in a decision to propose measures to mitigate avalanche impact on road infrastructure.

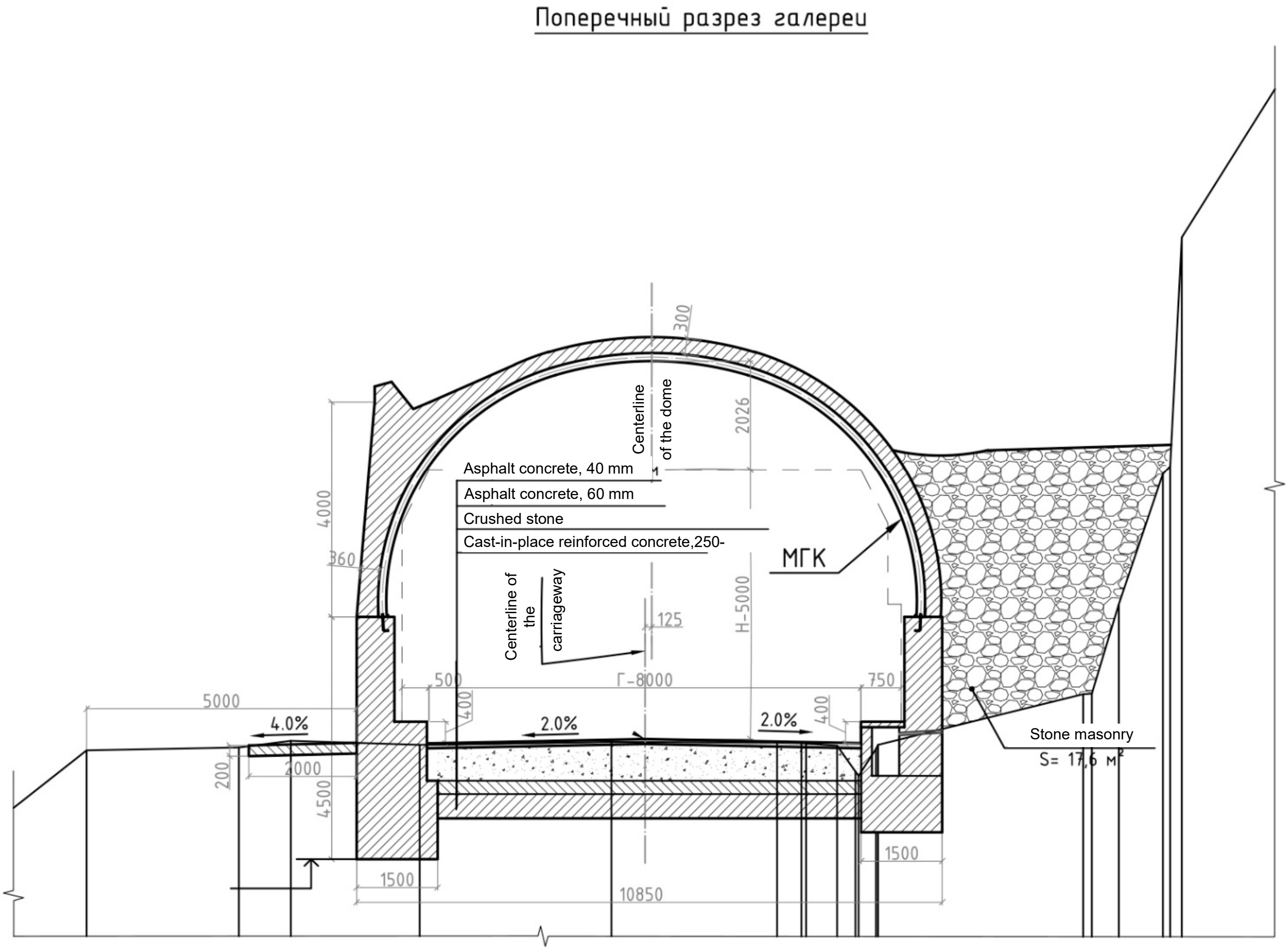
The measures we propose suggest that to ensure uninterrupted and safe traffic along these roads, it is needed to construct avalanche galleries in 65 locations as well as implement activities to mitigate avalanche impact in winter and spring. For the latter, the installation of avalanche retaining screens in 38 identified locations is considered.

The length of the sections prone to geo hazards was identified through the interview of the representatives of road maintenance enterprises who serve these road sections. Specialists with many years of road operation and maintenance experience showed the locations where physical and geological processes and phenomena are common (avalanches, erosion, flooding, landslides, mudflow manifestations, rock falls).

The proformas for some road sections indicate physical and geological processes that occur over big distances. For instance, these are avalanche sites up to 10,000 m long (Khorog—Ishkashim road section, Sta. 58+000 to Sta. 68+000). Avalanches release from every avalanche channel on these sites. However, avalanches do not release all at the same time along the entire site length. Depending on the condition/readiness of snow mass formed as a result of different climatic conditions, avalanches release at different locations and with different snow volumes. Overall, over a few seasons, avalanches release along the entire section but at small gaps. Traffic is disrupted along the entire section.

When choosing avalanche protection works for such sections, one should consider different types of structures, depending on the avalanche parameters to be identified/clarified at the detailed designing stage. It is also recommended to construct avalanche protection structures in phases, depending on the available funding.

Figure 3-2 Cross-Section of the Avalanche Gallery



The type of galleries that were assumed in the estimations is shown in Figure 3-2. Note that galleries with such parameters were assumed for each site where construction is proposed. More detailed estimates and gallery parameters may be produced only after detailed analysis of each case.

The total length of the avalanche galleries is approximately 11,385 m, while the area to install avalanche retaining screens is 60.3 ha (Table 3-5 and Table 3-7 below).

It should be noted that to construct new avalanches, it is required to explore patterns, characteristics of avalanches and snow cover in avalanche starting zones, study avalanche catchment morphology as well as conduct engineering geodetic, geological, and hydrometeorological surveys. They should underpin designs and cost estimates.

When costing the construction of culverts, we considered unit prices of the ongoing or past projects in Tajikistan.

As an example, the unit prices for types of works were taken from the ongoing Aini—Penjakent—Uzbek border road reconstruction project: Contract # 0301-TAJ: Ayni–Penjakent–Uzbekistan border Road approved in 2017 and financed by the Asian Development Bank (ADB) for the Client, i.e., the Ministry of Transport of Tajikistan.

Proposed avalanche gallery construction is illustrated for the Labijar—Karamik road section at Sta. 249+800 where frequent deadly avalanches occurred. We suggest that a gallery be constructed in this location.

Figure 3-3 Illustration of Proposed Avalanche Gallery

BEFORE

AFTER

The cost includes inter alia costs for all materials and their supply, tools, machinery, preparatory works, earthworks, concrete works, asphalt works, finishing works, and workforce.

The total cost of works, including all costs for material supply and works, is based on the unit price of US$ 17,889.5 per linear meter of an avalanche gallery.

The 2017 unit prices for services and materials are outdated and not valid today. In this connection, we factored in the cumulative inflation in Tajikistan for 2017—2020. The cumulative inflation factor for this period is 23.8% as shown in Annex D.

Table 3-4 Items included in the cost of Avalanche Galleries

Item	Description of works	Unit of measurement
100	Preparatory works: removal and stacking of the existing bitumen pavement	m
200	Rock excavation	m
300	Construction of the gravel and sand (or crushed stone) foundation for the structures	m
400	Cast-in-place concrete structures, Concrete Class B15, B25, B35	m
500	Bitumen-based membrane waterproofing of concrete structures' graveled surfaces	m
600	Manufacturing, supply, and installation of culverts	ea.
700	Filling of the back hollow between the gallery wall and the retaining wall, including portal parts, with cement grouted stone masonry	m
800	Construction of the road pavement including subbase, base, and top asphalt layer	m
900	Vertical markings	ea.
1000	Horizontal markings	Linear meter

Table 3-5 Avalanche Galleries Quantities and cost

Avalanche sites				Section length, m	Coordinates	Length of proposed galleries, m	Estimated cost of construction, US$
		Location					
Item	ID No.	Starting station	End station				
Kalaikumb—Khorog							
1	227	Sta. 470+000	Sta. 471+000	1,000	C:38°13'01» B:71°22'36»	450	8,050,275
2	228	Sta. 485+000	Sta. 485+200	200	C:38°05'17» B:71°19'24»	80	1,431,160
3	229	Sta. 502+000	Sta. 502+200	200	C:38°00'59» B:71°17'40»	120	2,146,740
4	230	Sta. 504+000	Sta. 504+200	200	C:37°59'38» B:71°16'53»	80	1,431,160

5	231	Sta. 512+000	Sta. 512+500	500	C:37°58'13» B:71°16'32»	200	3,577,900
6	232	Sta. 565+000	Sta. 565+500	500	C:37°49'24» B:71°35'26»	200	3,577,900
7	233	Sta. 572+000	Sta. 572+200	200	C:37°46'11» B:71°32'38»	80	1,431,160
8	234	Sta. 575+000	Sta. 575+200	200	C:37°42'28» B:71°33'04»	80	1,431,160
9	235	Sta. 586+000	Sta. 586+200	200	C:37°37'23» B:71°31'20»	110	1,967,845
Rushan—Basid—Savnob							
10	251	Sta. 39+000	Sta. 39+500	500	C:38°03'16» B:71°51'49»	200	3,577,900
11	252	Sta. 39+600	Sta. 40+000	400	C:38°03'40» B:71°51'56»	180	3,220,110
12	255	Sta. 54+300	Sta. 54+800	500	C:38°09'17» B:71°57'11»	200	3,577,900
13	257	Sta. 57+100	Sta. 57+300	200	C:38°08'56» B:72°00'07»	80	1,431,160
14	258	Sta. 57+400	Sta. 57+700	300	C:38°08'47» B:72°00'11»	130	2,325,635
15	259	Sta. 62+000	Sta. 62+500	500	C:38°07'36» B:72°02'15»	200	3,577,900
16	260	Sta. 83+000	Sta. 83+500	500	C:38°06'41» B:72°10'35»	200	3,577,900
17	261	Sta. 86+600	Sta. 87+000	1,000	C:38°08'10» B:72°13'01»	400	7,155,800
18	262	Sta. 92+200	Sta. 92+700	500	C:38°09'36» B:72°12'14»	180	3,220,110
Khorog—Ishkashim							
19	263	Sta. 8+000	Sta. 9+000	1,000	C:37°28'08» B:71°31'30»	400	7,155,800
20	264	Sta. 10+000	Sta. 12+000	2,000	C:37°26'04» B:71°30'08»	650	11,628,175
21	271	Sta. 39+000	Sta. 39+200	800	C:37°14'13» B:71°29'04»	220	3,935,690
22	273	Sta. 46+000	Sta. 46+200	200	C:37°11'29.5» B:71°27'50.3»	60	1,073,37
23	274	Sta. 51+000	Sta. 51+100	100	C:37°08'57» B:71°27'02»	50	894,475
24	275	Sta. 61+600	Sta. 63+000	1,400	C:37°04'04»	550	1,930

					B:71°25'52»		
Khorog—Murgab							
25	278	Sta. 642+000	Sta. 642+100	100	C:37°36'00» B:71°44'16»	40	715,580
26	279	Sta. 646+600	Sta. 647+100	500	C:37°37'03» B:71°45'30»	130	2,325,635
27	280	Sta. 649+000	Sta. 649+100	100	C:37°37'33» B:71°45'36»	55	983,922.5
28	281	Sta. 649+700	Sta. 650+100	400	C:37°37'54» B:71°45'44»	160	2,862,320
29	282	Sta. 662+600	Sta. 662+800	200	C:37°42'01» B:71°52'56»	80	1,431,160
30	283	Sta. 663+000	Sta. 663+500	500	C:37°42'12» B:71°53'12»	260	4,651,270
31	284	Sta. 671+000	Sta. 672+000	1000	C:37°42'56» B:71°58'45»	420	7,513,590
32	285	Sta. 690+000	Sta. 690+700	700	C:37°42'20» B:72°24'23»	200	3,577,900
33	286	Sta. 691+200	Sta. 691+500	300	C:37°41'59» B:72°25'36»	80	1,431,160
Dushanbe—Ayni							
34	288	Sta. 48+350	Sta. 48+500	150	C:38°55'57» B:68°48'11»	80	1,431,160
35	289	Sta. 58+200	Sta. 59+100	900	C:39°00'01» B:68°46'14»	210	3,756,795
36	290	Sta. 59+700	Sta. 60+100	400	C:39°00'30» B:68°46'39»	130	2,325,635
37	291	Sta. 60+300	Sta. 60+450	150	C:39°00'46» B:68°46'45»	60	1,073,370
38	292	Sta. 60+550	Sta. 60+750	200	C:39°00'54» B:68°46'48»	75	1,341,712.5
39	293	Sta. 61+800	Sta. 62+000	200	C:39°01'30» B:68°47'06»	60	1,073,370
40	294	Sta. 63+000	Sta. 63+900	900	C:39°02'05» B:68°46'37»	300	5,366,850
41	295	Sta. 64+950	Sta. 65+300	350	C:39°02'22» B:68°45'32»	110	1,967,845
42	296	Sta. 65+400	Sta. 67+000	1,600	C:39°02'30» B:68°45'15»	650	11,628,175

43	297	Sta. 68+200	Sta. 70+000	1,800	C:39°03'06» B:68°44'21»	650	11,628,175
44	298	Sta. 71+000	Sta. 72+000	1,000	C:39°03'36» B:68°43'06»	300	5,366,850
45	299	Sta. 78+900	Sta. 79+000	100	C:39°06'34» B:68°41'12»	40	715,580
46	300	Sta. 80+050	Sta. 80+300	250	C:39°07'11» B:68°41'08»	65	1,162,817.5
47	301	Sta. 120+900	Sta. 121+100	200	C:39°19'07» B:68°32'45»	65	1,162,817.5
Ayni—Istaravshan							
48	302	Sta. 156+000	Sta. 157+000	1,000	C:39°30'04» B:68°33'10»	350	6,261,325
49	303	Sta. 157+900	Sta. 158+100	200	C:39°30'21» B:68°33'11»	55	983,922.5
50	304	Sta. 159+400	Sta. 159+800	400	C:39°30'50» B:68°32'58»	120	2,146,740
Labijar—Karamik							
51	305	Sta. 246+500	Sta. 246+700	200	C:39°11'24» B:71°15'32»	60	1,073,370
52	306	Sta. 249+800	Sta. 250+000	200	C:39°11'57» B:71°16'21»	65	1,162,817.5
53	307	Sta. 256+300	Sta. 256+700	400	C:39°12'31» B:71°19'25»	100	1,788,950
54	308	Sta. 290+900	Sta. 291+000	100	C:39°21'15» B:71°35'47»	45	805,027.5
55	309	Sta. 291+550	Sta. 293+000	1,450	C:39°21'28» B:71°36'12»	460	8,229,170
56	310	Sta. 293+150	Sta. 293+300	150	C:39°22'07» B:71°37'19»	65	1,162,817.5
57	311	Sta. 297+500	Sta. 297+700	200	C:39°21'54» B:71°39'32»	60	1,073,370
58	312	Sta. 303+000	Sta. 303+600	600	C:39°23'35» B:71°42'07»	170	3,041,215
59	313	Sta. 306+800	Sta. 307+000	200	C:39°24'53» B:71°43'22»	40	715,580
60	314	Sta. 307+350	Sta. 307+500	150	C:39°24'56» B:71°43'51»	55	983,922.5
61	315	Sta. 308+600	Sta. 308+900	300	C:39°25'51» B:71°44'39»	80	1,431,160

62	316	Sta. 310+000	Sta. 310+500	500	C:39°26'04» B:71°44'48»	85	1,520,607.5
63	317	Sta. 311+200	Sta. 311+800	600	C:39°26'18» B:71°44'56»	120	2,146,740
64	318	Sta. 313+500	Sta. 313+700	200	C:39°27'02» B:75°45'41»	60	1,073,370
65	322	Sta. 315+600	Sta. 315+800	200	C:39°27'32» B:71°47'02»	75	1,341,712.5
						Total length:	11,385 m
						Cost:	$ 203,671,957.5
						Cost adjusted for the 2017—2020 cumulative inflation	$ 267,523,116.18

SNOW BARRIERS SPIDER® AVALANCHE

Given that Tajikistan's avalanche protection measures were limited only to the construction of avalanche galleries, we propose new solutions based on the experience of foreign companies specialized in confronting the impact of natural hazards on road infrastructure.

When choosing impact mitigation measures, we approached Geobrugg, a firm that produces structures using cutting-edge technologies.

Geobrugg is a leading global designer and producer of protection systems made from high-tensile steel wire. The systems are used to ensure engineered protection against hazards such as rock avalanches, scree, rock falls, landslides, mudflows, and snow avalanches as well as ensure safety of the population and infrastructure in civil engineering, mining, tunnels and metros, sports facilities including motor race tracks, and test sites.

Our prioritization of Geobrugg is justified. Over decades, Geobrugg has been a pioneer in avalanche protection, with its headquarters located in the Swiss Alps. The engineered protection systems have been specifically designed for installation in avalanche starting zones in close collaboration with Swiss and international research institutes. Snow barriers SPIDER® AVALANCHE do not only offer protection against snow avalanches: tests showed that the system is effective in protecting against rock avalanches and rock falls.

The advantages of these protection systems are many, including:

1. Light structures: cost-effective installation, manually or by a helicopter, implying time and cost efficiency owing to low weight of the structures. If being installed by a helicopter, up to three posts and three main nets can be transported in each rotation.
2. Gap-free structures: uncompromising safety as the system retains snow masses and rocks, thus offering solid protection against avalanches and rock falls.
3. High-tensile mesh against multiple hazards such as rock falls, rock avalanches, and scree since, apart from their main function, snow barriers SPIDER® AVALANCHE are stable and offer protection against rock falls with energies up to 500 kJ.

4. Pressure plates instead of foundations: a universal system with minimum anchoring costs as supports can be installed on the pressure plates and the barrier geometry can be adjusted to the terrain of avalanche starting zones.

A snow barrier structure made from high-tensile spiral rope nets (SPIDER® Avalanche) is based on, and certified in line with, the globally recognized and strictest standards for defense structures issued by the Swiss Institute for Snow and Avalanche Research (SLF, Davos) as part of the Swiss Federal Office for the Environment (BAFU).

The cost of installing snow barriers SPIDER® Avalanche is EUR 1 mln per ha in avalanche starting zones, and it includes five lines of snow barriers SPIDER® Avalanche 100 m each + mounting in an avalanche starting zone).

The prices have been provided by *Geobrugg* as of 2021.

The tentative cost of constructing snow barriers SPIDER® Avalanche is US$ 71,127,468.

The snow barrier structure and its components are shown in detail in Figure 3-4 below.

Figure 3-4 **Components of the SPIDER® AVALANCHE system**

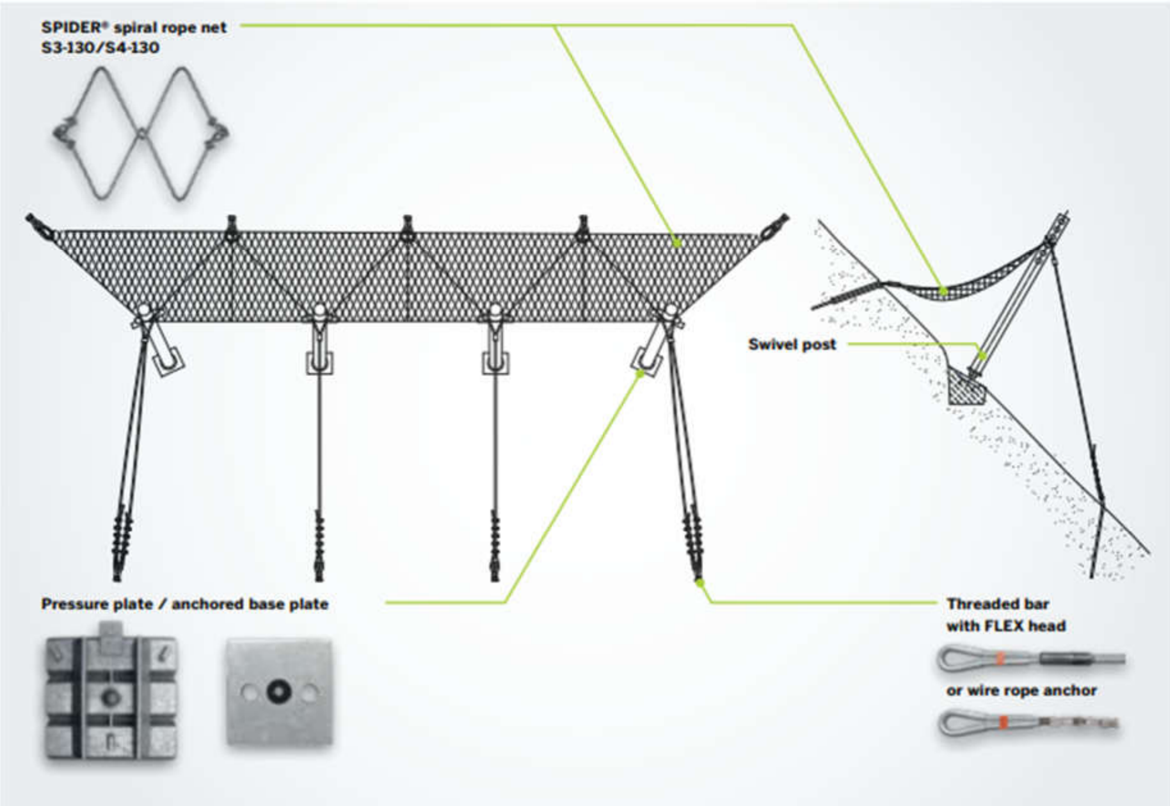


Table 3-6 **Items included in the cost of snow barriers**

Item	Description of works	Unit of measurement
100	Manufacturing of structures	ea.
200	Delivery of structures and materials	ea.
300	Slope preparation: topsoil clearing, rock scaling on unstable slopes	m²

400	Installation of snow barriers (five lines of snow barriers SPIDER Avalanche 100 m each) + additional helicopter costs	ha

An illustrative example of such a site is the identified Khorog—Karakul road section at Sta. 671+000. We suggest that snow barriers be installed in the upside of the slope to ensure protection against avalanches.

Figure 3-5 Illustration of Proposed Snow Barriers

BEFORE

AFTER

Table 3-7 Snow Barriers Quantities and cost

Avalanche starting zones				Section length, m	Coordinates	Starting zone area, ha	Estimated cost of construction, US$
Item	ID No.	Location					
		Starting station	End station				
Kalaikumb—Khorog							
1	220	Sta. 385+000	Sta. 385+400	400	C:38°28'40" B:70°56'45"	2	2,000,000
2	221	Sta. 395+000	Sta. 395+300	300	C:38°26'13" B:71°02'18"	1.5	1,500,000
3	222	Sta. 408+000	Sta. 408+500	500	C:38°25'27" B:71°05'31"	2.5	2,500,000
4	223	Sta. 442+000	Sta. 442+100	100	C:38°21'15" B:71°10'59"	0.8	800,000
5	224	Sta. 443+000	Sta. 443+100	100	C:38°21'11" B:71°11'02"	0.65	650,000
6	225	Sta. 460+000	Sta. 461+100	1,100	C:38°20'22" B:71°12'21"	5	5,000,000
7	226	Sta. 466+800	Sta. 467+100	300	C:38°14'45" B:71°22'31"	0.8	800,000
Rushan—Basid—Savnob							
8	236	Sta. 8+900	Sta. 9+000	100	C:37°59'33" B:71°38'57"	0.6	600,000
9	237	Sta. 10+000	Sta. 10+500	500	C:37°59'59" B:71°39'24"	1.2	1,200,000
10	238	Sta. 11+000	Sta. 11+400	400	C:38°00'07" B:71°39'39"	1.2	1,200,000
11	239	Sta. 12+000	Sta. 12+500	500	C:38°00'24" B:71°40'24"	1.8	1,800,000
12	240	Sta. 13+400	Sta. 13+840	440	C:38°00'05" B:71°41'28"	1.6	1,600,000
13	241	Sta. 15+900	Sta. 16+000	100	C:37°59'42" B:71°41'56"	0.4	400,000
14	242	Sta. 19+000	Sta. 19+500	500	C:37°58'29" B:71°44'07"	1.7	1,700,000
15	243	Sta. 20+000	Sta. 20+300	300	C:37°58'40" B:71°44'13"	0.8	800,000
16	244	Sta. 21+700	Sta. 22+000	300	C:37°59'31" B:71°44'08"	0.8	800,000

17	245	Sta. 23+000	Sta. 23+500	500	C:37°59'57" B:71°45'11"	2.1	2,100,000
18	246	Sta. 27+300	Sta. 27+500	200	C:37°59'44" B:71°47'09"	0.8	800,000
19	247	Sta. 28+000	Sta. 28+500	500	C:38°00'00" B:71°47'40"	1.8	1,800,000
20	248	Sta. 29+000	Sta. 29+500	500	C:38°00'23" B:71°48'15"	1.8	1,800,000
21	249	Sta. 30+000	Sta. 30+500	500	C:38°00'28" B:71°48'50"	2.1	2,100,000
22	250	Sta. 34+000	Sta. 34+200	200	C:38°01'05" B:71°50'52"	0.65	650,000
23	253	Sta. 42+300	Sta. 42+500	200	C:38°04'14" B:71°53'11"	0.65	650,000
24	254	Sta. 48+000	Sta. 48+500	500	C:38°06'28" B:71°55'42"	0.65	650,000
25	256	Sta. 56+800	Sta. 56+900	100	C:38°09'02" B:71°59'56"	0.4	400,000
Khorog—Ishkashim							
26	265	Sta. 14+000	Sta. 14+200	200	C:38°25'06" B:71°29'50"	0,85	850,000
27	266	Sta. 15+000	Sta. 15+300	300	C:37°24'40" B:71°29'59.8"	0,85	850,000
28	267	Sta. 18+000	Sta. 18+200	200	C:37°23'47" B:71°28'41"	0,55	550,000
29	268	Sta. 24+000	Sta. 24+200	200	C:31°21'21" B:71°29'36"	0,5	500,000
30	269	Sta. 30+000	Sta. 31+000	1,000	C:37°18'25" B:71°30'14"	3,5	3,500,000
31	270	Sta. 34+000	Sta. 34+300	300	C:37°16'03" B:71°29'27"	0,75	750,000
32	272	Sta. 42+000	Sta. 44+000	2,000	C:37°12'42" B:71°27'22"	6	6,000,000
33	276	Sta. 634+000	Sta. 635+000	1,000	C:37°32'26" B:71°40'27"	3,5	3,500,000
34	277	Sta. 637+000	Sta. 639+000	2,000	C:37°33'33" B:71°43'11"	6,5	6,500,000
Dushanbe—Ayni							
35	287	Sta. 48+200	Sta. 48+350	150	C:38°55'37"	1	1,000,000

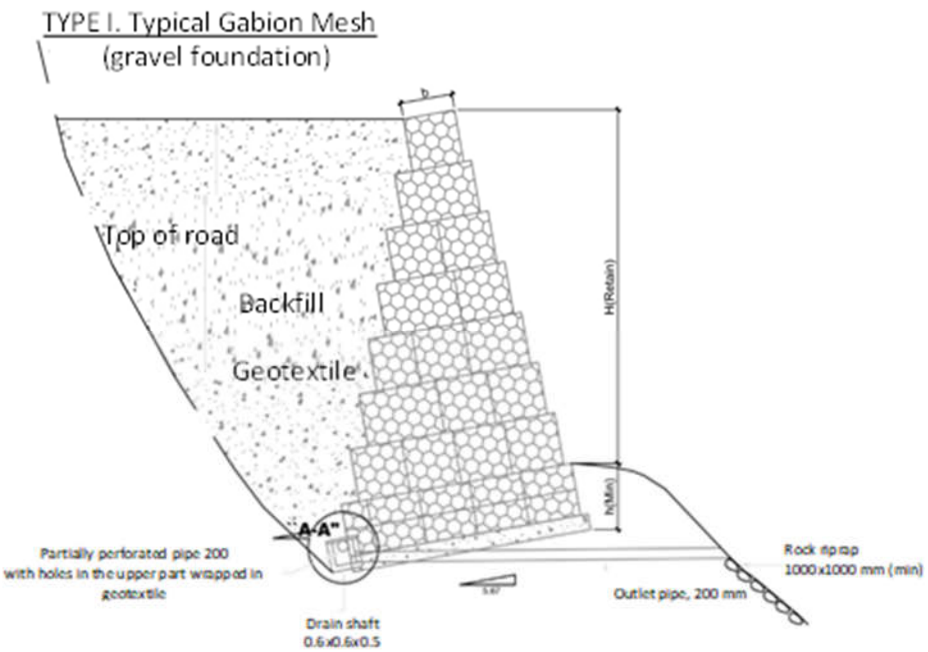
					B:68°48'12"		
Labijar—Karamik							
36	319	Sta. 313+900	Sta. 314+000	100	C:39°27'09" B:71°45'56"	0.55	550,000
37	320	Sta. 314+350	Sta. 314+500	150	C:39°27'13" B:71°46'07"	0.7	700,000
38	321	Sta. 314+800	Sta. 315+000	200	C:39°27'22" B:71°46'33"	0.75	750,000
Total area:						60.3 ha	
Cost:						$ 71,127,468	

GABION RETAINING WALLS

When costing the construction of gabion retaining walls, we considered unit prices used in similar ongoing or past projects in Tajikistan.

As an example, the unit prices for types of works were taken from the ongoing Dushanbe—Kurgan-Tyube road reconstruction project: <u>Contract No: CP-01: Rehabilitation and Improvement of the Dushanbe – Kurgonteppa Road</u> approved in 2017 and financed by the Asian Development Bank (ADB) for the Client, *i.e.,* the Ministry of Transport of Tajikistan.

The gabion retaining wall cubature depends on wall's height and width. Notably, the higher the wall is, the wider its base will be. The data is presented in Table 3-10.



The cost includes inter alia costs for all materials and their supply, including a gabion cage, gabion mattress, tools, machinery, preparatory works, earthworks, installation of gabion cages, finishing works, and workforce.

Gabions must meet the following requirements:

1. Gabions to be made from reinforced wire mesh of Class AI Ø4 and net Ø3.0 mm.
2. Gabions to be bound together with fastening wire Ø2.5 mm.
3. Gabion mesh cells to be 80x100 mm.
4. Boulders with high specific weight of solid impervious rocks to be used to fill gabions.
5. The used stones must be 1.5 to 2 times bigger than the gabion cells but not exceeding 250 mm.
6. The density of gabion fill must be at least 1,400/m².

The total cost of works, including all costs for material supply and works, is based on the unit price of US$ 76.3 per cubic meter. The total cubature is 59,420 m3.

A proposed gabion retaining wall is illustrated in Figure 3-6 below, for the Labijar—Karamik road section at Sta. 313+400 to protect against rock falls.

Figure 3-6 Illustration of a proposed Gabion Wall

BEFORE

AFTER

Table 3-8 Gabion Wall dimensions

Item	Wall body height, m	Foundation height, m	Upside wall width, m	Downside wall width, m	Wall cubature, m
1	1	0.5	1	1.5	1.5
2	1.5	0.5	1	1.5	2.5
3	2	0.5	1	2	3.75
4	2.5	0.5	1	2	4.5
5	3	1	1	2.5	7
6	4	1	1	3	10
7	5	1	1	3.5	13.5
8	6	1	1	4	17.5
9	7	1	1	4.5	22

Table 3-9 Items included in the cost of Gabions

Item	Description of works	Unit of measurement
100	Soil excavation for the foundation pit	m
200	Layout and compaction of the pit bottom	m
300	Installation of gravel bedding under the gabion	m
400	Installation of geotextile, density is 200-300 g/m2 (with overlap of 10%)	m
500	The installation of gabion meshes	m

600	Filling of the gabion cages with boulders 120-200 mm (not exceeding 250 mm)	m
700	Drainage gravel backfill behind the gabion walls	m

Table 3-10 Gabion Walls Cost of works

Gabion retaining wall								
Item	ID No.	Location		Section length, m	Coordinates	Length of proposed wall, m	Wall height, m	Wall cubature, m3
		Staring station	End station					
Kalaikumb—Khorog								
1	2	Sta. 365+000	Sta. 365+250	250	C:38°27'34" B:70°51'26"	130	2,5	585
2	3	Sta. 442+000	Sta. 443+000	1,000	C:38°21'18" B:71°10'57"	200	3	1,400
3	5	Sta. 460+470	Sta. 460+800	330	C:38°16'11" B:71°21'37"	110	3	770
4	6	Sta. 463+000	Sta. 464+000	1,000	C:37°11'01" B:71°22'19"	250	2	937.5
5	7	Sta. 575+000	Sta. 576+000	1,000	C:37°42'28" B:71°33'04"	260	3	1,820
6	76	Sta. 423+000	Sta. 424+000	1,000	C:38°25'30" B:71°05'56"	500	3	3,500 9,012.5
Khorog—Ishkashim								
7	9	Sta. 18+000	Sta. 19+000	1,000	C:37°23'29" B:71°28'38"	335	2.5	837.5
8	10	Sta. 30+000	Sta. 31+000	1,000	C:37°18'18" B:71°30'07"	400	2.5	1,000
9	11	Sta. 31+000	Sta. 34+000	3,000	C:37°17'04" B:71°29'44"	900	3	2,700
10	13	Sta. 58+000	Sta. 68+000	10,000	C:37°04'54" B:71°26'03"	2,800	2	5,600
11	85	Sta. 46+000	Sta. 47+000	1,000	C:37°11'50" B:71°27'40"	600	2	1,200 11,337.5
Ayni—Penjakent								

12	27	Sta. 5+300	Sta. 5+800	500	C:39°26'39" B:68°29'00"	140	2.5	630
Labijar—Karamik								
13	40	Sta. 308+600	Sta. 308+900	300	C:39°25'51" B:71°44'39"	80	3	560
14	41	Sta. 310+000	Sta. 311+000	1,000	C:39°26'08" B:71°44'51"	240	3	1,680
15	71	Sta. 175+000	Sta. 175+500	500	C:39°04'28" B:70°30'59"	250	2	937.5
16	72	Sta. 191+500	Sta. 193+000	1,500	C:39°05'15" B:70°40'30"	800	2	3,000
17	73	Sta. 198+050	Sta. 199+000	950	C:39°05'20" B:70°44'05"	560	2	2,100
18	93	Sta. 299+400	299+700	300	C:39°22'29" B:71°40'27"	200	2	750
19	94	Sta. 302+800	Sta. 303+000	1,000	C:39°23'28" B:71°42'09"	500	2	1,375
20	95	Sta. 304+600	Sta. 304+800	200	C:39°24'08" B:71°42'45"	150	3	1,050
21	96	Sta. 305+700	Sta. 306+000	300	C:39°24'40" B:71°43'07"	180	3	1,260
22	97	Sta. 308+050	Sta. 308+400	650	C:39°25'11" B:71°44'20"	300	2,5	1,350
23	98	Sta. 310+000	Sta. 310+500	500	C:39°26'04" B:71°44'48"	200	2,5	900
24	99	Sta. 312+000	Sta. 313+000	1,000	C:39°26'34" B:71°45'09"	400	2	1,500 17,092.5
Labijar—Kalaikumb								
25	43	Sta. 67+300	Sta. 67+600	300	C:38°43'56" B:70°35'54"	160	2	600
26	70	Sta. 167+850	Sta. 168+100	250	C:39°03'21" B:70°26'30"	170	2	637.5 1,237.5
Rushan—Basid—Savnob								
27	16	Км 16+500	Км 16+800	300	C:37°59'17" B:71°42'41"	150	2	562.5
28	49	Sta. 39+300	Sta. 40+000	700	C:38°03'30" B:71°51'52"	300	2	1,125
29	51	Sta. 48+200	Sta. 49+000	800	C:38°06'31"	400	2	1,500

					B:71°55'44"			
30	79	Sta. 27+000	Sta. 28+000	1,000	C:37°59'55" B:71°47'30"	400	3	2,800
31	80	Sta. 72+300	Sta. 72+800	500	C:38°09'38" B:72°12'15"	200	3	1,400
32	83	Sta. 92+000	Sta. 92+500	500	C:38°09'38" B:72°12'15"	240	2,5	1,080
33	84	Sta. 93+000	Sta. 93+300	300	C:38°11'00" B:72°13'09"	150	2	562.5 8,467.5
Dushanbe—Ayni								
34	86	Sta. 85+300	Sta. 85+500	500	C:39°09'19" B:68°38'58"	300	2	1,125
35	87	Sta. 89+000	Sta. 89+300	300	C:39°10'43" B:68°37'39"	160	2	600
36	88	Sta. 95+800	Sta. 96+100	300	C:39°12'04" B:68°37'33"	230	3	1,610
Ayni—Istaravshan								
37	89	Sta. 138+100	Sta. 139+000	900	C:39°25'03" B:68°31'02"	550	2	2,062.5
Vakdat—Obigarm								
38	90	Sta. 39+900	Sta. 40+500	500	C:38°34'37" B:69°24'42"	160	2	600
39	91	Sta. 40+400	Sta. 40+800	400	C:38°34'57" B:69°25'02"	150	2	562.5
40	92	Sta. 65+800	Sta. 67+000	1,200	C:38°42'12" B:69°38'56"	600	2	2,250
Guliston—Pyanj								
41	100	Sta. 82+500	Sta. 83+000	500	C:37°13'48" B:69°11'22"	200	3	1,400
42	101	Sta. 225+000	Sta. 226+000	1,000	C:37°48'18" B:70°08'46"	400	2	1,500 11,710
Total cubature:							59,420 м	
Total cost:							$ 4,533,746	
Cost adjusted for the 2017—2020 cumulative inflation:							$ 5,612,777.55	

FLEXIBLE ROCK FALL PROTECTION BARRIERS

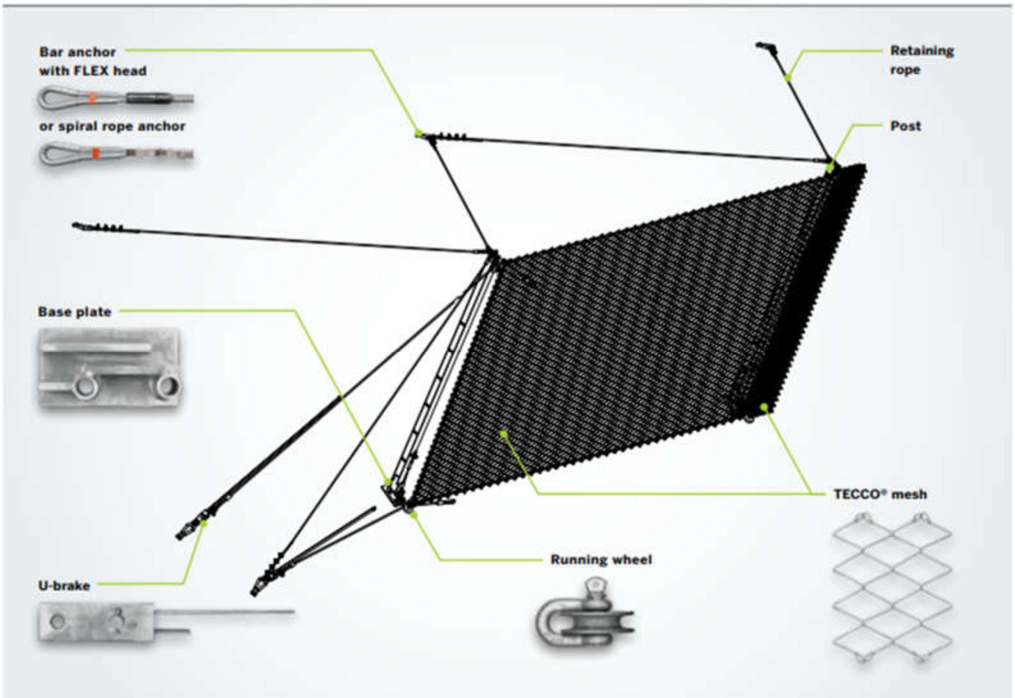
The key principle of rock fall protection barriers is rock fall energy dissipation by means of an elastic net and braking elements, with further load transfer to the anchors and soil. Key factors that determine structural characteristics of each barrier are maximum kinetic energy of rocks and associated height of predicted rock rebound.

The GBE barriers meet the strictest safety standards. The unique structure of barriers sheds extremely low loads onto the anchors even for the strongest impacts with kinetic energy up to 3,000 kJ. Coupled with the ease of installation, this feature makes the GBE barrier series an outstandingly reliable and economical solution. The GBE barriers of 100 to 3,000 kJ are delivered to the construction site in a pre-assembled form for ultrafast installation. Barriers of these energy levels meet the ETAG 027 standards for the highest A Category.

The cost of the GBE® barriers is EUR 500 to 10,000 per linear meter, depending on the energy level.

The prices have been provided by Geobrugg as of 2021. For calculations, we used an average cost of US$ 800 per linear meter of a barrier.

Figure 3-7 Components of the GBE-1000A barrier



A flexible rock fall protection barrier is illustrated in

Figure 3-8 below for the Rushan—Basid—Savnob road section at Sta. 30+150.

Figure 3-8 Illustration of Rock Fall Protection Barrier

BEFORE

AFTER

Table 3-11 Items included in the cost of Rock Fall Protection Barriers

Item	Description of works	Unit of measurement

100	Manufacturing of structures	ea.
200	Delivery of structures and materials to the site	ea.
300	Slope preparation: topsoil clearing, rock scaling on unstable slopes	м²
400	Drilling for anchors, foundation casting and anchoring	ea.
500	Preparation of posts: retaining ropes, rods	ea.
600	Installation of flexible rock fall protection barriers GBE®	linear meter

Table 3-12 Flexible Rock Fall Barriers Quantities and cost

Flexible rock fall protection barriers GBE®						
Item	ID No.	Location		Section length, m	Coordinates	Length of proposed barrier, m
		Starting station	End station			
Labijar—Kalaikumb						
1	1	Sta. 12+000	Sta. 12+200	200	C:38°49'48" B:70°12'16"	110
Khorog—Ishkashim						
2	15	Sta. 89+500	Sta. 91+000	500	C:36°50'46" B:71°32'37"	200
Rushan—Basid—Savnob						
3	17	Sta. 25+000	Sta. 25+500	500	C:39°00'07" B:71°46'18"	200
4	18	Sta. 26+600	Sta. 26+800	200	C:37°59'40" B:71°46'56"	80
5	19	Sta. 28+000	Sta. 29+000	1,000	C:39°00'05" B:71°47'49"	300
6	20	Sta. 30+150	Sta. 30+400	250	C:38°00'29" B:71°49'02"	180
Dushanbe—Ayni						
7	25	Sta. 115+300	Sta. 116+000	700	C:39°16'42" B:68°32'37"	320
8	26	Sta. 118+900	Sta. 122+000	3,100	C:39°19'03" B:68°32'26"	800
Ayni—Penjakent						
9	30	Sta. 24+950	Sta. 25+100	150	C:39°26'31" B:68°19'23"	75

10	32	Sta. 153+000	Sta. 153+400	400	C:39°19'03" B:68°02'24"	230
Labijar—Karamik						
11	33	Sta. 233+700	Sta. 235+500	1,800	C:39°10'17" B:68°02'24"	690
12	34	Sta. 236+000	Sta. 236+300	300	C:39°10'41" B:71°08'10"	190
13	35	Sta. 264+900	Sta. 265+200	300	C:39°15'58" B:71°22'13"	100
14	39	Sta. 305+000	Sta. 306+080	1,080	C:39°24'40" B:71°43'07"	750
15	42	Sta. 313+400	Sta. 314+000	600	C:39°26'57" B:71°45'37"	260
					Total length:	4,755 m
					Cost:	$ 3,804,000

ROCK FALL DRAPES, NAIL GRID SYSTEM TECCO / SPIDER

The nail grid system is suitable to stabilize any slope, irrespective of its steepness or geological structure. Selection of parameters and tests are done in the software RUVOLUM® that was developed taking into account all specificities of the TECCO® and SPIDER® systems. Coupled with either of three different sized spike plates, these types of systems allow substantially increasing the distance between nails within the nail field and reducing the slope stabilization costs manifold without compromising quality.

TECCO® (for slopes composed of loose soils) or SPIDER® (for slopes composed of weathered rocks) are systems based on high-tensile steel wire mesh with a tensile strength of more than 1770 N/mm² used together with nails to stabilize slopes. The system fully meets the EAD 230025-00-0106 standard (European Assessment Document – guarantee for the compliance of construction materials with claimed properties certified by minimum three test-in-situ results at scale 1:1).

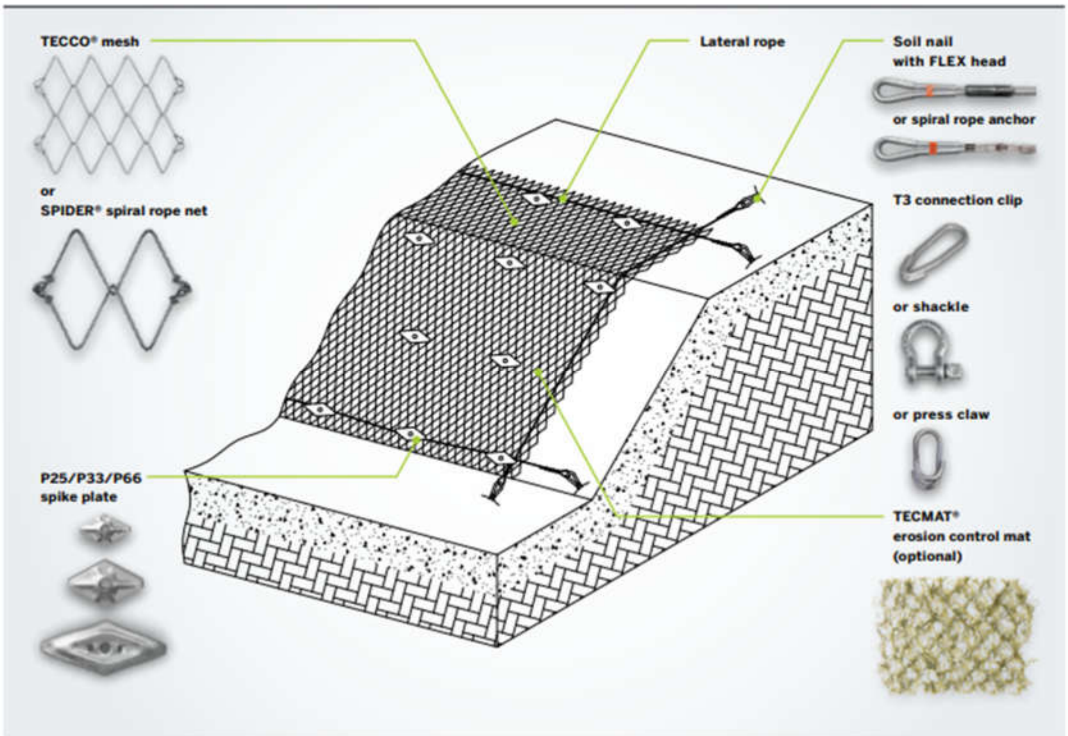
The cost of the nail grid active protection system TECCO® is EUR 80 to 180 per 1 m² (depending on the access to the site, i.e., use of mobile equipment or industrial climbing)

For calculations, we used the cost of US$ 94 per 1 m² of net.

The prices have been provided by Geobrugg as of 2021.

The scheme of rock fall drapes, nail grid active systems TECCO / SPIDER is presented in Figure 2 -9 below.

Figure 3-9 Slope stabilization with the TECCO® or the SPIDER® system



The use of rock fall drapes, nail grid active systems TECCO/SPIDER is illustrated in Figure 3-10 below for the Labijar—Karamyk road section at Sta. 236+000.

Figure 3-10 Illustration of Nail Grid Active System

BEFORE


REDMI NOTE 8 PRO
AI QUAD CAMERA

AFTER


REDMI NOTE 8 PRO
AI QUAD CAMERA

Table 3-13 Items included in the cost of Rock Fall Protection Measures

Item	Description of works	Unit of measurement
100	Manufacturing of structures	ea.
200	Delivery of structures and materials to the site	ea.
300	Slope preparation: topsoil clearing, rock scaling on unstable slopes, levelling and profiling (for a cut slope), drainage (if needed)	m^2
400	Drilling, casting of nails and anchoring	ea.
500	Installation of a net	m^2
600	Connection of net sheets	m^2
700	Installation and regulation of lateral ropes	linear meter
800	Installation and bolting-up of spike plates	m^2

Table 3-14 Nail Grid Active Systems Quantities and cost

Nail grid active systems, *e.g.* TECCO® / SPIDER®								
Item	ID No.	Location		Section length, m	Coordinates	Required length to protect the slope, m	Slope height , m	Mesh surface area, m2
		Starting station	End station					
Kalaikumb—Khorog								
1	4	Sta. 459+200	Sta. 460+100	900	C:38°16'20" B:71°21'17"	400	70	28,000
Khorog—Ishkashim								
2	8	Sta. 16+000	Sta. 17+000	1,000	C:37°24'31" B:71°29'58"	420	80	33,600
3	12	Sta. 51+000	Sta. 52+000	1,000	C:37°08'43" B:71°26'55"	400	75	30,000
4	14	Sta. 78+000	Sta. 79+000	1,000	C:36°55'43" B:71°29'28"	380	80	30,400
Rushan—Basid—Savnob								
5	21	Sta. 31+500	Sta. 32+000	500	C:38°00'15" B:71°49'38"	260	70	18,200
6	22	Sta. 69+600	Sta. 70+000	400	C:38°06'03" B:72°05'29"	200	70	14,000
7	23	Sta. 99+400	Sta. 100+000	600	C:38°12'42" B:72°15'56"	300	60	18,000
Dushanbe—Ayni								

8	24	Sta. 60+600	Sta. 60+700	100	C:39°00'53" B:68°46'48"	80	50	4,000
Ayni—Penjakent								
9	28	Sta. 14+700	Sta. 16+600	1,900	C:39°27'25" B:68°24'52"	800	70	56,000
10	29	Sta. 15+650	Sta. 16+500	850	C:39°27'15" B:68°24'29"	500	75	37,500
11	31	Sta. 37+700	Sta. 38+400	700	C:39°27'06" B:68°11'44"	400	60	24,000
Labijar—Karamik								
12	36	Sta. 290+000	Sta. 293+000	3,000	C:39°21'49" B:71°36'51"	870	60	52,200
13	37	Sta. 296+000	Sta. 296+100	100	C:39°22'08" B:71°38'36"	55	60	3,300
14	38	Sta. 297+300	Sta. 298+350	1,050	C:39°21'54" B:71°39'32"	650	60	39,000
Total area:							388,200 m²	
Cost:							US$ 36,490,800	

DEBRIS FLOW BARRIER UX/VX

Flexible mudflow protection barriers have been designed as a cost-effective alternative to the traditional reinforced concrete structures. Despite their low weight, flexible barriers should withstand huge loads. This poses specific requirements to identifying the field of their use, designing, and construction. The comparative ease of their installation and operation allows significantly reducing costs for engineered protection, while the structure of such a barrier and its responsible designing offer safety.

In the changed situation when mountain slopes undergo increasing development, engineered protection against relatively small mudflows of thousands to tens of thousands of cubic meters comes to the fore.

In this connection, solutions developed by small mountainous countries (Switzerland, Austria, etc.) become particularly important, for they have been a solution to similar tasks for many years. The latest advances in the field of mudflow protection with flexible trapping systems (flexible debris flow barriers) offer economical protection even on the sites where protection measures have been considered either impossible or too expensive.

When costing the installation of debris flow barriers UX/VX, we used the unit price of US$117,760 for the installation of one barrier.

The prices have been provided by Geobrugg as of 2021.

The scheme and components of debris flow barriers are presented in Figure 3-11 below.

The use of a flexible debris flow barrier UX/VX is illustrated in Figure 3-12 for the Ayni—Penjakent road section at Sta. 32+600.

Figure 3-11 Components of a UX debris flow barrier

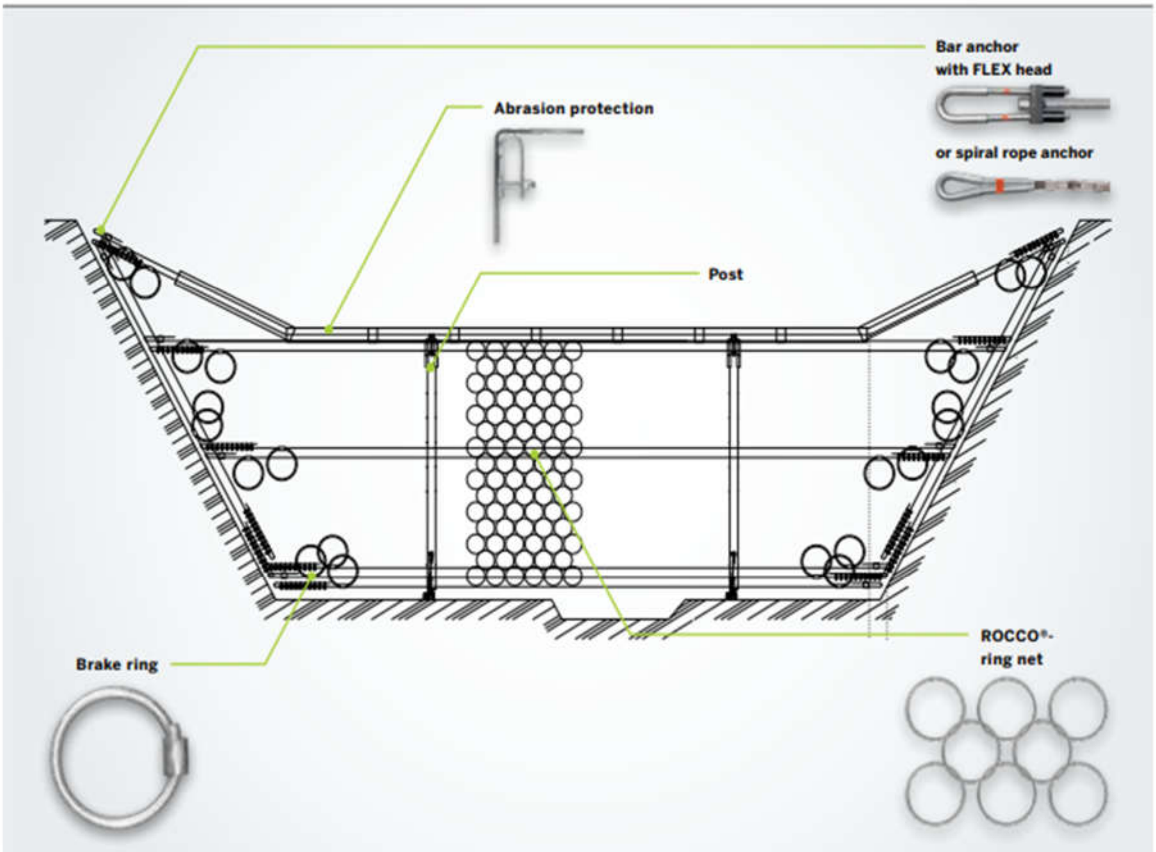


Table 3-15 Items included in the cost of Debris Flow Barriers

Item	Description of works	Unit of measurement
100	Manufacturing and delivery of structures and materials	ea.
200	Slope preparation: topsoil clearing, rock scaling on unstable slopes	linear meter
300	Drilling for anchors, foundation casting and anchoring	ea.
400	Preparation of posts: retaining ropes, rods, etc. (posts only for UX)	ea.
500	Installation of overturn protection devices and posts with pre-installed structural elements using a crane or helicopter (posts only for UX)	ea.
600	Installation of a net and connection of net sheets	m²
700	Installation of the remaining elements (ropes, abrasion protection, etc.)	ea.

Figure 3-12 Illustration of Debris Flow Barrier

BEFORE

AFTER

Table 3-16 Debris Flow Barrier Quantities and cost

Debris flow barrier UX/VX						
Item	ID No.	Location		Coordinates	Quantity, ea.	Estimated cost, US$
		Starting station	End station			
Labijar—Kalaikumb						
1	102	Sta. 0+000	Sta. 1+000	C:38°51'47" B:70°06'55"	2	235,512
2	110	Км 31+000	Км 31+100	C:38°47'22" B:70°18'08"	1	117,756
3	111	Sta. 40+000	Sta. 40+200	C:38°44'28" B:70°20'49"	1	117,756
4	112	Sta. 49+000	Sta. 49+150	C:38°43'24" B:70°25'31"	1	117,756
5	113	Sta. 57+000	Sta. 58+000	C:38°42'32" B:70°30'12"	2	235,512
6	114	Sta. 63+100	Sta. 63+400	C:38°43'48" B:70°33'56"	1	117,756
7	115	Sta. 65+000	Sta. 65+100	C:38°43'30" B:70°34'5611"	1	117,756
Kalaikumb—Khorog						
8	116	Sta. 368+800	Sta. 369+000	C:38°28'19" B:70°53'15"	2	235,512
9	117	Sta. 390+000	Sta. 390+300	C:38°29'25" B:70°59'34"	1	117,756
10	118	Sta. 416+000	Sta. 416+100	C:38°22'48" B:71°18'41"	1	117,756
11	119	Sta. 453+000	Sta. 453+400	C:38°18'38" B:71°36'51"	1	117,756
12	120	Sta. 461+000	Sta. 461+100	C:38°15'42" B:71°22'14"	1	117,756
13	121	Sta. 489+000	Sta. 489+300	C:38°15'42" B:71°22'14"	1	117,756
14	122	Sta. 500+300	Sta. 500+800	C:38°02'51" B:71°18'27"	1	117,756
15	123	Sta. 502+000	Sta. 502+200	C:35°00'59" B:71°17'40"	1	117,756
16	124	Sta. 574+600	Sta. 574+800	C:35°42'37" B:71°33'09"	1	117,756

17	125	Sta. 579+000	Sta. 579+200	C:37°41'33" B:71°32'41"	1	117,756
Rushan—Basid—Savnob						
18	126	Sta. 4+800	Sta. 5+000	C:37°58'08" B:71°36'46"	1	117,756
19	127	Sta. 18+560	Sta. 19+000	C:37°58'22" B:71°43'57"	1	117,756
20	128	Sta. 22+000	Sta. 22+500	C:37°59'47" B:71°44'47"	1	117,756
21	129	Sta. 24+000	Sta. 24+400	C:38°00'40" B:71°45'54"	1	117,756
22	130	Sta. 24+800	Sta. 25+000	C:38°00'08" B:71°46'21"	1	117,756
23	131	Sta. 29+500	Sta. 30+000	C:38°00'28" B:71°48'29"	1	117,756
24	132	Sta. 46+000	Sta. 46+300	C:38°05'35" B:71°54'48"	1	117,756
25	133	Sta. 53+000	Sta. 53+300	C:38°08'94" B:71°56'43"	1	117,756
26	134	Sta. 56+000	Sta. 56+300	C:38°09'26" B:71°59'41"	1	117,756
27	135	Sta. 107+700	Sta. 108+000	C:38°16'04" B:72°17'21"	1	117,756
Khorog—Ishkashim						
28	137	Sta. 8+000	Sta. 9+000	C:37°27'41" B:70°31'00"	2	235,512
29	138	Sta. 14+000	Sta. 14+200	C:37°25'28" B:70°29'53"	1	117,756
30	139	Sta. 19+000	Sta. 19+200	C:36°46'23" B:71°34'07"	1	117,756
31	140	Sta. 24+000	Sta. 24+400	C:37°21'39" B:71°29'39"	1	117,756
32	141	Sta. 31+000	Sta. 32+000	C:37°18'08" B:71°29'50"	2	235,512
33	142	Sta. 38+000	Sta. 28+200	C:37°14'30" B:71°29'07"	1	117,756
34	143	Sta. 48+000	Sta. 48+100	C:37°10'54" B:71°27'16"	1	117,756
35	144	Sta. 53+700	Sta. 53+800	C:37°07'41" B:71°26'36"	1	117,756
36	145	Sta. 65+000	Sta. 67+000	C:37°02'21"	3	353,268

				B:71°26'59"		
37	146	Sta. 80+000	Sta. 80+100	C:39°54'57" B:71°29'52"	1	117,756
38	147	Sta. 85+700	Sta. 86+000	C:36°53'01" B:71°31'30"	1	117,756
39	148	Sta. 99+000	Sta. 99+500	C:36°46'23" B:71°34'07"	1	117,756
Khorog—Murgab						
40	149	Sta. 637+000	Sta. 639+000	C:37°33'47" B:71°43'19"	3	353,268
41	150	Sta. 654+300	Sta. 654+350	C:37°39'50" B:71°49'15"	1	117,756
42	151	Sta. 657+500	Sta. 657+600	C:37°40'53" B:71°50'48"	1	117,756
43	152	Sta. 661+700	Sta. 662+000	C:37°41'41" B:71°52'15"	1	117,756
44	153	Sta. 667+200	Sta. 667+400	C:37°41'52" B:71°55'34"	1	117,756
45	154	Sta. 673+800	Sta. 674+100	C:37°43'21" B:71°02'05"	1	117,756
46	155	Sta. 688+100	Sta. 688+600	C:37°41'50" B:71°12'25"	1	117,756
47	158	Sta. 845+000	Sta. 846+000	C:37°49'53" B:73°40'05"	2	235,512
48	159	Sta. 852+000	Sta. 853+000	C:37°51'52" B:73°47'27"	2	235,512
Murgab—Karakul-Kizilart						
49	162	Sta. 182+000	Sta. 182+100	C:39°13'46" B:73°25'29"	1	117,756
50	160	Км 853+000	Км 853+800	C:38°13'32" B:74°02'13"	1	117,756
Dushanbe—Ayni						
51	163	Sta. 42+500	Sta. 42+700	C:38°53'13" B:68°49'42"	1	117,756
Ayni—Penjakent						
52	172	Sta. 51+100	Sta. 51+150	C:39°27'42" B:68°03'26174"	1	117,756
53	174	Sta. 53+400	Sta. 53+500	C:39°28'17" B:68°02'11"	1	117,756

54	175	Sta. 63+200	Sta. 63+300	C:39°27'14" B:67°55'34"	1	117,756
Khujand—Asht						
55	179	Sta. 76+400	Sta. 76+500	C:40°33'15" B:70°18'28"	1	117,756
56	186	Sta. 117+000	Sta. 117+100	C:40°45'11" B:70°40'56"	1	117,756
57	187	Sta. 117+500	Sta. 117+600	C:40°45'14" B:70°41'09"	1	117,756
58	188	Sta. 118+000	Sta. 118+100	C:40°45'18" B:70°41'25"	1	117,756
Dehmoy—Konibodom						
59	189	Sta. 52+300	Sta. 52+500	C:40°14'35" B:70°02'32"	1	117,756
60	190	Sta. 53+600	Sta. 53+800	C:40°14'40" B:70°03'05"	1	117,756
61	191	Sta. 57+200	Sta. 57+300	C:40°14'54" B:70°07'05"	1	117,756
62	192	Sta. 58+500	Sta. 58+700	C:40°14'55" B:70°08'42"	1	117,756
63	193	Sta. 64+400	Sta. 64+600	C:40°14'08" B:70°12'48"	1	117,756
64	194	Sta. 69+000	Sta. 69+100	C:39°21'49" B:71°36'51"	1	117,756
65	195	Sta. 73+950	Sta. 74+050	C:40°13'41" B:7°19'15"	1	117,756
66	196	Sta. 86+000	Sta. 86+100	C:40°16'26" B:70°26'22"	1	117,756
Vakdat—Obigarm						
67	200	Км 31+000	Км 31+100	C:38°32'56" B:69°19'51"	1	117,756
68	201	Sta. 37+000	Sta. 37+100	C:38°34'36" B:69°23'01"	1	117,756
Labijar—Karamik						
69	202	Sta. 194+500	Sta. 194+600	C:39°04'30" B:70°41'54"	1	117,756
70	203	Sta. 195+450	Sta. 195+600	C:39°04'37" B:70°42'44"	1	117,756
71	204	Sta. 202+500	Sta. 202+800	C:39°06'17"	1	117,756

				B:70°49'34"		
72	205	Sta. 203+600	Sta. 203+800	C:39°06'28" B:70°47'29"	1	117,756
73	206	Sta. 249+000	Sta. 250+000	C:39°11'52" B:71°16'25"	2	235,512
74	207	Sta. 261+000	Sta. 261+050	C:39°14'51" B:71°20'10"	1	117,756
75	208	Sta. 290+000	Sta. 290+100	C:39°21'03" B:71°35'19"	1	117,756
76	209	Sta. 310+000	Sta. 310+500	C:39°26'04" B:71°44'48"	1	117,756
Khovaling—Vose						
77	210	Sta. 2+000	Sta. 2+200	C:38°21'13" B:69°58'12"	1	117,756
Guliston—Pyanj						
78	216	Sta. 49+500	Sta. 49+800	C:37°19'53" B:69°21'03"	1	117,756
Kulob-Kalaikumb						
79	219	Sta. 288+000	Sta. 289+000	C:38°05'39" B:70°25'29"	2	235,512
					Total number:	95
					Cost:	$ 11,187,200

CULVERTS

When costing the construction of culverts, we considered unit prices used in similar ongoing or past projects in Tajikistan.

As an example, the unit prices for types of works were taken from the ongoing Dushanbe—Kurgan-Tyube road reconstruction project: Contract No: CP-01: Rehabilitation and Improvement of the Dushanbe – Kurgonteppa Road approved in 2017 and financed by the Asian Development Bank (ADB) for the Client, i.e., the Ministry of Transport of Tajikistan.

The cost includes inter alia costs for all materials and their supply, tools, machinery, preparatory works, earthworks, installation of culverts, back filling, and workforce

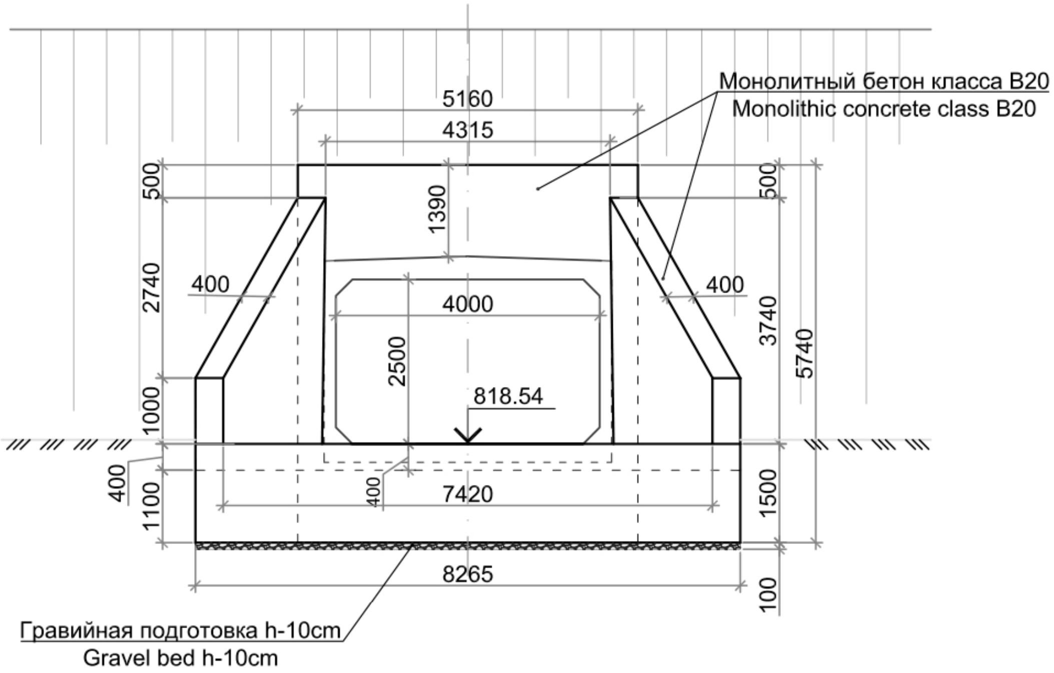
The minimum roadbed width for Category V is 8.0 m. For culverts on Category V roads, we calculated the minimum length of a culvert to be installed perpendicular to the road centerline, i.e., 9 m. Here, we did not take into account either the depth of culvert installation or the ravine vis-à-vis the road.

The cost of works, including all costs for material supply and works, is based on the unit price of US$ 441.6 per 1 m of a pipe culvert Ø 1.0 and US$ 1785.6 per 1 m of a box culvert Ø 4.0 x 2.5m.

Figure 3-13 Box Culvert Diagram

Box culvert Ø 4.0 x 2.5 m

Выходная оголовка.
Outlet head wall
M1:100



Поперечное сечение тело трубы
Cross section of culvert body
M1:100

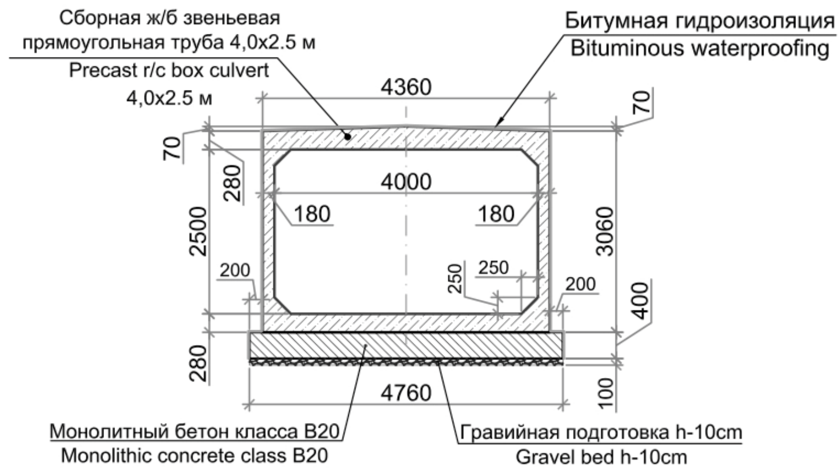
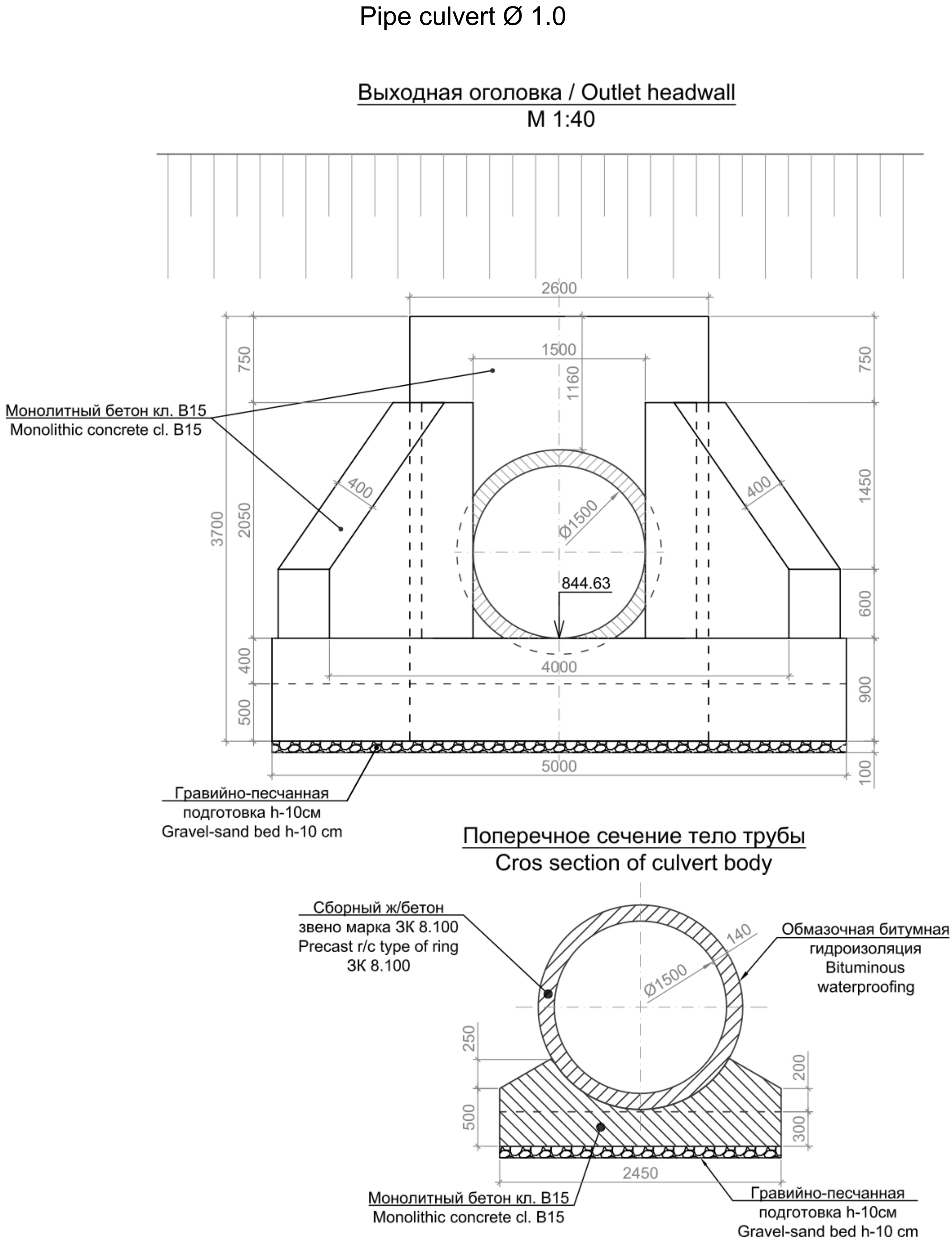


Figure 3-14 Pipe Culvert Diagram



The installation of a pipe culvert is illustrated in Figure 3-15 below for the Labijar—Kalaikumb road section at Sta. 3+000.

Figure 3-15 Illustration of a Pipe Culvert

BEFORE

AFTER

Table 3-17 Items included in the cost

Item	Description of works	Unit of measurement
100	Preparatory works, trench digging	m
200	Preparation of the gravel and sand bedding	m
300	Installation of the culvert	linear meter
400	Backfilling and compaction	m
500	Headwall installation	m

Table 3-18 Culvert Construction Quantities and cost

Culvert construction								
Item	ID No.	Location		Existing culvert, Ø	Cooridantes	New culvert,Ø	Culvert length, m	Estimated cost, US$
		Starting station	End station					
Labijar—Kalaikumb								
1	103	Sta. 2+000	Sta. 2+100	No culvert	C:38°51'02» B:70°07'02»	Ø 1.0	9	3,974.4
2	104	Sta. 3+000	Sta. 3+100	No culvert	C:38°50'48» B:70°06'59»	Ø 1.0	9	3,974.4
3	105	Sta. 4+000	Sta. 4+040	No culvert	C:38°50'43» B:70°06'60»	Ø 1.0	9	3,974.4
4	106	Sta. 7+300	Sta. 7+400	No culvert	C:38°50'50» B:70°08'39»	Ø 1.0	9	3,974.4
5	107	Sta. 8+000	Sta. 8+100	No culvert	C:38°50'48» B:70°08'54»	Ø 1.0	9	3,974.4
6	108	Sta. 9+000	Sta. 9+150	No culvert	C:38°50'29» B:70°09'15»	Ø 1.0	9	3,974.4
7	109	Sta. 23+500	Sta. 23+700	No culvert	C:38°47'32» B:70°14'03»	Ø 1.0	9	3,974.4
Murgab – Karakul-Kizilart								
8	161	Км 35+000	Км 40+000	Нет трубы	C:38°24'58» B:73°58'08»	Ø 4,0 x 2,5м	9	16,070.4
Rushan—Basid—Savnob								
9	45	Sta. 19+000	Sta. 20+000	No culvert	C:37°58'32» B:71°44'09»	Ø 4.0 x 2.5м	6	16,070.4
Khorog—Murgab								
10	156	Sta. 700+100	Sta. 700+600	No culvert	C:37°40'06» B:72°29'11»	Ø 1.0	9	3,974.4

11	157	Sta. 844+600	Sta. 844+690	No culvert	C:37°49'04» B:73°38'06»	Ø 1.0	9	3,974.4
Ayni—Penjakent								
12	164	Sta. 14+700	Sta. 15+600	No culvert	C:39°27'25» B:68°24'52»	Ø 1.0	9	3,974.4
13	165	Sta. 15+650	Sta. 16+500	No culvert	C:39°27'15» B:68°24'29»	Ø 1.0	9	3,974.4
14	166	Sta. 19+850	Sta. 20+050	No culvert	C:39°27'27» B:68°22'25»	Ø 1.0	9	3,974.4
15	167	Sta. 22+800	Sta. 22+900	Culvert Ø1.1	C:39°26'59» B:68°20'50»	Ø 4.0 x 2.5м	9	16,070.4
16	169	Sta. 47+400	Sta. 47+800	Culvert Ø1.1	C:39°27'08» B:68°05'35»	Ø 4.0 x 2.5м	9	16,070.4
17	170	Sta. 48+200	Sta. 48+500	No culvert	C:39°27'16» B:68°04'54»	Ø 1.0	9	3,974.4
18	171	Sta. 50+950	Sta. 51+050	No culvert	C:39°27'38» B:68°03'34»	Ø 1.0	9	3,974.4
19	173	Sta. 52+250	Sta. 52+350	No culvert	C:39°27'42» B:68°03'26»	Ø 1.0	9	3,974.4
20	176	Sta. 57+900	Sta. 58+000	Culvert Ø1.1	C:40°32'39» B:70°13'28»	Ø 4.0 x 2.5м	9	16,070.4
Khujand—Asht								
21	177	Sta. 74+500	Sta. 74+700	Culvert Ø1.1 x 2	C:40°33'23» B:70°17'12»	Ø 4.0 x 2.5м	9	16,070.4
22	178	Sta. 76+200	Sta. 76+300	Culvert Ø1.1	C:40°33'16» B:70°18'15»	Ø 4.0 x 2.5м	9	16,070.4
23	180	Sta. 77+200	Sta. 77+400	Culvert Ø1.1	C:40°33'17» B:70°19'09»	Ø 4.0 x 2.5м	9	16,070.4
24	181	Sta. 78+100	Sta. 78+200	Culvert Ø1.1	C:40°33'19» B:70°19'36»	Ø 4.0 x 2.5м	9	16,070.4
25	182	Sta. 78+950	Sta. 79+000	Culvert Ø1.1	C:40°33'25» B:70°20'15»	Ø 4.0 x 2.5м	9	16,070.4
26	183	Sta. 80+300	Sta. 80+400	Culvert Ø 0.8 x 2	C:40°33'41» B:70°21'09»	Ø 4.0 x 2.5м	9	16,070.4
27	184	Км 80+600	Км 80+700	Труба Ø 1 x 0,4	C:40°33'41» B:70°21'09»	Ø 4,0 x 2,5м	9	16,070.4
28	185	Sta. 80+600	Sta. 80+700	Culvert Ø1.1	C:40°34'11» B:70°23'20»	Ø 4.0 x 2.5м	9	16,070.4
Konibodom—Isfara								
29	197	Sta. 5+000	Sta. 6+000	No culvert	C:40°12'40» B:70°22'57»	Ø 1.0	9	3,974.4

30	198	Sta. 14+000	Sta. 14+200	Culvert Ø1.1	C:40°11'59» B:70°28'57»	Ø 4.0 x 2.5м	9	16,070.4
31	199	Sta. 23+600	Sta. 23+700	Culvert Ø1.5	C:40°08'60» B:70°33'32»	Ø 4.0 x 2.5м	9	16,070.4
Labijar—Karamik								
32	204	Sta. 202+500	Sta. 202+800	No culvert	C:39°06'17» B:71°36'51»	Ø 1.0	9	3,974.4
33	205	Sta. 203+600	Sta. 203+800	No culvert	C:39°22'28» B:70°47'29»	Ø 1.0	9	3,974.4
34	206	Sta. 249+000	Sta. 250+000	No culvert	C:39°11'52» B:71°16'25»	Ø 1.0	9	3,974.4
Khovaling—Vose								
35	211	Sta. 67+700	Sta. 68+000	Culvert Ø1.5	C:37°54'54» B:69°42'48»	Ø 4.0 x 2.5м	9	16,070.4
Guliston—Pyanj								
36	212	Sta. 42+000	Sta. 43+000	No culvert	C:37°23'36» B:69°20'36»	Ø 1.0	9	3,974.4
37	213	Sta. 43+500	Sta. 43+700	Culvert Ø1.5	C:37°23'19» B:69°20'34»	Ø 4.0 x 2.5м	9	16,070.4
38	214	Sta. 43+800	Sta. 43+900	Culvert Ø1.5	C:37°22'45» B:69°20'27»	Ø 4.0 x 2.5м	9	16,070.4
39	215	Sta. 44+300	Sta. 44+500	Culvert Ø0.5	C:37°22'28» B:69°20'23»	Ø 4.0 x 2.5м	9	16,070.4
40	217	Sta. 45+200	Sta. 47+000	No culvert	C:39°11'52» B:71°16'25»	Ø 1.0	9	3,974.4
Total length:							Ø 1.0 x 9	189 m
Total length:							Ø 4.0 x 2.5м x 9	171 m
Total cost:							$ 388,800,00	
Cost adjusted for the 2017—2020 cumulative inflation:							$ 481,334.40	

BRIDGES

When costing the construction of bridges, we considered unit prices used in similar ongoing or past projects in Tajikistan.

As an example, the unit prices for types of works were taken from the ongoing Ayni—Penjakent—Uzbek border road reconstruction project: Contract- 0301-TAJ: Ayni–Penjakent–Uzbekistan border Road approved in 2017 and financed by the Asian Development Bank (ADB) for the Client, i.e., the Ministry of Transport of Tajikistan.

The cost should include inter alia costs for all materials and their supply, tools, machinery, preparatory works, earthworks, construction of a temporary bypass road with a temporary culvert, construction of bridge substructure and superstructure, construction of abutments, installation of fences, road marking, and workforce

The total cost of a bridge is estimated on the basis of the road width. The higher the category is, the wider a bridge will be.

For the Khorog—Murgab road section of Category IV, the bridge width was assumed 10.5 m. The total cost of a reinforced concrete girder bridge is US$ 8,739.1 per 1 linear meter.

For the Dushanbe—Ayni road section of Category III, the bridge width was assumed 13.5 m. The total cost of a reinforced concrete girder bridge is US$ 11,236.0 per 1 linear meter.

For the Guliston—Farkhor—Pyanj road section of Category IV, the bridge width was assumed 10.5 m. The total cost of a reinforced concrete girder bridge is US$ 8,739.1 per 1 linear meter.

Figure 3-16 Bridge Centre Section Diagram

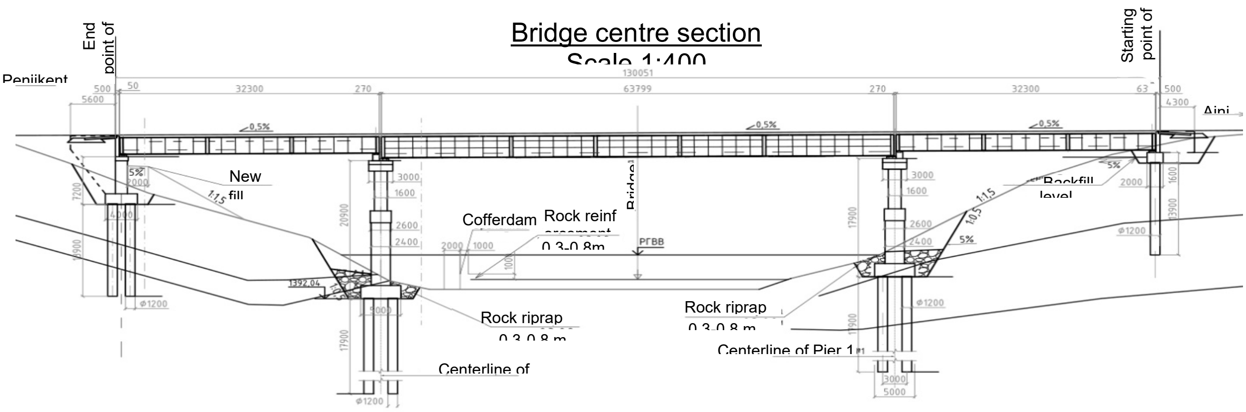


Table 3-19 Items included in the cost of Bridges

Item	Description of works	Unit of measurement
100	Preparatory works / dismantling of the existing structures	m
200	Earthworks	m
300	Construction of a new bypass road	m
400	Installation of a temporary culvert under the bypass road	linear meter
500	Construction of substructure	ea.
600	Construction of superstructure	ea.
700	Construction of the carriageway	m²
800	Installation of fences	ea.
900	Vertical markings	ea.
1000	Horizontal markings	m²

Table 3-20 Bridges Quantities and cost

<table>
<tr><th colspan="10">Bridge construction</th></tr>
<tr><th rowspan="2">Item</th><th rowspan="2">ID No.</th><th colspan="2">Location</th><th rowspan="2">Existing bridge, m</th><th rowspan="2">Coordinates</th><th rowspan="2">Road category</th><th rowspan="2">Cost per linear meter, US$</th><th rowspan="2">Bridge length, m</th><th rowspan="2">Estimated cost, US$</th></tr>
<tr><th>Starting station</th><th>End station</th></tr>
<tr><td colspan="8">Murgab-Karakol-Kizilart</td><td></td><td></td></tr>
<tr><td>1</td><td>162</td><td>Sta. 182+000</td><td>Sta. 182+100</td><td>Existing bridge destroyed</td><td>C:39°13'46
B:73°25'29</td><td>IV</td><td>8,739.1</td><td>65</td><td>568,041.5</td></tr>
<tr><td colspan="8">Dushanbe—Ayni</td><td></td><td></td></tr>
<tr><td>2</td><td>163</td><td>Sta. 42+500</td><td>Sta. 42+700</td><td>Insufficient headroom of the existing bridge</td><td>C:38°53'13
B:68°49'42</td><td>III</td><td>11,236.0</td><td>40</td><td>449,440</td></tr>
<tr><td colspan="8">Khujand—Asht</td><td></td><td></td></tr>
<tr><td>3</td><td>179</td><td>Sta. 76+400</td><td>Sta. 76+500</td><td>Existing bridge</td><td>C:40°33'15
B:70°18'28</td><td colspan="3">Bank fortification works required</td><td></td></tr>
<tr><td colspan="9">Guliston—Farkhor—Pyanj</td><td></td></tr>
<tr><td>4</td><td>216</td><td>Sta. 44+800</td><td>Sta. 45+100</td><td>Insufficient headroom of the existing bridge</td><td>C:37°21'59
B:69°20'08</td><td>IV</td><td>8,739.1</td><td>30</td><td>262,173</td></tr>
<tr><td colspan="7">Cost:</td><td colspan="3">$ 1,279,654.5</td></tr>
<tr><td colspan="7">Cost adjusted for the 2017—2020 cumulative inflation:</td><td colspan="3">$ 1,584,212.27</td></tr>
</table>

ROAD REALIGNMENT

Road realignment is a last resort when other types of measures cannot be applied in a given case. Each case requires geological and geodetic surveys as well as designing. We estimated the cost of constructing 1 km of a new road, including all types of works from preparation to finishing.

When costing road realignment, we considered unit prices used in similar ongoing or past projects in Tajikistan.

As an example, the unit prices for types of works were taken from the ongoing Dushanbe—Kurgan-Tyube road reconstruction project: Contract No: CP-01: Rehabilitation and Improvement of the Dushanbe – Kurgonteppa Road approved in 2017 and financed by the Asian Development Bank (ADB) for the Client, i.e., the Ministry of Transport of Tajikistan.

The cost includes inter alia costs for all materials and their supply, tools, machinery, preparatory works, earthworks, installation of subbase and base courses, road pavement, road furniture, and workforce

The cost of works for a road 6 m wide, including all costs for materials and works, is based on the unit price of US$ 522,597.65 per 1 km of a road.

Table 3-21 Items included in the cost of road realignment

Item	Description of works	Unit of measurement
100	Tree cutting and grubbing	ea.
200	Removal of topsoil	m
300	Removal of soft/swamp material	m
400	Contruction of roadbed	m
500	Earth excavation	m
600	Levelling of a sub-grade and levelling of slopes of a cut and fill	m²
700	Construction of subbase course	m
800	Construction of base course	m
900	Tack coating	m²
1000	Binder course	m²
1100	Wearing layer	m²
1200	Backfilled road shoulder	m
1300	Horizontal road marking	m²
1400	Vertical markings	ea.

Table 3-22 Road Realignment Quantities and cost

Road realignment							
Item	ID No.	Location		Existing length, m	Coordinates	New road length, m	Estimated cost, US$
		Starting station	End station				
Labijar—Kalaikumb							
1	324	Sta. 13+700	Sta. 14+000	300	C:38°49'46" B:70°11'13"	1,200	627,117
Rushan—Basid—Savnob							
2	136	Sta. 118+000	Sta. 119+000	1,000	C:38°17'45" B:72°22'50"	1,360	710,732.8
						Total length:	2,560 m
						Total cost:	US$ 1,337,849.8
						Cost adjusted for the 2017—2020 cumulative inflation:	US$ 1,656,258.05

REPLACEMENT OF SOFT/SWAMP MATERIAL

When costing soil replacement, we considered unit prices used in similar ongoing or past projects in Tajikistan.

As an example, the unit prices for types of works were taken from the ongoing Dushanbe—Kurgan-Tyube road reconstruction project: Contract No: CP-01: Rehabilitation and Improvement of the Dushanbe – Kurgonteppa Road approved in 2017 and financed by the Asian Development Bank (ADB) for the Client, i.e., the Ministry of Transport of Tajikistan.

The cost includes inter alia costs for the excavation of inappropriate soil, soil transport, soil placement and compaction, machinery, and workforce.

The replacement of swamp material implies the complete replacement of the equilateral trapezoid roadbed. The cost does not include costs for road pavement.

The cost of works to replace inappropriate soil, including all costs for materials and works, is based on the unit price of US$ 6.7 per 1 m3 of soil.

Table 3-23 Items included in the cost of removal of soft material

Item	Description of works	Unit of measurement
100	Excavation of roadbed earth	m
200	Soil transport, soil placement, watering, compaction	m

Table 3-24 Replacement of Soft Material Quantities and cost

Replacement of soft/swamp material										
Item	ID No.	Location		Exitisng length, m	Coordinates	New road length, m	Roadbed height, m	Roadbed width, m	Volume, m	Estimated cost, US$
		Starting station	End station							
Labijar—Kalaikumb										
1	323	Sta. 6+500	Sta. 7+000	500	C:38°50'37" B:70°08'18"	500	2,5	10	15,625	104,687.5
2	324	Sta. 13+700	Sta. 14+000	300	C:38°49'46" B:70°11'13"	300	2	10	7,200	48,240
3	325	Sta. 17+000	Sta. 17+800	200	C:38°50'37" B:70°08'18"	200	8	10	28,800	192,960
Khovaling—Vose										

4	330	Sta. 9+300	Sta. 9+500	200	C:38°17'45" B:72°22'50"	200	2	10	4,000	32,160
Total volume:							55,625 m			
Total cost:							US$ 372,687.5			
Cost adjusted for the 2017—2020 cumulative inflation:							US$ 461,387.13			

RAISING OF ROADBED

When costing the raising of a roadbed, we considered unit prices used in similar ongoing or past projects in Tajikistan.

As an example, the unit prices for types of works were taken from the ongoing Dushanbe—Kurgan-Tyube road reconstruction project: Contract No: CP-01: Rehabilitation and Improvement of the Dushanbe – Kurgonteppa Road approved in 2017 and financed by the Asian Development Bank (ADB) for the Client, i.e., the Ministry of Transport of Tajikistan.

The cost includes inter alia costs for soil delivery, soil placement and compaction, road furniture, machinery, and workforce

The cost of works to raise a roadbed, including all costs for materials and works, is based on the unit price of US$ 10.46 per 1 m3 of soil.

Figure 3-17 Illustration of Road Bed Raising

BEFORE

AFTER

Table 3-25 Items included in the cost of road bed raising

Item	Description of works	Unit of measurement
100	Construction of embankment	m
200	Levelling of a sub-grade and levelling of slopes of a cut and fill	m²
300	Backfilled road shoulder	m

Table 3-26 Road Bed Raising Quantities and cost`

Rasing of roadbed										
Item	ID No.	Location		Section length, m	Coordinates	New section length, m	Roadbed height, m	Roadbed widht, m	Volume, m	Estimated cost, US$
		Starting station	Edn station							
Rushan—Basid—Savnob										
1	44	Sta. 16+000	Sta. 16+500	500	C:37°59'42" B:70°08'18"	500	3	6	11,250	117,675
2	46	Sta. 22+400	Sta. 23+000	600	C:37°59'51"	600	3	6	13,500	141,210

					B:71°44'54"					
3	47	Sta. 28+000	Sta. 29+000	1,000	C:38°00'12" B:71°47'56"	1,000	3	6	22,500	235,350
4	48	Sta. 38+000	Sta. 38+500	500	C:38°02'48" B:71°51'36"	500	3	6	11,250	117,675
5	50	Sta. 42+000	Sta. 43+000	1,000	C:38°04'07" B:71°53'04"	1,000	3	6	22,500	235,350
6	52	Sta. 50+000	Sta. 51+000	1,000	C:38°07'51" B:71°56'34"	1,000	3	6	22,500	235,350
7	53	Sta. 54+200	Sta. 54+400	200	C:38°09'15" B:71°57'07"	200	3	6	4,500	47,070
8	54	Км 55+200	Sta. 55+550	400	C:38°09'23" B:71°57'49"	400	3	6	9,000	94,140
9	55	Км 56+900	Sta. 57+000	400	C:38°08'60" B:72°00'01"	400	3	6	9,000	94,140
10	56	Км 62+000	Sta. 62+500	400	C:38°06'01" B:72°03'54"	400	3	6	9,000	94,140
11	57	Км 68+400	Sta. 68+800	400	C:38°06'23" B:72°05'08"	400	3	6	9,000	94,140
12	58	Sta. 69+600	Sta. 70+000	400	C:38°06'00" B:72°05'34"	400	3	6	9,000	94,140
13	59	Sta. 72+000	Sta. 72+800	800	C:38°06'04" B:70°05'27"	800	3	6	18,000	188,280
14	60	Sta. 81+000	Sta. 81+600	600	C:38°06'36" B:72°09'15"	600	3	6	13,500	141,210
15	61	Sta. 83+000	Sta. 83+500	500	C:38°06'41" B:72°10'37"	500	3	6	11,250	117,675
16	62	Sta. 84+000	Sta. 86+000	2,000	C:38°06'55" B:72°11'20"	2,000	3	6	45,000	470,700
17	63	Sta. 99+400	Sta. 99+800	400	C:38°12'43" B:72°15'54"	400	3	6	9,000	94,140
18	64	Sta. 100+200	Sta. 100+700	500	C:38°13'08" B:72°16'01"	500	3	6	11,250	117,675
19	65	Sta. 103+400	Sta. 104+000	1,600	C:38°14'46" B:72°16'53"	1,600	3	6	36,000	376,560
20	66	Sta. 105+000	Sta. 105+500	500	C:38°15'22" B:72°16'20"	500	3	6	11,250	117,675

21	67	Sta. 106+000	Sta. 106+500	500	C:38°15'28" B:72°16'54"	500	3	6	11,250	117,675
22	68	Sta. 108+000	Sta. 109+000	1,000	C:38°16'06" B:72°17'35"	1,000	3	6	22,500	235,350
23	69	Sta. 113+000	Sta. 114+000	1,000	C:38°17'17" B:72°20'03"	1,000	3	6	22,500	235,350
Labijar—Karamik										
24	74	Sta. 255+000	Sta. 255+300	300	C:39°12'16" B:71°18'56"	350	3	6	7,875	82,372.5
Gulistan – Farkhor - Pyanj										
25	331	Км 72+900	Км 73+200	300	C:37°16'16" B:69°14'47"	300	3	6	5,400	56,484
Total volume:							377,775 м			
Total cost:							$ 3,951,526.5			
Cost adjusted for the 2017—2020 cumulative inflation:							$ 4,891,989.81			

CONSTRUCTION OF A SURFACE WATER DRAIN

When costing the construction of surface water drains, we considered unit prices used in similar ongoing or past projects in Tajikistan

As an example, the unit prices for types of works were taken from the ongoing Dushanbe—Kurgan-Tyube road reconstruction project: Contract No: CP-01: Rehabilitation and Improvement of the Dushanbe – Kurgonteppa Road approved in 2017 and financed by the Asian Development Bank (ADB) for the Client, i.e., the Ministry of Transport of Tajikistan.

The cost includes inter alia costs for the manufacturing of curbs, drain gutters, installation of drains, machinery, and workforce

The cost of works to construct a surface water drain, including all costs for materials and works, is based on the unit price of US$ 32.93 per 1 linear meter of a drain gutter.

Table 3-27 Items included in the cost of surface water drainage

Item	Description of works	Unit of measurement
100	Earthworks	m
200	Installation of drain gutters	linear meter
300	Installation of curbs	linear meter

Table 3-28 Surface Water Drainage Quantities and cost

Construction of a surface water drain

Item	ID No.	Location		Section length, m	Coordinates	Length of a section to be reconstructed, m	Loength of the drain, m	Estimnated cost, US$
		Starting station	End station					
Rushan—Basid—Savnob								
1	326	Sta. 24+800	Sta. 26+100	1,300	C:38°00'09" B:71°46'22"	800	600	19,758
2	78	Км 26+000	Км 26+500	500	C:38°00'02" B:71°46'51"	250	200	6,586
3	81	Км 85+000	Км 85+300	300	C:38°07'32" B:72°12'25"	150	150	4,939.5
4	82	Км 89+000	Км 89+250	250	C:38°09'21" B:72°12'56"	200	140	4,610.2
Kalaikumb - Khorog								
5	77	Км 457+000	Км 457+300	7000	C:38°18'18" B:71°20'09"	500	300	9,879
Murgab—Karakul								
6	327	Sta. 104+000	Sta. 106+000	2,000	C:38°44'54" B:73°29'44"	1,500	1,100	36,223
Labijar—Karamik								
7	329	Sta. 298+000	Sta. 298+100	100	C:39°21'57" B:71°39'45"	80	75	2,469.75
Khovaling—Vose								
8	330	Sta. 8+200	Sta. 9+000	800	C:38°18'42" B:69°55'29"	650	600	19,758
Guliston—Pyanj								
9	331	Sta. 72+900	Sta. 73+200	300	C:37°16'16" B:69°14'47"	250	230	7,573.9
Total length:							3,395 пм	
Total cost:							$ 111,797.00	
Cost adjusted for the 2017—2020 cumulative inflation:							$ 138,404.69	

3.6 OVERALL COSTS OF MITIGATION

COSTS OF MITIGATING INVESTMENTS

Table 3-29 presents the total cost of disaster mitigation measures. It should be noted, that these costs are tentative, and a more detailed cost may be estimated after a close study of site conditions for each identified case. Also, the cost includes the cumulative inflation factors, as set out above for the four-year period, 2017—2020.

Table 3-29 Total costs of Mitigation Measures

Item	Types of disaster mitigation measures	Quantities	Estimated cost, US$
1	Construction of avalanche galleries	11,385 m	US$ 267,523,116.18
2	Snow retaining barriers	60.3 ha	US$ 71,127,468.00
3	Gabion retaining walls	59,420 м	$ 5,612,777.55
4	Flexible rock fall protection barriers	4,755 m	US$ 3,804,000.00
5	Rock fall drapes, nail grid system	388,200 m²	US$ 36,490,800.00
6	Debris flow barrier	95 шт.	$ 11,187,200.00
7	Construction of culverts	40 шт.	$ 481,334.40
8	Construction of bridges	3 ea.	US$ 1,584,212.27
9	Road realignment	2,560 m	US$ 1,656,258.05
10	Replacement of soft/swamp material	55,625 m	US$ 461,387.13
11	Rasing of roadbed	341,775 м	$ 4,891,989.81
12	Construction of surface water drains	3,395 пм	$ 138,404.69
Total costs:			**$ 404,958,948.08**

4 THE IMPACT OF CLIMATE CHANGE

4.1 HOW CLIMATE CHANGE MAY AFFECT ROAD INFRASTRUCTURE

An important aspect of this study is to assess how climate change will impact the number and severity of future disasters. This is particularly important in a country such as Tajikistan where the impact of climate change will vary between regions and will affect different hazards in different ways. The following sections set out this assessment, including assumptions made regarding the future trends on the different hazards.

The road transport infrastructure in Tajikistan is sensitive to projected changes in climate variables. Foreseen climate changes will impact the road transport infrastructure in two ways: 1) through change in air temperature, precipitation, and 2) through changing patterns of extreme weather events. The following are potential impacts of climate change on the road transport infrastructure in Tajikistan[28].

- Increases in hot days and heat waves
    - Deterioration of pavement integrity, such as softening, traffic-related rutting, and migration of liquid asphalt due to increase in temperature
    - Thermal expansion of bridge expansion joints and paved surfaces
- Increases in temperature in very cold areas
    - Changes in road subsidence and weakening of bridge supports due to thawing of permafrost
    - Reduced ice loading on structures such as bridges
- Later onset of seasonal freeze and earlier onset of seasonal thaw
    - Deterioration of pavement due to increase in freeze–thaw conditions
- Increase in intense precipitation events
    - Damage to roads, subterranean tunnels, and drainage systems due to flooding
    - Increase in scouring of roads, bridges, and support structures
    - Damage to road infrastructure due to landslides
    - Overloading of drainage systems
    - Deterioration of structural integrity of roads, bridges, and tunnels due to increase in soil moisture levels
- Increases in drought conditions
    - Damage to infrastructure due to increased susceptibility to wildfires
    - Damage to infrastructure from mudslides in areas deforested by wildfires

4.2 IMPACT OF CLIMATE CHANGE IN TAJIKISTAN

Table 4-1 below shows the relationship between different climate parameters and the frequency and scale of different hazards that are known to affect the road network. This highlights the upward pressure on all types of hazard as a result of climate change. This is particularly true for the types of hazard that most affect Tajikistan's road network, avalanches and mudflows.

[28] ADB (2011). Guidelines for climate proofing investment in the transport sector: Road infrastructure projects.

Table 4-1 Projected impacts of climate change on extreme events[29]

Projected Impacts of Climate Change on Extreme Events		Projected Changes in Climatic Parameters											
		Extreme max temp	Duration of heat wave	Spring temperature	Extreme min. temp.	No. of Freezing days	No. of warming days	Annual precipitation	Heavy precipitation	Seasonal precipitation	Long-lasting dry spell	Actual Evaporation	Climatic Water balance
		+++	+++	+	+	-	+	++	+	++	++	--	++
Trend of Extreme Events	Heat Wave	↑↑	↑										
	Cold Wave				↑	↑							
	Drought	↑	↑				↑				↑↑	↑	↑
	Wildfire	↑	↑								↑		
	Flooding								↑	↑			
	Flash Flood			↑					↑				
	GLOF	↑		↑			↑						
	Avalanche	↑		↑						↑			
	Mudslide	↑							↑				
	Landslide								↑				

4.3 CLIMATE CHANGE IMPACTS ON DIFFERENT REGIONS

The climate change impacts on different regions is summarized in Table 4-2, based on the results of Participatory Climate Risk Assessment in Tajikistan in 2014.[30] It should be noted that the impacts of climate change will not be uniform across the country.

Table 4-2 The regional impacts of Climate Change in Tajikistan[31]

Climate Change Impacts	GBAO		Sughd		Khatlon		RRP	
	East	West	Zeravshan	Sughd	SW	Khatlon	East	West
Decrease in temperature	X	X	X					
Increase in temperature					x			X
Duration of snow cover		X					X	
Pasture degradation			X		x	X	X	
Agricultural insects					x			X
Avalanches		X					X	X
Drought				X	x			X
Dust storms					x			X
Windstorms	X			X	x			X

[29] CA-CRM, 2014: Assessment of Climate Risks in Tajikistan. The Central Asian Climate Risk Management Programme, Dushanbe.
[30] CA-CRM, 2014. Assessment of Climate Risks in Tajikistan. The Central Asian Climate Risk Management Programme, Dushanbe.
[31] CA-CRM, 2014: Assessment of Climate Risks in Tajikistan. The Central Asian Climate Risk Management Programme, Dushanbe.

4.4 IMPACT ON FUTURE DISASTERS

Tajikistan is a landlocked country in Central Asia, see Figure 2.3. About 93% of the country's area are mountainous, which widely vary in height from several hundred meters to 6,000 - 7,000 meters above sea level. Therefore, Tajikistan is prone to many types of natural hazards, including floods, mudflows, landslides/mudslides, droughts/wildfires, snow avalanches, and wind storm, which have caused frequent damage to the road transport infrastructure. The following briefly summarizes observed impacts of the aforementioned hazards to the road transport infrastructure[32].

- **Flooding and Inundation:** The dynamics of the water courses relevant to the road infrastructure is featured by two different patterns of the annual water flow: a) spring-summer high water and b) autumn-winter low water. The difference in the regime of the rivers is in the predominance of the feed source. The water courses intersected by the road, according to the type of feed, belong to the snow-rain type, characteristic of low-mountain peripheral regions. The projected increase in extreme precipitation events increases the potential risk of flooding or inundation of road infrastructure, e.g. due to overloading of drainage systems. The projected increase in intensity of extreme precipitation events implies that this risk increases in the future.
- **Mudflow and Landslide:** Mudflows are widespread in the mountainous and foothill regions and extremely devastating due to their unpredictability and lack of methods for calculating glacial mudflows that are formed during the melting of glaciers. Active physical weathering, sparse vegetation, intense rainfall activity and significant snow reserves contribute to the formation of high flow maxima with solid content, causing a descent of mudflows. The highest annual discharges of water courses intersected by the road are in April-May due to heavy rainfall which, as a rule, are characterized by frequent short-term destructive mudflows. Potential later onset of seasonal freeze and earlier onset of seasonal thaw may lead to an increase in freeze–thaw conditions which could increase the risk and of slope instability and occurrence of landslides and/or rockfall due to weathering effects.
- **Snow avalanche:** The major reason of avalanches in Tajikistan is fresh snow formation. Large amounts of fresh snow not yet consolidated, are likely to be set in motion. In addition, the interface between fresh and old snow is rather unstable and tends to create sliding planes. Most avalanches in Tajikistan are observed in February and March[33]. Projected increases in extreme precipitation events during cold weather conditions could result in extreme snowfall events which may lead to avalanching, especially if combined with warm spells, which are likely to increase under the projected climate change scenarios. The occurrence of heavy snow and avalanches will likely increase considering the projections of increases in extreme precipitation and higher minimum daily temperatures.
- **Heatwave, Drought, Wildfire:** The substantial projected increase in air temperatures as well as annual number of days where daily maximum temperature exceeds 25 °C, indicates that heat waves are more likely to occur and may last longer. This poses potential increased risks related to asphalt pavement integrity and thermal expansion of bridge expansion joints and paved surfaces. Wildfires may occur more frequently due to the projected increase in annual consecutive dry days. This may lead to increased drought conditions which could result in an increased risk for wildfires. The risk of mudflows may also increase as their occurrence can be linked to deforestation by wildfire and increasing precipitation extremes.

[32] Avtostrada, 2017): Vahdat-Rasht-Jirgatal Kyrgyzstan Border Road (From km 72 to km 158). Stage I Hydrological Report 16-16-EGE. Dushanbe.
33 ADRC, 2006: Tajikistan. Country Report. Asian Disaster Reduction Center.

- **Mountain permafrost:** Thawing of mountain permafrost and glacial melt does not pose direct risks to the project road for the intermediate future, as permafrost is not very likely to be present in the subsoil in close proximity to road alignments.

4.5 KEY CLIMATIC PARAMETERS FOR CLIMATE-RESILIENT ROAD DESIGN

Considering the type of climate hazards and risks in the mountainous areas of Tajikistan, and the area-specific climate change projections, the most serious threat comes from the expected increase in extreme precipitation events. This may not only lead to higher extreme discharges (i.e. flash floods) but can also lead to more frequent and more powerful mudflows, landslides, and avalanches. These may pose additional risk for bridge foundations and drainage systems (i.e. culverts) by discharge levels and solid loads exceeding the systems' design capacity.

Increases in the number of precipitation extremes is also likely to increase the frequency of landslides and rockfall, making any road stretches close to steep terrain vulnerable.

Similarly, an increase in extreme snowfall events may lead to an increase in the frequency of avalanches.

4.6 IMPACT ON THE NUMBER AND TYPE OF DISASTERS

Having identified the historic situation regarding patterns of disasters, forecasts of how the numbers and severity of disasters will change over time are needed to assess future costs and the viability of mitigation measures. These forecasts are based upon historic patterns, amended to take into account the expected impacts of climate change. As the time horizon for this study is ten years, forecasts have been produced for this period. The forecasts take into account rises or falls in total precipitation, changes in the number of extreme precipitation events, and the impact of temperature rises, amongst others, to predict how different events will change in terms of patterns of likelihood and severity.

As can be seen in Section 4.1, the impacts will vary across the country, which will effect future patterns of disasters. Whilst overall there is upward pressure on the number of disasters across the different types of hazard, this is not uniform. Based upon the analysis above, for the purposes of this assessment, it has been assumed that the numbers of different hazards will rise, on average, as follows:

- Avalanche – 4% per annum
- Mudflow – 2% per annum
- Flooding – 2% per annum
- Landslide/Rockfall/Slope Failure – 2% per annum

Overall, it is estimated that the number of disasters affecting the road network will rise by 3% per annum. However, this should not be taken as a prediction of the number of events that will occur each year as, as has been shown, the number of disasters is affected by a wide range of factors and cannot be predicted with any certainty. Taking the average number of disasters reported by CoESCD for 2018 and 2019, as a starting point, it is estimated that the number of events will rise as shown in Table 4-3.

Table 4-3 Future Number of Disasters by Type

Year	Avalanche	Rockfall	Mudflow	Landslide	Flooding	Slope Failure	Total
2018	16	7	5	4	0	0	32
2019	44	4	7	5	3	1	64
Average 2018/2019	30	5.5	6	4.5	1.5	0.5	48
2020	31.2	5.6	6.1	4.6	1.5	0.5	49.6
2021	32.4	5.7	6.2	4.7	1.6	0.5	51.2
2022	33.7	5.8	6.4	4.8	1.6	0.5	52.8
2023	35.1	6.0	6.5	4.9	1.6	0.5	54.6
2024	36.5	6.1	6.6	5.0	1.7	0.6	56.4
2025	38.0	6.2	6.8	5.1	1.7	0.6	58.2
2026	39.5	6.3	6.9	5.2	1.7	0.6	60.2
2027	41.1	6.4	7.0	5.3	1.8	0.6	62.1
2028	42.7	6.6	7.2	5.4	1.8	0.6	64.2
2029	44.4	6.7	7.3	5.5	1.8	0.6	66.3
2030	46.2	6.8	7.5	5.6	1.9	0.6	68.6
2031	48.0	7.0	7.6	5.7	1.9	0.6	70.9
2032	50.0	7.1	7.8	5.8	1.9	0.6	73.2

Source: Consultants' Estimates

5 ESTIMATING THE ECONOMIC COSTS OF DISASTERS

5.1 COST CATEGORIES

ASSESSMENT OF ECONOMIC COSTS OF DISASTERS

As set out in the terms of reference and the Inception Report, the economic costs of disasters can be categorised as follows:

- The costs of damage to infrastructure, measured as the repair cost;
- The direct costs of disasters, including the costs of emergency response and clean up, loss of life, and the costs of traffic being diverted; and
- The indirect costs of disasters, related to loss of access to economic opportunities, social and health facilities and the long term impact of successive disasters.

Each of these will be assessed separately, as discussed below.

5.2 EFFECT OF GROWTH IN TRAFFIC AND POPULATION

Whilst the number of disasters is generally affected by natural conditions, the impact of those disasters is, at least partly, determined by growth in population and the number of vehicles using affected roads. To estimate future growth in these two important variables, a review of past trends has been undertaken.

POPULATION GROWTH

Official population statistics for Tajikistan have been used to assess trends from recent years. Total population in Tajikistan has risen from 8.35 million in 2014 to 9.31 million in 2019, a growth of 11.1% in 6 years. This gives a compound growth rate of 1.55% per annum. This has been based upon published sources, including official Government of Tajikistan figures and United Nations data[34].

Growth in the national population, based upon published United Nations data is shown in Table 5-1 below.

Table 5-1 Growth in National Population

Year	Annual Growth
2020	2.32%
2021	2.22%
2022	2.13%
2023	2.05%
2024	1.98%
2025	1.93%
2026	1.88%

[34] UN World Population Prospects

2027	1.83%
2028	1.80%
2029	1.79%
2030	1.79%
2031	1.79%
2032	1.79%

GROWTH IN TRAFFIC INTENSITY

The growth in traffic intensity in recent years has been assessed using Ministry of Transport data on traffic intensity collected across the republican road network. This data is collected regularly and reported centrally. For the purposes of this assessment, overall growth in the number of vehicle kilometers run on the network as a whole has been estimated. Whilst there are significant concerns regarding the accuracy of the traffic intensity data collected, by aggregating this to a national level, it is considered that some inaccuracies should be balanced out.

Based upon this information, total vehicle kilometers on the road network has been estimated as shown in Table 5-2.

Table 5-2 Total Vehicle Kilometers[35]

Year	Total million vehicle km per day	Growth
2011	7.04	
2017	9.07	+3.05% per annum
2018	7.92	-13%
2019	10.68	+35%

As can be seen, these figures vary greatly, with no obvious pattern, or connection to other determining variables. However, taking the total figures across the period 2011 to 2019, total growth has been around 52%. This equates to an annual growth rate of around 3.05%, suggesting that the trend between 2011 and 2017 is valid across this period. For the purposes of this assessment, it has been assumed that annual growth in traffic intensity will continue to be around 3.05% per annum.

5.3 DAMAGE AND REPAIR TO ROAD INFRASTRUCTURE

COSTS OF DAMAGE TO INFRASTRUCTURE

The Ministry of Infrastructure in Tajikistan keeps good records of disasters that affect the road network. This data includes both the impacts of individual incidents and amalgamated data showing the overall costs, by region and nationally. This data has been cross-checked with data from the Committee on Emergency Situations and Civil Defence (CoESCD) and other sources, to develop a robust understanding of these costs.

[35] This omits the road between Dushanbe – Ayni – Khujand and Chanok, as only partial data was available

As shown in Table 2-11, data has been provided for the period 2014 to 2020, giving the opportunity to examine trends in costs and the number of disasters over this period. As noted elsewhere, there is no clear patterns of disasters, in terms of the number or severity of disasters. It has therefore been assumed that, for the purposes of this assessment, an annual average of the costs incurred for the period 2014 to 2019 represents a good approximation of the annual average costs and that this can be used as a starting point for future estimates. The growth in the number of disasters shown in Table 4-3 has been used to determine how overall damage and repair costs will grow over time. Table 5-3 below summarises the estimates of future damage and repair costs produced under this study.

Table 5-3 Estimates of Future Damage and Repair Costs (million somoni)

Total costs	Damage			Repairs			Total	Total
	Roads	Bridges	Pipes	Roads	Bridges	Pipes	Damage cost	Repair cost
2014 - 19 average	6.286	6.051	0.674	1.291	1.010	0.015	13.011	2.317
2020	6.490	6.247	0.696	1.333	1.043	0.015	13.434	2.392
2021	6.702	6.451	0.719	1.377	1.077	0.016	13.871	2.470
2022	6.921	6.662	0.742	1.422	1.112	0.016	14.325	2.550
2023	7.148	6.880	0.766	1.468	1.149	0.017	14.794	2.634
2024	7.383	7.106	0.792	1.517	1.187	0.017	15.280	2.721
2025	7.626	7.340	0.818	1.567	1.226	0.018	15.784	2.810
2026	7.878	7.583	0.845	1.618	1.266	0.019	16.305	2.903
2027	8.139	7.834	0.873	1.672	1.308	0.019	16.845	2.999
2028	8.409	8.094	0.902	1.727	1.352	0.020	17.405	3.099
2029	8.689	8.363	0.932	1.785	1.397	0.021	17.984	3.202
2030	8.979	8.643	0.963	1.845	1.443	0.021	18.585	3.309
2031	9.280	8.932	0.995	1.906	1.491	0.022	19.207	3.420
2032	9.591	9.232	1.028	1.970	1.542	0.023	19.851	3.534

Source: Consultants Estimates

5.4 SEARCH AND RESCUE COSTS

This category includes a range of costs, including the initial emergency response (search and rescue, emergency relocation), immediate clean up costs (removal of debris and damaged infrastructure) and longer term reactions (supply of emergency food and medicines). These costs are typically difficult to estimate, as the organisations involved account for these costs in very different ways. In particular Governments rarely report these costs specifically.

Within this study, these costs have been assessed based upon data provided by the CoESCD, data from NGOs operating in the sector, and information collected from comparable countries and organisations. It should be noted that much of this information has been provided on a confidential basis, making the reporting of individual sources impossible.

The data provided suggests that for a typical disaster the costs of search and rescue is around Somoni 85,000 per event. The aspects that are included in this figure are unclear, but this is considered to be a good working number.

Alongside this, a further significant cost relates to long term relief and support for affected communities. This will include provision of emergency medical supplies, food and water, and emergency accommodation. These costs can be considerable and will be incurred after many disasters. However, for the purposes of this assessment, these costs have been excluded as the direct connection between these costs and a disaster affecting the road network is unclear.

For the purposes of this assessment, the predicted number of disasters shown in Table 4-3 has been used as the basis for these calculations. Table 5-4 summarises the predictions of future search and rescue costs related to natural disasters affecting the road network.

Table 5-4 Total Future Search and Rescue Costs (somoni)

	Number of events	Rescue costs
2020	49.56	4,200,210
2021	51.18	4,337,098
2022	52.85	4,478,840
2023	54.58	4,625,616
2024	56.37	4,777,615
2025	58.23	4,935,034
2026	60.15	5,098,077
2027	62.15	5,266,953
2028	64.21	5,441,884
2029	66.35	5,623,097
2030	68.56	5,810,829
2031	70.86	6,005,327
2032	73.24	6,206,846

5.5 LOSS OF LIFE

Information from MoT and CoESCD has been used to identify the number of people killed as a result of disasters affecting the road network. These figures are limited to those killed as they use the road, or as part of response teams, but exclude those killed away from the road, for example those killed by a mudslide, before the slide reaches the road. Data on the number of people killed has been estimated by the consultants' team based upon local data, as discussed in Section 2.4. As has been noted elsewhere, the number of people killed annually varies greatly. It has therefore been necessary to use the average number killed between 2009 and 2019 as a starting point for the analysis, as shown in Table 2-10. Table 5-5 below summarises the estimates of future casualties.

Table 5-5 Future Casualties as a Result of Disasters

Year	Number of fatalities
2009 – 2019 Average	4.55
2020	4.69
2021	4.85
2022	5.00
2023	5.17
2024	5.34
2025	5.51
2026	5.70

2027	5.89
2028	6.08
2029	6.28
2030	6.49
2031	6.71
2032	6.94

Source: Consultants' Estimates

ESTIMATING THE RESOURCE VALUE OF A LIFE LOST

To estimate the economic costs of a life lost, it is essential to identify a number of elements:

- The age profile of casualties
- The average number of working years lost
- Average annual income
- A factor to reflect the willingness to pay to avoid the loss of a loved one

Little information is available regarding the profile of casualties killed in disasters, except that all are of working age (between 15 and 65 in Tajikistan). Therefore, it was necessary to utilize the profile of the overall population as a proxy for the profile of casualties. Table 5-6 below summarises the profile of population in Tajikistan. Based upon this profile the profile of casualties has been assumed, as shown in Table 5-7.

Table 5-6 Tajikistan Population Profile 2019[36]

Age	Number	Proportion	Proportion of working age
0-4	1143.2	36%	
5-9	1101.5	35%	
10-14	946.4	30%	
15-19	839	50%	14%
20-24	855.2	50%	15%
25-29	847.3	51%	15%
30-34	798.6	49%	14%
35-39	603.7	56%	10%
40-44	475.3	44%	8%
45-49	423	53%	7%
50-54	375.3	47%	6%
55-59	342.2	59%	6%
60-64	235.8	41%	4%
65-69	146.8	45%	
70-74	74.5	23%	
75-79	49.9	15%	
80+	56.1	17%	
Total	9313.8		

[36] Tajikistan in Figures 2020

The average number of working years lost has been estimated for each age group, by assuming that each individual will work until the age of 65. In reality, it is likely that a proportion of individuals will die before the age of 65 and some will retire before this age, but the data necessary to estimate these effects is not currently available.

The total income lost was calculated by multiplying the number of working years lost by the average annual salary in Tajikistan. Annual salary was taken as the key measure rather than income, recognising that the majority of road users are more likely to be in paid employment, rather than subsistence activities. The latter figure was taken from the latest published information. As information regarding the regional breakdown of casualties was not available, it was assumed that all casualties would attract the same average income. This assumption ignores the fact that average incomes vary significantly across Tajikistan, with incomes in Dushanbe being substantially higher than elsewhere. These calculations are shown in Table 5-7.

In addition to the resource costs of casualties, socio-economic theory proposes additional costs, including:

- The costs of search and rescue
- The costs of healthcare and burial costs
- The costs of administration of deaths

For the purposes of this study it has been assumed that the above costs are either covered by other cost categories, such as search and rescue, or are insignificant in terms of the overall calculations and can therefore be omitted.

Social theory also suggests one other cost category that should be considered, related to the distress caused to family members and friends, as a result of losing a family member. This is known as the 'Willingness to Pay' to avoid the loss of this person. This is a complex area, which should normally be resolved through the completion of stated preference surveys designed to assess people's willingness and ability to pay. This factor is influenced by a range of cultural, economic and social factors, which should be taken into account, to ensure that the factor used isn't unrealistically high. Such surveys are beyond the scope of this study, but an extensive literature search has elicited appropriate factors to be used. Based upon the literature available covering this area, a factor of 1.4, to be applied to the identified resource cost, has been identified[37].

[37] Establishing a Monetary Value for Lives Saved: Issues and Controversies, Dr Peter Abelson, WP 2008-02, Sydney University

Table 5-7 Calculation of the Average Cost of Casualties by Age Range

Range	Population 000's	Percent of population	Percent of Casualties	Average Age	Average Working Years Lost	Average Annual Income[38]	Income Lost per Casualty	Weighted Average Income Lost	WTP factor	Total Value of life
0 - 15	3,191.1	34%	0%	7.19	45	16,020	720,900	0	1.4	0
15 - 25	1,694.2	18%	29%	20.02	44.98	16,020	720,517	210,633	1.4	505,518
25 - 35	1,645.9	18%	28%	29.93	35.07	16,020	561,885	159,576	1.4	382,982
35 - 45	1,079	12%	19%	39.70	25.30	16,020	405,266	75,453	1.4	181,088
45 - 55	798.3	9%	14%	49.85	15.15	16,020	242,693	33,430	1.4	80,233
55 - 65	578	6%	10%	59.54	5.46	16,020	87,473	8,724	1.4	20,938
65+	327.3	4%	0%	74.02	0.00	16,020	0	0	1.4	0

Source: Consultants' Estimates

Based upon these calculations, the average total lost income from casualties resulting from disasters is estimated at somoni 1,170,759. In order to calculate the total cost of lives lost, this amount has been applied to the estimated future number of casualties, as shown in Table 5-8.

Table 5-8 Calculation of Total Cost of Casualties (somoni)

Year	Number of fatalities	Average value of life	Total Cost
2009 – 2019 Average	4.55		
2020	4.69	1,170,759	5,494,583
2021	4.85	1,170,759	5,673,656
2022	5.00	1,170,759	5,859,078
2023	5.17	1,170,759	6,051,086
2024	5.34	1,170,759	6,249,927
2025	5.51	1,170,759	6,455,857
2026	5.70	1,170,759	6,669,144
2027	5.89	1,170,759	6,890,063
2028	6.08	1,170,759	7,118,902
2029	6.28	1,170,759	7,355,960
2030	6.49	1,170,759	7,601,545
2031	6.71	1,170,759	7,855,981
2032	6.94	1,170,759	8,119,602

Source: Consultants Estimates

5.6 DISRUPTION TO TRAFFIC

Whilst this category of cost typically makes up a substantial proportion of the total economic costs of disasters, in the case of Tajikistan, this is less likely to be the case. The topography of Tajikistan and the nature of the road network means that, practically, alternative routes do not exist, meaning that rather than incurring additional travel time and distance, traffic will be stuck either side of a disaster

[38] Tajikistan in Figures 2020

site. Measuring this cost item is therefore restricted to the costs of delays to traffic, in terms of how long traffic cannot use a particular route.

The calculation of the costs of traffic disruption was based upon Equation 5-1 below.

Equation 5-1 Traffic Disruption Calculation

Costs of traffic disruption =

Number of disasters per annum x

Number of vehicles affected x

Average length of closure x

Value of time

NUMBER OF DISASTERS BY ROAD SECTION

To estimate the likely impact of disasters on traffic flows on each road section, various sources have been used to determine, which is the predominant type of disaster affecting each road section. These sources include:

- Data on past disasters from Ministry of Transport;
- Details of disasters in GBAO, provided by AKAH[39];
- The results of other studies of resilience, by the Road Design Institute[40] and AKAH; and
- The road inspections carried out for this study.

Having identified the most likely type of disaster to affect each link, it was possible to assign a typical length of closure, based upon Table 5-12.

To estimate the number of times in a typical year that a road section is likely to be closed, data on past disasters was used. Data from the CoESCD was used to determine the number of times each road section had been closed in 2018 and 2019. This data gave details of the type and location of each disaster, although the descriptions were not always straightforward to identify. As shown in Table 2-9, a total of 32 disasters in 2018 and 64 disasters in 2019 were analysed. Each disaster was connected to a specific road section and maintenance district, co-inciding with the standard road sections utilized by the Ministry of Transport. A summary of the locations of past disasters is shown in Table 5-9.

Table 5-9 Breakdown of Disasters 2018/19

Road Section	Maintenance District	Number of disasters
Rb01	Varzob	19
Rb01	Ayni	8
Rb03	Sangvor	3
Rb04	Darvaz	13
Rb04	Kulob	1

[39] Record of avalanches in GBAO, 2007 to date
[40] Study of Avalanches on road Section Dushanbe – Ayni, 2017

Rb04	Murgob	1
Rb04	Rushan	8
Rb04	Shamsiddin Shohin	1
Rb04	Shohin	5
Rb04	Shugnan	10
Rb04	Vanch	4
Rb06	Ishkashim	8
Rb07	Darvaz	1
Rb07	Lakhsh	1
Rb07	Tajikabad	4
Rb08	Pyanj	1
RB13	Penjakent	1
Rt85	Rushan	4

NUMBER OF VEHICLES AFFECTED

To estimate the number of vehicles affected by each closure, the Annual Average Daily Traffic (AADT) for each link was identified, based upon data provided by the Ministry of Transport, as discussed in Section 5.2. Little information is available regarding the breakdown of traffic between different types of vehicle, or between short and long distance traffic. The former would be particularly important in assessing the costs of disruption to traffic. It has therefore been necessary to use proxy data to provide an indication of the proportion of traffic that is passenger cars and how much is goods vehicles.

Data from past feasibility studies in Tajikistan has been used to determine rules of thumb that could be used to assess the proportion of traffic that is trucks and buses. For the feasibility studiesfor the upgrading of the Sayron – Karamik and Vose – Khovaling roads[41], traffic intensity surveys were carried out. Previously, for the feasibility study for the upgrading of the Ayni – Penjakent road[42], traffic surveys were undertaken at 4 locations. The results of these surveys are shown in Table 5-10. The roads surveyed are very different in nature, giving a broad coverage across the country, with an important international highway, a road of national importance and a more local feeder road.

Table 5-10 Traffic Survey Results

Road	Year	% cars	% buses	% trucks
Sayron – Karamik section 1	2013	53%	5%	42%
Sayron – Karamik section 2	2013	50%	10%	40%
Sayron – Karamik section 3	2013	46%	13%	41%
Sayron – Karamik section 4	2013	55%	6%	39%
Vose – Khovaling section 1	2013	77%	9%	14%
Vose – Khovaling section 2	2013	83%	6%	11%

[41] Central Asia Regional Economic Cooperation Corridors 3 and 5 Enhancement Project, Economic Appraisal Report, 2013,IMC Worldwide
[42] TA-8052 (TAJ) Roads Improvement Project, Economic Appraisal Report, 2012, Ramboll UK Ltd

Vose – Khovaling section 3	2013	78%	5%	17%
Vose – Khovaling section 4	2013	78%	6%	16%
Ayni – Penjakent section 1	2012	84%	0%	16%
Ayni – Penjakent section 2	2012	80%	1%	19%
Ayni – Penjakent section 3	2012	74%	0%	26%
Ayni – Penjakent section 4	2012	81%	0%	19%

Traffic survey data collected in 2007 for the ADB financed technical assistance to develop a road maintenance system for Tajikistan is shown in Table 5-11 below[43]. For comparison purposes, these categories can be combined to give proportions of cars 70%, buses 12%, goods vehicles 18%. Given the age of this data, these proportions should be treated with some caution, but they do offer useful comparative data, given the scale and scope of the surveys completed. Within the survey results there was wide variation with the proportion of cars being between 19% and 89% depending upon the type of road.

Table 5-11 Traffic Intensity Data from Strengthening Implementation of Road Maintenance Financing System Project

Vehicle Category	% of Total Volume
Light Vehicle (Cars / Jeeps / Vans)	70.04%
Mini Bus	10.02%
Standard Bus	1.76%
Light Goods Vehicles – up to 2.5 tonnes	2.57%
Light Goods Vehicles – up to 4 tonnes	2.42%
Light Goods Vehicles – up to 8 tonnes	3.25%
2 Axle Trucks – 8 to 10 tonnes	2.22%
3 Axle Trucks	5.79%
Multi Axle trucks (Semi Articulated /Articulated)	0.79%
Tractor and Tractor with Trailor	1.04%

Given the wide variance in the above figures, for the purposes of this study, two separate sets of assumptions were used, as follows:

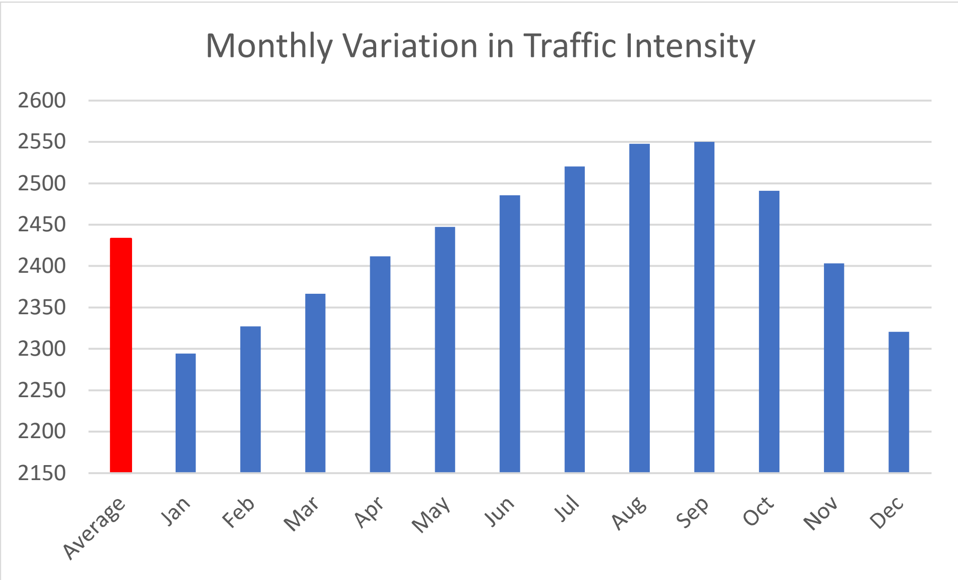
- International highways – cars 50%, buses 10%, trucks 40%
- Other republican roads – cars 80%, buses 6%, trucks 14%

Monthly Variation in Traffic Intensity

[43] Strengthening Implementation of Road Maintenance Financing System, TA 4294 – TAJ, Tajikistan, ADB

Traffic intensity data has been provided by MoT for the whole of the republican road network, for 2017 to 2019. This shows total daily traffic by road section (showing how traffic intensity falls as distance to Dushanbe increases), for each month of the year (showing how traffic intensity reduces in winter months). As shown in **Figure 5-1**, data provided by the Ministry of Transport shows that traffic levels in the period May to October tend to be higher than the annual average, with traffic levels in January, February and December being the lowest months. As shown in Figure 2-4, January, February and March are the most important months for disasters.

Figure 5-1 Average Daily Traffic Intensity - Republican Road Network



AVERAGE LENGTH OF CLOSURE

A key part of this analysis was to identify the likely length of each closure. To do this each of the hazard types was considered separately, identifying an average closure time for each. This analysis was based upon anecdotal evidence from a number of sources, including the socio-economic surveys undertaken for this study, information from the Ministry of Transport and other secondary information. As shown in Table 5-12, these assumed closure lengths reflect the differing nature of disaster events, with some being more deadly, but causing less damage and requiring less clear up, whilst others are less deadly, but cause more damage and need extensive clean-up operations.

Table 5-12 Typical Lengths of Road Closures by Hazard Type

Type	Average delay hours
Avalanche	24
Flooding	72
Landslide	48
Mudflow	120
Rockfall	6

Source: Consultants Estimates

VALUE OF TIME

Measuring the total costs of disruption to traffic requires the estimation of an appropriate value of time. This is used to multiply the total hours of disruption to reach a monetized measure of the costs. As very few of the roads in Tajikistan have a viable alternative that could be used during a closure, the main cost relates to the time lost by vehicles that are trapped either side of a closure. Quantifying this cost is complicated by the need to reflect the breakdown of traffic between different types, as discussed below. For this assessment, vehicle occupancy was assumed based upon observations and the results of surveys undertaken in Tajikistan in the past. In this case, average occupancy of people undertaking work trips was assumed to be 2 for cars (driver and 1 passenger), 3 for buses (driver and 2 passengers) and 3 for trucks (driver and 2 loaders).

For the purposes of this study, the value of time has been estimated separately for each region, taking into account significantly different income levels and patterns of work. This reflects very different working patterns in Dushanbe. Table 5-13 summarises the calculation of VoT for this study.

Table 5-13 Calculation of Value of Time per hour (somoni)

Region	Average monthly wages[44]	Days worked	Hours per day	Working Hours	Work VOT per hour	Total VOT Car	Total VOT Bus	Total VOT Truck
National	3362.90	275	7.5	2062.5	19.57	39.13	58.70	58.70
Dushanbe	4483.15	300	8	2400	22.42	44.83	67.25	67.25
GBAO	2735.49	200	7	1400	23.45	46.89	70.34	70.34
RRS	2192.22	200	7	1400	18.79	37.58	56.37	56.37
Khatlon	2294.30	200	7	1400	19.67	39.33	59.00	59.00
Sughd	2946.07	220	7	1540	22.96	45.91	68.87	68.87

Source: Consultants Estimates

VALUE OF CARGO

Whilst it is possible to estimate the proportion of heavy goods vehicles, based upon the figures shown in Table 5-10 and Table 5-11, no current data has been identified showing the mix of cargoes carried. Whilst it can be assumed that the majority of vehicles entering Tajikistan are full, and the majority leaving are empty, there is little evidence to back this up. In the absence of specific information relating to traffic on the Republican road network, it is impossible to make an estimate of the average value of cargo. It should be noted that only perishable cargoes will deteriorate during delays, such as fresh foods, animals and pharmaceuticals. In these cases the costs of delay may be significant, depending upon the rate of deterioration. Many cargoes, such as fuel, raw materials and electricals will not deteriorate significantly, and therefore the costs of delays are negligible

Whilst it is not possible to determine the costs incurred due to delays to goods vehicles, an estimate of the number of hours delay experienced each year has been made. Based upon the assumptions detailed in this report, it is estimated that total delays to goods vehicles will amount to around 1.94 million hours per annum. It is likely that this is a slight over-estimate as truck traffic is lower during

[44] Tajikistan in Figures 2020

winter months, and some trucks will be able to stagger their travel times when disasters occur. However, this is considered to be usable working assumption.

CALCULATION OF OVERALL COSTS OF TRAFFIC DISRUPTION

The detailed calculation of the total costs of traffic disruption is shown in Annex C. Table 5-14 below summarises the costs estimated to be incurred for each road section affected by disasters.

Table 5-14 Summary of Calculation of Traffic Disruption Costs (somoni)[45]

Road	Section	District	Costs
РБ 01 Dushanbe - Chanok	11 - 84,5	Varzob	38,376,936
РБ 01 Dushanbe - Chanok	84,5-198	Ayni	27,794,391
РБ 01 Dushanbe - Chanok	198-253,7	Shakristan	10,784,912
РБ 03 Labijar - Kalaikumb	0-102	Tavildara	3,643,581
РБ 03 Labijar - Kalaikumb	102-136	Darvoz	16,871,488
РБ-04 Dushanbe – Khorog – Murgab	147-189	Vose	3,008,798
РБ-04 Dushanbe – Khorog – Murgab	189-197	Kulob	4,385,298
РБ-04 Dushanbe – Khorog – Murgab	286-441	Darvoz	7,271,497
РБ-04 Dushanbe – Khorog – Murgab	441-481	Vanj	6,566,055
РБ-04 Dushanbe – Khorog – Murgab	481-574	Rushan	6,347,397
РБ-04 Dushanbe – Khorog – Murgab	574-611	Shugnon	4,162,388
РБ-04 Dushanbe – Khorog – Murgab	622-822	Shugnon	4,006,113
РБ-04 Dushanbe – Khorog – Murgab	822-1023	Murgab	3,847,948
РБ 05 Murgab – Karakul - Kizilart	0-187	Murgab	1,084,661
РБ 06 Khorog - Ishkashim	0-31	Shugnon	6,337,036
РБ 06 Khorog - Ishkashim	31,7-320,4	Ishkashim	3,016,229
РБ 07 Vakdat – Jirgatol -	87-142,5	Rogun	10,552,776
РБ 07 Vakdat – Jirgatol -	142,5-193	Nurobod	9,755,865
РБ 07 Vakdat – Jirgatol -	193-228	Rasht	6,972,378
РБ 07 Vakdat – Jirgatol -	228-288	Tojikobod	6,054,801
РБ 07 Vakdat – Jirgatol -	288-329	Lyaksh	4,929,447
РБ 07 Vakdat – Jirgatol -	14-62	Lyaksh	4,604,875
РБ 08 Gulistan – Pyanj – Dusti	69,4-114,5	Pyanj	4,018,139
РБ 13 Ayni - Penjakent	0-47	Ayni	497,063
РБ 13 Ayni - Penjakent	47-112,7	Penjakent	906,490
РБ 14 Konibodom - Dehmoy	0-56.8	Konibodom	3,916,504
РБ 19 Khujand - Asht	28-122	Asht	4,090,829
РЧ 032 Vose - Khovaling	0-40	Vose	1,263,653
РЧ 032 Vose - Khovaling	40-87.7	Khovaling	1,174,356
РЧ 069 Konibodom – Isfara	0-4,8	Konibodom	10,447,269
РЧ 069 Konibodom - Isfara	4,8-27	Isfara	6,578,383
РЧ 085 Rushon – Basid - Savnob	0-11,3	Rushon	2,107,703

[45] It has been assume that road sections not affected by a disaster in 2018 or 2019 (according to official reports) will not be affected in the future

The total costs of traffic disruption have been estimated based upon the figures in Table 5-14, inflated to take into account the effect of climate change and growth in traffic intensity. Table 5-15 below summarises the costs estimated.

Table 5-15 Estimated Total Costs of Traffic Disruption (somoni)

Year	Total
2020	230,199,098
2021	244,951,366
2022	260,671,834
2023	277,425,352
2024	295,281,183
2025	314,313,313
2026	334,600,774
2027	356,227,994
2028	379,285,170
2029	403,868,666
2030	430,081,442
2031	458,033,509
2032	487,842,417

5.7 COSTS OF SEVERANCE OF COMMUNITIES

There are many impacts that communities are likely to suffer as a result of natural hazards. These include measurable reductions in income, costs associated with lost education, health related costs, and long term poverty effects. The degree to which these can be quantified and monetised vary, although in a data-poor environment such as Tajikistan, these opportunities are limited.

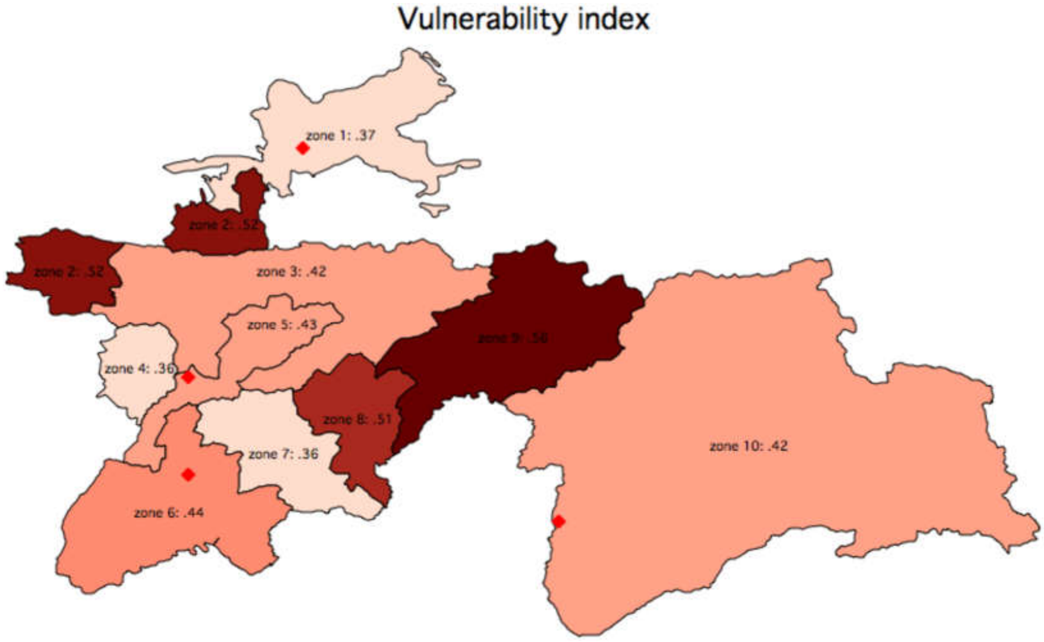
The impacts of natural disasters and climate change are not felt uniformly across Tajikistan, with many issues affecting how communities are impacted and how quickly they recover from a disaster. Climate change can potentially deepen poverty by lowering agricultural yields, raising food prices, and increasing the spread of water-borne diseases as well as the frequency and severity of disasters. Regions with greater dependence on agriculture and lower socioeconomic indicators, particularly the east mountain area of the Regions of Republican Subordination (RRS), the Southern Sughd hills, and Khatlon hills and lowlands, are most vulnerable to climate change, with rural areas more at risk than urban locations[46].

While there is insufficient survey data in Tajikistan to quantify the impact of disasters by welfare status, evidence from global studies shows that the poor tend to be disproportionately affected by disasters, as their housing is of inferior quality and often constructed in hazardous locations. This conclusion is supported by the results of the surveys undertaken for this study. Poorer people also cannot afford the costs of migration to less hazard-prone locations, and after disasters occur, it takes them longer to restore their livelihoods because they tend to have non-diversified incomes and little savings. This

[46] Tajikistan: Economic and Distributional Impact of Climate Change, Rasmus Heltberg, Anna Reva, and Salman Zaidi, World Bank Knowledge Brief April 2012

creates a situation where inter-generational poverty becomes a major issue. Parts of Tajikistan that have been identified as increasingly vulnerable are shown in Figure 5-2 below.

Figure 5-2 Vulnerability to Climate Change and Natural Disasters



Source: World Bank staff estimates based on data from several sources. Darker areas on the map represent locations with the highest vulnerability[47].

USING THE RESULTS OF THE SOCIO-ECONOMIC SURVEYS

As part of this study, a series of socio-economic surveys were completed at seven locations across Tajikistan. Whilst it should be noted that the surveys cannot be considered to present a representative sample of communities across the country, they do provide important insight into the impact of disasters that affect the road network. To estimate the overall impact of the impact of a loss of access for rural communities, it has been necessary to combine the survey results with secondary sources, to build up an overall picture of these costs. This process is described below.

For the purposes of this assessment, the effect of community severance has been split between what might be considered to be permanent effects and effects that are temporary. The former relates to either permanent loss of employment or long term impacts in terms of lifetime reductions in income. Temporary effects are where income is lost for just a few days, with employment returning to normal.

IMPACT ON TYPICAL INCOMES

Households regularly affected by disasters are typically poorer than others in the same district. These issues are exacerbated by issues related to the rural nature of much of Tajikistan. Typically, poor people depend more on natural resources for their livelihoods and are most vulnerable to

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[47] The regional index of vulnerability for Tajikistan is based on the simple average of the exposure, sensitivity, and adaptive capacity subindices. Indicators of past climate variability and the frequency of disasters are used to assess exposure to climate change; health, livelihood, food security, and demographic characteristics are used to determine sensitivity to climate impacts; and social, economic, and institutional characteristics are used to assess adaptive capacity.

environmental imbalances, particularly to processes associated with climate, desertification, land and water degradation and the aftermath of natural disasters, including droughts and floods[48]. Reliance upon natural resources for livelihoods is a direct result of a lack of employment opportunities. These employment opportunities are scarce in rural areas affected by disasters, creating a vicious circle of lack of opportunity, increased deprivation, reduced resilience and lack of opportunity. The effect of this is shown by the multi-dimensional poverty index calculated as part of this study, shown in Table 5-16 below.

Table 5-16 Multi-Dimensional Poverty Index

District	Score
National average	0.64
Ayni	0.74
Asht	0.79
Varzob	0.81
Khorog	0.26
Shughnon	0.68
Farkhor	0.77
Khovaling	0.84

Source: Consultants Estimates

Average income levels for each of the survey districts have been estimated based upon the survey results. These figures are shown in Table 5-17 below. These have been compared with the national average income, which in 2019 was 476 somoni per month.

Table 5-17 Average Monthly Incomes from Socio-Economic Surveys (somoni)

District	Less than 100	100 - 200	200 - 300	300 - 400	400 - 500	more than 500	Implied average	% of National average
National Average[49]							476	
Ayni	21.5%	26.6%	7.6%	1.3%	1.3%	41.7%	419	88%
Asht	34.2%	30.3%	18.4%	9.2%	2.6%	5.3%	203	43%
Varzob	18.9%	33.3%	17.8%	11.1%	6.7%	12.2%	275	58%
Khorog	6.7%	45.0%	23.3%	11.7%	8.3%	5.0%	249	53%
Shughnon	9.1%	60.6%	21.2%	3.0%	0.0%	6.1%	210	45%
Farkhor[50]	27.5%	67.5%	5.0%	0.0%	0.0%	0.0%	134	29%
Khovaling	10.3%	55.2%	10.3%	13.8%	0.0%	10.4%	248	53%

Based upon these figures it was possible to estimate the overall financial impact of disasters. From the socio-economic survey results, it was possible to identify the proportion of the population in each district that consider themselves to be susceptible to the effects of disasters. This information was an important input to the calculation of the typical impact that each disaster would have on each person affected. To calculate this, an assessment was made of the total income reduction caused by disasters that affect each district, as shown in Table 5-18. Based upon these calculations the

[48] Tajikistan: Poverty in the Context of Climate Change, National Human Development Report 2012, UNDP, 2012
[49] Tajikistan in Figures 2020
[50] Data for Farkhor may be skewed by the selection of a village that is highly disaster prone

monetary effect of each disaster on residents in the different districts varies between 15 somoni in the more prosperous areas, to 174 somoni in the poorer areas.

Table 5-18 Calculation of Average Income Impact Per Person Per Disaster (somoni)

	Number of people[51]	Proportion susceptible[52]	No susceptible	Income deficit[53]	Effect on total income	No of disasters[54]	Effect per disaster	Per person
Asht	168,100	30%	50,430	273	13,747,218	3.097	4,438,882	26
Ayni	83,600	35%	29,260	57	1,667,089	1.249	1,334,739	16
Farkhor	170,800	56%	95,648	342	32,675,748	2.000	16,337,874	96
Khovaling	57,900	45%	26,055	228	5,946,402	1.551	3,833,915	66
Khorog	30,500	37%	11,285	227	2,560,849	1.468	1,744,447	57
Shughnon	38,000	39%	14,820	266	3,941,750	0.637	6,187,990	163
Varzob	82,200	57%	46,854	201	9,407,112	0.656	14,340,110	174

For the purposes of this assessment the number of disasters that affect each district was taken from the socio-economic surveys, as shown in Table 5-19 below. These figures are difficult to interpret and rely upon the personal opinion of respondents and the particular circumstances within each surveyed village. For the purposes of this assessment, it has been assumed that weekly or monthly occurrence of disasters refers only to winter and spring (so November to April), as the vast majority of disasters occur in these months. Based upon these calculations rural communities in Tajikistan will suffer a disaster between once every two years and three times per year. This makes no allowance for the scale or scope of a disaster, as the impact of a single larger disaster and many smaller disasters may be similar.

Table 5-19 Estimation of the Number of Disasters Affecting each District[55]

	Ayni	Asht	Varzob	Khorog	Shughnon	Farkhor	Khovaling	Total
Every week	0.0%	5.1%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%
Once per month	1.3%	10.1%	0.0%	1.7%	0.0%	0.0%	0.0%	2.5%
Once every six months	56.6%	49.4%	30.0%	58.3%	15.2%	100.0%	58.6%	50.6%
Once a year	3.9%	17.7%	5.6%	20.0%	33.3%	0.0%	37.9%	13.8%
During precipitation / depending on weather conditions	3.9%	3.8%	56.7%	5.0%	0.0%	0.0%	3.4%	15.0%
At the moment, we do not suffer from natural disasters / rarely suffer / until there wasn't	34.2%	13.9%	7.8%	15.0%	51.5%	0.0%	0.0%	17.2%
Average No of disasters per annum	1.249	3.097	0.656	1.468	0.637	2.000	1.551	1.560

[51] Population estimated from https://en.wikipedia.org/wiki/Districts_of_Tajikistan
[52] From Socio-economic Surveys
[53] See Table 5-17
[54] See Table 5-19
[55] Calculated as (Every week * 26) + (Once per month * 6) + (Once every six months * 2) + (Once a year * 1) + (During precipitation * 0.5) + (Do not suffer * 0)

PERMANENT IMPACT OF A LOSS OF ACCESS

Using the figures above, an assessment of the total permanent loss of income has been made. Each road section affected by natural disasters has been compared with the districts included in the survey, to identify the most similarity. This assessment was made on the basis of geography, type of disaster suffered and socio-economic situation. Based upon this, the figures above showing the effect of each disaster were applied. This choice triggered the use of factors for the typical proportion of the population that are affected by any one disaster, and the long term monetary effect.

Studies of similar impacts of repeated disasters in Latin America[56] suggest that income effects could be between 12% and 50% of lifetime income, depending upon the type of disasters experienced. The impact has been shown to depend upon the number of disasters experienced and the destructive effect of each disaster. Catastrophic events such as earthquakes tend to create the greatest immediate and long term impacts, whilst disasters with less widespread impact such as landslides and avalanches have much lower long term impacts.

These estimates are in many ways supported by ongoing research into the educational and life outcome impacts of the COVID19 restrictions. These suggest that children that have lost significant amounts of schooling during the restrictions, are likely to suffer a 3% reduction in lifetime income, as a result[57]. This figure was estimated based upon research from May 2020, so is likely to now be higher, as more education has been lost. This impact mirrors the impact of repeated disasters affecting a particular area, where children are likely to lose many days of education over their school life.

Quantifying these effects in the context of Tajikistan is beyond the scope of this study. However, it is likely that the effects do exist and this is therefore presented as contributory evidence to support the assumptions made in this assessment.

There is also strong evidence from a number of publications that those with poorer educational attainment suffer from shorter life expectancy[58]. Amongst OECD countries the range of this effect is between 3 and 10 years. This effect results from a number of effects, including that a higher education level not only provides the means to improve the socio-economic conditions in which people live and work, but may also promote the adoption of healthier lifestyles and facilitate access to appropriate health care[59]. Poorer educational attainment can result from many causes, but repeated loss of access to education due to disasters is a significant cause in Tajikistan. Whilst this impact is difficult to quantify, or even substantiate, in the context of Tajikistan, due to data inadequacies and the need for detailed modelling of these effects, it is considered reasonable to expect that similar impacts would be seen. However, due to these difficulties, this has not been included in the assessment of socio-economic costs.

TEMPORARY IMPACT DUE TO TEMPORARY LOSS OF ACCESS

The assessment of the short term loss of income has been completed on the basis that individuals cut off from their place of work will lose a number of days income, but will retain their job. The calculation of the daily amount lost, makes use of the same statistics on average monthly income, collected

[56] The Legacy of Natural Disasters: The Intergenerational Impact of 100 Years of Natural Disasters in Latin America, German Daniel Caruso, University of Illinois at Urbana-Champaign, October 2014
[57] The Economic Impacts of Learning Losses, Eric A. Hanushek and Ludger Woessmann, September 2020, OECD
[58] https://www.newscientist.com/article/2166833-more-education-is-what-makes-people-live-longer-not-more-money/
[59] OECD (2017), "Life expectancy by sex and education level", in Health at a Glance 2017: OECD Indicators, OECD Publishing, Paris.

during the socio-economic surveys. For the purposes of this assessment an average 22 day working month has been assumed[60]. Whilst average working hours per week for all people in Tajikistan is 13.1[61], this figure is heavily biased by non-workers or those in informal employment, or who rely upon subsistence agriculture.

For the purposes of this assessment, it has been assumed that the amount of income lost per person, per disaster, is related to the length of the closure. This has been based upon the assumptions in Table 5-12, with the loss of income being the number of days that a road is closed, plus 1 day, multiplied by the average daily income in each location.

Whilst there is no directly comparable evidence, the 2015 Murgab Earthquake In Depth Assessment Report[62] suggests that as a result of the Murgab earthquake around 13% of those surveyed had not been able to work in their normal jobs after the disaster, after a period of 6 months, although 10% of these had been able to find an alternative job.

Table 5-20 shows the calculation of temporary income loss, for the districts included in the socio-economic surveys. It should be noted that from this survey, it was possible to assess the proportion of the population affected by disasters. This information is used as a key aspect of the calculation.

Table 5-20 Calculation of Average Temporary Income Loss

	Proportion affected	Hazard type	Days lost	Average income[63]	No of people[64]	Total loss per disaster	Per person
Asht	57.1%	Avalanche	2	9	168,100	1,774,852	11
Aini	5.3%	Avalanche	2	19	83,600	168,783	2
Farkhor	56.7%	Flooding	4	6	170,800	2,366,065	14
Khovaling	50%	Rockfall	1.25	11	57,900	407,562	7
Khorog	0%[65]	Avalanche	2	11	30,500	-	-
Shughnon	50%	Avalanche	2	10	38,000	362,770	10
Varzob	43.8%	Avalanche	2	13	82,200	900,826	11

Source: Consultants estimates

TOTAL COSTS OF LOSS OF EMPLOYMENT AND INCOME

For the purposes of this assessment, the calculation of total permanent and temporary losses have been combined. The following Table 5-21 summarises the results of this calculation.

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[60] There is little evidence for this assumption, except that legally in Tajikistan employees can only work up to 40 hours per week, implying a 5 day working week of 8 hours each - see http://tpp.tj/put2011/about_employment_eng.htm#:~:text=Under%20the%20Tajik%20labour%20law,work%2040%20hours%20per%20week
[61] https://knoema.com/data/average-working-hours+tajikistan
[62] Prepared for REACT Tajikistan by the Disaster Risk Management Programme, UNDP Tajikistan, based on collaboration with Focus Humanitarian Assistance, Red Crescent Society of Tajikistan and WFP Tajikistan. July 2016
[63] See Table 5-17
[64] Population estimated from https://en.wikipedia.org/wiki/Districts_of_Tajikistan
[65] For Khorog district no survey respondent stated that they suffered a temporary loss of income, most likely due to the more urban nature of the district meaning that nobody is ever completely cut off.

Table 5-21 Calculation of Income Losses 2020 (somoni)

Road	Section	Comparator District	Costs
РБ 01 Dushanbe - Chanok	11 - 84,5	Varzob	29,319,751
РБ 01 Dushanbe - Chanok	84,5-198	Ayni	1,776,035
РБ 01 Dushanbe - Chanok	198-253,7	Ayni	928,382
РБ 03 Labijar - Kalaikumb	0-102	Varzob	1,846,851
РБ 03 Labijar - Kalaikumb	102-136	Varzob	1,902,336
РБ-04 Dushanbe – Khorog – Murgab	147-189	Khovaling	12,313,063
РБ-04 Dushanbe – Khorog – Murgab	189-197	Khovaling	12,210,691
РБ-04 Dushanbe – Khorog – Murgab	286-441	Varzob	6,816,703
РБ-04 Dushanbe – Khorog – Murgab	441-481	Varzob	9,770,608
РБ-04 Dushanbe – Khorog – Murgab	481-574	Shughnon	4,661,663
РБ-04 Dushanbe – Khorog – Murgab	574-611	Shughnon	6,866,016
РБ-04 Dushanbe – Khorog – Murgab	622-822	Shughnon	6,866,016
РБ-04 Dushanbe – Khorog – Murgab	822-1023	Shughnon	2,872,885
РБ 05 Murgab – Karakul - Kizilart	0-187	Murgab	1,068,981
РБ 06 Khorog - Ishkashim	0-31	Shughnon	5,109,593
РБ 06 Khorog - Ishkashim	31,7-320,4	Shughnon	4,423,832
РБ 07 Vakdat – Jirgatol -	87-142,5	Varzob	2,039,066
РБ 07 Vakdat – Jirgatol -	142,5-193	Varzob	3,796,085
РБ 07 Vakdat – Jirgatol -	193-228	Varzob	5,890,636
РБ 07 Vakdat – Jirgatol -	228-288	Varzob	2,126,917
РБ 07 Vakdat – Jirgatol -	288-329	Varzob	3,070,159
РБ 07 Vakdat – Jirgatol -	14-62	Varzob	3,070,159
РБ 08 Gulistan – Pyanj – Dusti	69,4-114,5	Farkhor	3,670,265
РБ 13 Ayni - Penjakent	0-47	Ayni	131,558
РБ 13 Ayni - Penjakent	47-112,7	Ayni	476,820
РБ 14 Konibodom - Dehmoy	0-56.8	Konibodom	332,200
РБ 19 Khujand - Asht	28-122	Asht	906,969
РҶ 032 Vose - Khovaling	0-40	Vose	4,581,605
РҶ 032 Vose - Khovaling	40-87.7	Khovaling	1,225,288
РҶ 069 Konibodom – Isfara	0-4,8	Konibodom	1,138,972
РҶ 069 Konibodom - Isfara	4,8-27	Isfara	1,478,343
РҶ 085 Rushon – Basid - Savnob	0-11,3	Shughnon	3,469,145

Source: Consultants Estimates

5.8 TOTAL ECONOMIC COSTS

The total economic costs assessed under this study are shown in Table 5-22. This table summarises the predictions of future costs over the period 2022 – 2032. The estimated economic costs of disasters affecting the road network rise from somoni 508 million in 2022 to more than somoni 900 million in 2032. At current exchange rates this equates to USD45 million rising to USD80 million per annum.

Table 5-22 Summary of Total Economic Costs (somoni)

Year	Damage to infrastructure	Costs of repairs	Rescue costs	Casualties	Traffic disruption	Costs of community severance	Total
2022	14,324,653	2,550,450	4,478,840	5,859,078	260,671,834	157,036,892	444,921,747
2023	14,794,086	2,634,031	4,625,616	6,051,086	277,425,352	165,493,502	471,023,673
2024	15,280,226	2,720,586	4,777,615	6,249,927	295,281,183	174,301,047	498,610,585
2025	15,783,699	2,810,228	4,935,034	6,455,857	314,313,313	183,503,204	527,801,335
2026	16,305,156	2,903,071	5,098,077	6,669,144	334,600,774	193,113,038	558,689,260
2027	16,845,273	2,999,237	5,266,953	6,890,063	356,227,994	203,143,770	591,373,291
2028	17,404,754	3,098,851	5,441,884	7,118,902	379,285,170	213,650,736	626,000,297
2029	17,984,327	3,202,041	5,623,097	7,355,960	403,868,666	224,698,063	662,732,155
2030	18,584,750	3,308,945	5,810,829	7,601,545	430,081,442	236,336,470	701,723,982
2031	19,206,812	3,419,700	6,005,327	7,855,981	458,033,509	248,598,444	743,119,774
2032	19,851,329	3,534,454	6,206,846	8,119,602	487,842,417	261,518,293	787,072,942

Source: Consultants Estimates

Total GDP for Tajikistan in 2019 was 8.1 billion somoni[66]. Total GDP has been growing steadily, at approximately 7% per annum. In 2020 there was expected to be a small contraction in the economy due to COVID19 related factors, but it is expected that growth will return to previous trends in 2021[67]. Total GDP in 2022 is therefore expected to be around 8.6 billion somoni. Assuming total losses due to disasters affecting the road network of approximately 445 million somoni, losses are likely to be in the region of 0.5% of total GDP per annum.

[66] World Bank Estimate
[67] World Bank Forecasts

6 ASSESSING THE VIABILITY OF MITIGATION

6.1 METHODOLOGY

COST BENEFIT ANALYSIS OF MITIGATION MEASURES

The cost benefit analysis of mitigation measures utilises the results of the two sets of analyses described above.

The costs side of this analysis has come from the analysis of the costs of mitigation measures, assuming these are implemented over a four year period. This is detailed in Section 3.6. An implementation period of four years has been taken, assuming that the majority of the funding for the proposed investments will be externally financed, with only a relatively small number being included in maintenance budgets.

The benefits side of the analysis has come from the analysis of the costs of disasters. The assessment of benefits takes into account that only a proportion of the costs of disasters can be avoided. Whilst the mitigation measures will reduce the likelihood of some disasters and in some cases the severity, they won't eliminate either. As such some disaster risk will remain. Without a detailed analysis of the benefits of each individual investment it is not possible to estimate with any certainty the amount of residual risk. For the purposes of this assessment, a base assumption is that 50% of the risk will remain. This has been subject to a series of sensitivity tests, as discussed below.

The CBA has been completed for a period of ten years, which is in line with the economic life of many of the measures being proposed. Standard economic indicators, such as Internal Rate of Return and Benefit Cost Ratio have been calculated.

APPRAISAL LENGTH

Recognising the relatively short lives of many of the proposed interventions, for the purposes of this study an appraisal period of 2021 – 2032 has been used. This is shorter than the 20 years usually used, but this is justified on the basis of the uncertainty related to longer term benefits, and the short life of many mitigation measures. Adopting this shorter appraisal period, avoids the need to estimate longer term climate change effects and how these will affect the design of mitigation measures in the very long term. A longer appraisal period would have the effect of slightly improving the economic viability of those measures with longer lives, such as road relocation and avalanche galleries, but would have minimal effect on the viability of measures that would need to be replaced during the appraisal period.

DISCOUNT RATE

The cost benefit analysis adopts the standard discounted cash flow methodology. This involves the calculation of each cost and benefit stream in case terms, without discounting. A standard discount rate has then been applied in the calculation of net present value.

Given the level of uncertainty related to climate change adaptation and disaster risk mitigation investments, it may be appropriate to utilise a higher discount rate. This reflects the uncertainty regarding costs and benefits in the longer term, putting greater emphasis on benefits in early years. Whilst there is no specific guidance on this factor, there has been discussion of the issues, specifically in relation to the appraisal of climate change and disaster risk mitigation investments[68]. However, there is an argument that using a higher discount rate effectively works against climate change and disaster risk investments, as it reduces the impact of longer term impacts on the appraisal result. However, it is considered in this appraisal, that given the relatively short life of many of the mitigation measures, a larger discount rate is appropriate.

For the purposes of this study, a discount rate of 12% has been used in the central case, with a discount rate of 8% being used as a sensitivity test. Whilst the alternative discount rate would affect the calculation of net present value, no change in the internal rate of return would result.

6.2 COST BENEFIT ANALYSIS INPUTS

EXPENDITURE PROFILE OF COSTS

For the purposes of this assessment, it has been necessary to assume a multi-year investment programme for the mitigation measures. The following breakdown of expenditure has been assumed, reflecting the likely funding sources for the investments, the time required to prepare many of the mitigation measures and the need for international procurement for some measures.

- 2021 – 15%
- 2022 – 25%
- 2023 – 40%
- 2024 – 20%

BENEFITS PROFILE

In the same way as for costs, the full benefits of the investments won't be accrued immediately. It has therefore been necessary to assume a profile for the timing of when benefits will accrue, as shown below:

- 2021 – 0%
- 2022 – 20%
- 2023 – 60%
- 2024 – 85%
- 2025 onwards – 100%

6.3 COST BENEFIT ANALYSIS RESULTS

WHOLE PROGRAMME

The results of the cost benefit analysis are shown in Table 6-1. As can be seen, on the basis of the assumptions discussed above, the internal rate of return for the whole programme of mitigation measures is -14.5%, meaning that the programme is not considered to be economically viable.

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[68] Investment Decision Making Under Deep Uncertainty Application to Climate Change, Policy Research Working Paper 6193, World Bank

Table 6-1 Cost Benefit Analysis Results – All road sections

Year	Costs of increasing resilience	Total Costs	Reduced costs after resilience is increased							Benefits-costs
			Damage to infrastructure	Costs of clean up	Rescue costs	Casualties	Traffic disruption	Costs of community severance	Total	
2021	685,615,240	685,615,240	0	0	0	0	0	0	0	-685,615,240
2022	1,142,692,067	1,142,692,067	1,432,465	255,045	447,884	585,908	26,067,183	15,703,689	44,492,175	-1,098,199,892
2023	1,828,307,307	1,828,307,307	4,438,226	790,209	1,387,685	1,815,326	83,227,606	49,648,051	141,307,102	-1,687,000,205
2024	914,153,653	914,153,653	6,494,096	1,156,249	2,030,486	2,656,219	125,494,503	74,077,945	211,909,499	-702,244,155
2025	0	0	7,891,849	1,405,114	2,467,517	3,227,929	157,156,657	91,751,602	263,900,668	263,900,668
2026	0	0	8,152,578	1,451,536	2,549,038	3,334,572	167,300,387	96,556,519	279,344,630	279,344,630
2027	0	0	8,422,637	1,499,619	2,633,477	3,445,032	178,113,997	101,571,885	295,686,646	295,686,646
2028	0	0	8,702,377	1,549,425	2,720,942	3,559,451	189,642,585	106,825,368	313,000,149	313,000,149
2029	0	0	8,992,163	1,601,021	2,811,549	3,677,980	201,934,333	112,349,032	331,366,077	331,366,077
2030	0	0	9,292,375	1,654,472	2,905,415	3,800,773	215,040,721	118,168,235	350,861,991	350,861,991
2031		0	9,603,406	1,709,850	3,002,664	3,927,991	229,016,754	124,299,222	371,559,887	371,559,887
2032		0	9,925,665	1,767,227	3,103,423	4,059,801	243,921,208	130,759,146	393,536,471	393,536,471
									NPV	-2,350,796,732
									IRR	-14.5%

INDIVIDUAL ROAD SECTIONS

It should be noted that within the whole programme the proposed mitigation measures for some road sections would be viable, whilst others, where the costs are high and traffic levels low, are unlikely to be viable. To better understand this, the programme of measures for each road has been assessed separately.

Whilst these results give an indication it should be noted that these calculations have required certain simplifications that introduce a small degree of inaccuracy into the individual results. These can be summarised as:

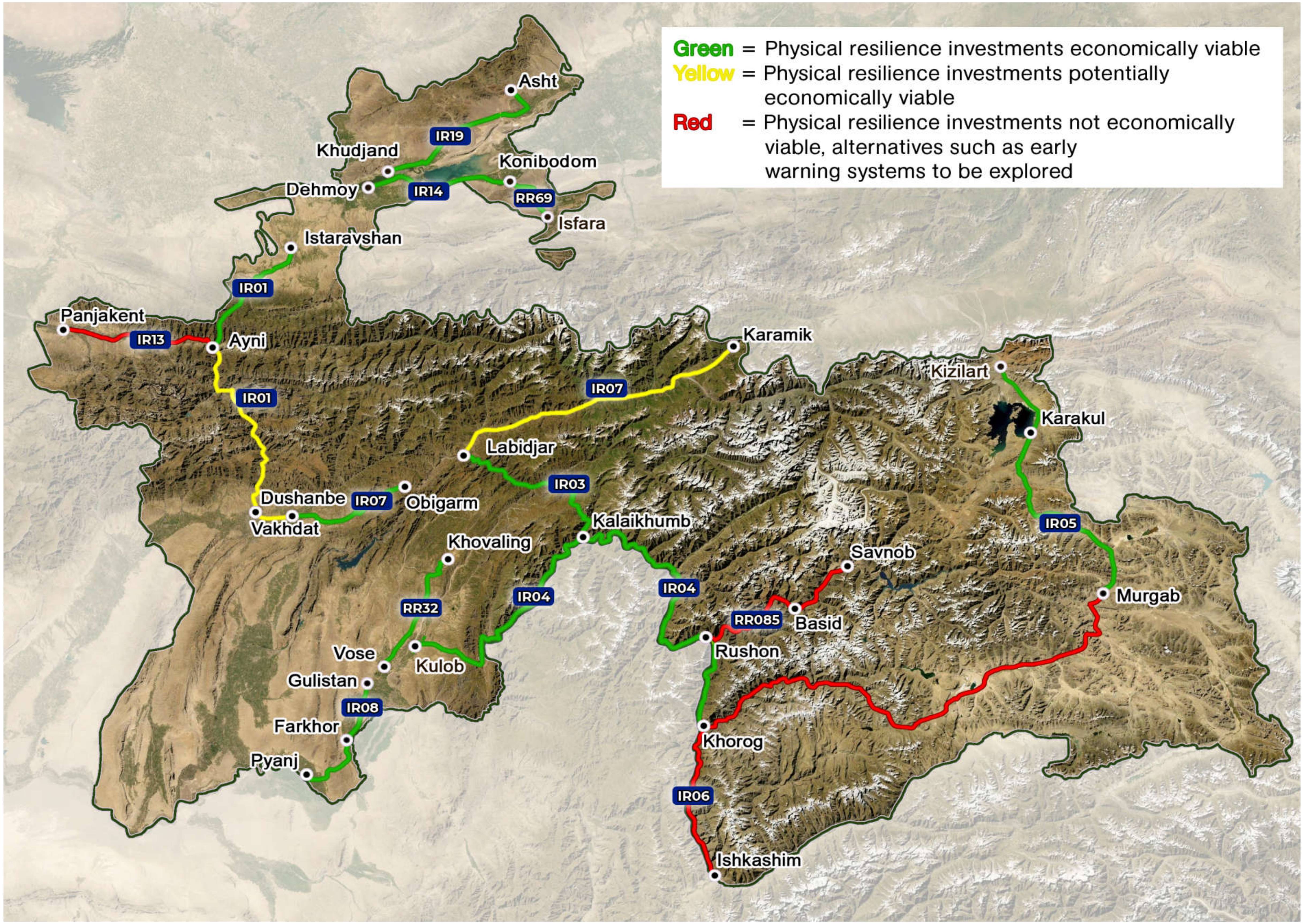
- The total costs of damage and repair cannot be disaggregated by road section, so have been divided equally between all road sections;
- The costs of emergency response cannot be disaggregated by road section, so have been divided equally between all road sections;
- Clear records of where fatalities occurred have not been made available and therefore the costs associated with fatalities have been divided equally between road sections.

The cost categories discussed above account for around 5% of the total economic costs of disasters affecting the road network. On this basis the results in Table 6-2 below are considered to be a good reflection of the likely viability of each road section. These results are summarised in Figure 6-1 below.

Table 6-2 CBA Results by Road Section

Road No	Road Section	IRR
IR01	Dushanbe – Ayni	-15%
IR01	Ayni - Istaravshan	13%
IR03	Labijar - Kalaikumb	67%
IR04	Kulob – Kalaikumb	Over 100%
IR04	Kalaikumb – Khorog	-18%
IR04	Khorog – Murgab	-25%
IR05	Murgab - Karakul - Kizilart	18%
IR06	Khorog - Ishkashem	Cannot be calculated
IR07	Vakdat - Obigarm	Over 100%
IR07	Labijar - Karamik	-15%
IR08	Guliston - Pyanj	68%
IR13	Ayni - Penjakent	Cannot be calculated
IR19	Khujand - Asht	65%
IR14	Dehmoy - Konibodom	35%
RR69	Konibodom - Isfara	Over 100%
RR32	Khovaling - Vose	Over 100%
RR085	Rushan – Basid - Savnob	Cannot be calculated

Figure 6-1 Summary of CBA Results by Road Section



7 CONCLUSIONS

7.1 OVERALL STUDY

This study has assessed the quantifiable economic costs of disasters that affect the road network. Natural disasters are a constant threat in Tajikistan, particularly during winter and spring. These disasters cause both short term and long lasting damage, to infrastructure, economic activity and social wellbeing. To provide a justification for increased investment in the road network, specifically to increase the level of resilience, it is important to have a clear understanding of these costs.

As part of this study, extensive field work has been undertaken. This includes over 400 surveys with affected communities, 15 key informant interviews in the same areas, and inspections of more than 2,000 kilometres of the road network.

7.2 ROAD HAZARD SITES

In total 331 sites have been identified where some level of hazard exists. Many of these are sites where past disasters have occurred, but a significant proportion have never experienced a disaster before. At each site, detailed observations were taken and recorded, enabling the assessment of the cause of each hazard and the identification of potential mitigating measures. An assessment of the impact of climate change on the location, magnitude and frequency of natural hazards was completed. Whilst it wasn’t possible to use this analysis to identify additional sites where natural hazards may occur in the future, the analysis has identified potential trends in the number and magnitude of some hazards in the future, which have been used to inform future costs.

Based upon outline cost estimates for typical interventions, an outline cost has been applied to each location. This has enabled the estimation of the total amount of investment that would be needed to make the network more resilient. Based upon the preliminary analysis undertaken for this study, it is estimated that in order to provide appropriate measures for all 331 sites, an investment of approximately US$ 404 million will be required.

It should be noted throughout that 100% resilience is impossible to achieve. The measures identified therefore focus not only on eliminating a particular hazard (e.g. avalanche control fences), but also on mitigating the effects of the hazard (retaining walls to collect rockfalls). However, even with these measures significant risks will remain which need to be mitigate wherever possible. It is recommended that the Government of Tajikistan continues its investment in improved search and rescue and emergency response capability in areas regularly affected by disasters. Equally important are investments in early warning systems to detect the early signs of a hazard occurring, to warn road users, affected communities and first responders to be ready for an event. These systems would reduce loss of life and enable faster response times to disasters, as equipment and people will be more likely to be in the right place.

7.3 SOCIO-ECONOMIC SURVEYS

Over 400 surveys were undertaken at 7 locations across Tajikistan, focusing on places which are regularly affected by disasters. The purpose of the surveys was to collect information that could be used later to inform the assessment of socio-economic costs of disasters. The surveys had two main aims; 1) to assess relative susceptibility to different types of disasters, and 2) to provide information that could be used to inform the estimation of the costs of disasters.

Based upon the survey results it was possible to draw a number of conclusions, that were useful for subsequent assessments. These include comparative estimates of total annual household income, estimates of the frequency at which households in different areas were affected by a disaster, the impact of disasters in terms of the length and frequency of road closures, and the impact of disasters on employment status, amongst others. These estimates were key inputs to the assessment of total economic costs. As the survey sample did not constitute a statistically robust sample, wherever possible, corroborating evidence has been sought from secondary sources.

7.4 ASSESSMENT OF TOTAL COSTS

The assessment of the costs of disasters has been undertaken from first principles, where possible, with a series of cost categories being used to predict costs. These cost categories include:

- Physical damage to infrastructure and the costs of repair
- Costs of search and rescue and emergency response
- Loss of life
- The costs of disruption to traffic
- The socio-economic costs of community severance

Estimates of each of these cost items have been made, taking into account the effect of climate change on the number and magnitude of disasters, the effect of population growth on the number of people affects, and the effect of growth in traffic intensity on the costs of disruption. Each of these was assessed based upon data either provided by the Ministry of Transport, or published information.

It is estimated that the total costs of disasters which affect the road network represent around 0.5% of national GDP for Tajikistan, around somoni 445 million per annum in 2022, rising to somoni 787 million by 2032.

7.5 COST BENEFIT ANALYSIS

Cost benefit analysis has been completed for the proposed programme of mitigation measures. As a base scenario the whole programme has been appraised as a single programme. This produced an economic internal rate of return of -14.5% showing that the whole programme would not be economically viable.

However, within the programme, there are road sections where the proposed measures would be considered to be economically viable. Evidence for this has been provided by undertaking cost benefit analysis for each road section separately. On this basis, the programmes for road sections such as Labijar – Kalaikumb, Murgab - Karakul – Kizilart, Guliston - Pyanj and Dehmoy – Konibodom, would be economically viable.

ANNEX A LIST OF EMERGENCIES FROM COESCD 2018 AND 2019

Date	Type of Natural Disaster	Location
15/02/2018	Avalanche	km 66 of the Dushanbe-Khujand road in the territory of Varzob District
26/02/2018	Avalanche	km 69-70 of the Dushanbe-Khujand road in the territory of Varzob District
07/03/2018	Avalanche	km 71 of the Dushanbe-Khujand road in the territory of Varzob District
10/03/2018	Avalanche	km 72 of the Dushanbe-Khujand road in the territory of Varzob District
14/03/2018	Avalanche	km 48 of the Dushanbe-Khujand road in the territory of Varzob District
20/03/2018	Rockfall	Road in the territory of Zidehi Jamoat, Varzob District
15/02/2018	Avalanche	km 622 of the Khorog-Murgob road in Bidurv village and km 638 in Barsen village, Shugnan District, GBAO
14/02/2018	Avalanche	km 489 of the Dushanbe-Khorog road, GBAO
15/02/2018	Avalanche	km 564 of the road in the territory of Pasthuf village and km 573 of the road in the territory of Sinsilahi village in Pasthufi Jamoat, Rushan District, GBAO
15/02/2018	Avalanche	km 634-635 and km 637-639 of the road in the territory of Barsem village in Suchon Jamoat and km 645 of the road in the territory of Tang village in Suchon Jamoat, Shugnan District, GBAO
15/02/2018	Avalanche	km 335 of the road in the territory of Sangez village and km 344 of the road in the territory of Yogedi village in Nulvandi Jamoat, Darvaz District, GBAO
13/03/2018	Avalanche	km 562 of the Dushanbe-Khorog road in the territory of Pasthuf village, Rushan District, GBAO
13/03/2018	Avalanche	km 676 of the Khorog-Murgob road in the territory of GBAO
30/10/2018	Landslide	km 220 of the Dushanbe-Shurobod-Khorog road in the territory of Kabudchari village, Sh. Shohin District, Khatlon Region
30/10/2018	Landslide	km 224-225 of the Shurobod-Khorog road in the territory of Nuriddin Mahmoodi Jamoat, Sh. Shohin District, Khatlon Region
12/03/2018	Mudflow	km 370 of the Dushanbe-Khorog road in the territory of Darvaz District, GBAO
08/01/2018	Rockfall	km 225 of the Dushanbe-Kulob-Khorog road
14/02/2018	Rockfall	km 461 of the Dushanbe-Khorog road in the territory of Heheki village in Yazgulom Jamoat, Vanch District, GBAO
15/02/2018	Rockfall	km 225 of the Dushanbe-Khorog road in the territory of N. Mahmood Jamoat, GBAO
29/09/2018	Rockfall	km 347 of the Dushanbe-Darvoz road in the territory of Shirgovadi village in Nulvandi Jamoat, Darvaz District, GBAO
14/02/2018	Avalanche	km 31-35 of the Khorog-Ishkashim road in the territory of Barchut village in Askar Zamirov Jamoat, Ishkashim District, GBAO
15/02/2018	Avalanche	km 31-35 of the Khorog-Ishkashim road in the territory of Barchut village in Askar Zamirov Jamoat, Ishkashim District, GBAO
15/02/2018	Avalanche	km 41-42 and km 51-52 of the Khorog-Ishkashim road in the territory of Buchuri village in Askar Zamirov Jamoat, Ishkashim District, GBAO
30/12/2018	Avalanche	km 31-33 of the Khorog-Ishkashim road in the territory of GBAO
10/03/2018	Mudflow	km 196 of the Dushanbe-Rasht-Lakhsh road in the territory of Tajikabad District
11/03/2018	Mudflow	km 196 and km 201 of the Dushanbe-Rasht-Lakhsh road in the territory of Tajikabad District
11/04/2018	Mudflow	km 20 of the Dushanbe-Vahdat-Nurobod-Rasht road
15/02/2018	Rockfall	km 10-15 of the Rasht-Sangvor road in the territory of Kaftarguzar village, GBAO

15/02/2018	Mudflow	Road in the territory of Lohuti village in Kabud Saifidinovi Jamoat, Panj District, Khatlon Region
20/03/2018	Landslide	Road in the territory of Fagna and Rudaki villages in Voruh Jamoat, Penjikent town, Sugh Region
13/03/2018	Landslide	Road in the territory of Chashmasor Mahalla in Somoni District, Dushanbe city
26/02/2018	Rockfall	km 17-18 of the Rasht-Sarichar-Sangvor road in the territory of Posuni village in Childara Jamoat, Sangvor District
11.01.2019	Avalanche	km 159 of the Dushanbe-Khujand road in the territory of Aini District, Sughd Region
05.02.2019	Avalanche	km155 of the Dushanbe-Khujand road in the territory of Aini District, Sughd Region
05.02.2019	Avalanche	km 56-57-63-69 of the Dushanbe-Khujand road in the territory of Varzob District
06.02.2019	Avalanche	km 71 of the Dushanbe-Khujand road in the territory of Varzob District
12.02.2019	Avalanche	km 52-57-59-61-72 of the Dushanbe-Khujand road in the territory of Varzob District
19.02.2019	Avalanche	km 70-71 of the Dushanbe-Khujand road in the territory of Varzob District
28.02.2019	Avalanche	km 57-60-65-68-69 of the Dushanbe-Khujand road in the territory of Varzob District
03.03.2019	Avalanche	km 58-59 of the Dushanbe-Khujand road in the territory of Varzob District
03.03.2019	Avalanche	km 58-59 of the Dushanbe-Khujand road in the territory of Varzob District
13.03.2019	Avalanche	km 65 of the Dushanbe-Khujand road in the territory of Varzob District
17.03.2019	Avalanche	km 156-157 of the Dushanbe-Khujand road in the territory of Aini District, Sughd Region
20.03.2019	Avalanche	km 65-300 of the Dushanbe-Khujand road in the territory of Varzob District
26.03.2019	Avalanche	km 72 of the Dushanbe-Khujand road in the territory of Varzob District
28.03.2019	Avalanche	km 80,600 and km 157 of the Dushanbe-Khujand road in the territory of Aini District, Sughd Region
28.03.2019	Avalanche	km 71 of the Dushanbe-Khujand road in the territory of Varzob District
28.03.2019	Avalanche	km 157-200 of the Dushanbe-Khujand road in the territory of Aini District, Sughd Region
28.03.2019	Avalanche	km 71-800 of the Dushanbe-Khujand road in the territory of Varzob District
01.04.2019	Avalanche	km 67 of the Dushanbe-Khujand road in the territory of Varzob District
04.11.2019	Flooding	km 48 of the Aini-Kuhistoni Mastchoh road in the territory of Aini District, Sughd Region
26.07.2019	Landslide	km 22-24 of the Aini-Kuhistoni Mastchoh road in the territory of Aini District, Sughd Region
27.04.2019	Slope failure	km 153 of the Dushanbe-Khujand road in the territory of Aini District, Sughd Region
03.07.2019	Mudflow	km 8-30-37-40 of the Labichar-Sangvor road in the territory of Sangvor District
14.07.2019	Mudflow	km 57 of the Sangvor-GBAO road and km 47 of the Labichar-Sangvor road in the territory of Sangvor District
31.10.2019	Rockfall	km 20 of the Sangvor-Darvoz road in the territory of Sangvor District
16.01.2019	Avalanche	km 334-344-363-364 of the Dushanbe-Khorog road in the territory of Darvoz District, GBAO
16.01.2019	Avalanche	km 462 of the Dushanbe-Khorog road in the territory of Vanch District, GBAO
16.01.2019	Avalanche	km 566-574 of the Dushanbe-Khorog road in the territory of Rushan District, GBAO

16.01.2019	Avalanche	km 559-594-601 of the Dushanbe-Khorog road in the territory of Shugnan District, GBAO
16.01.2019	Avalanche	km 624 of the Khorog-Murgab road in the territory of Shugnan District, GBAO
01.02.2019	Avalanche	km 288 of the Sh. Shohin-Darvoz road in the territory of Darvoz District, GBAO
04.02.2019	Avalanche	km 497-498 of the Dushanbe-Khorog road in the territory of Rushan District, GBAO
05.02.2019	Avalanche	km 328 of the Dushanbe-Khorog road in the territory of Darvoz District, GBAO
05.02.2019	Avalanche	km 638 of the Khorog-Murgab road in the territory of Shugnan District, GBAO
11.02.2019	Avalanche	km 623 of the Khorog-Murgab road in the territory of Shugnan District, GBAO
13.02.2019	Avalanche	km 17-18 of the Khorog-Murgab road in the territory of GBAO
14.02.2019	Avalanche	km 608 of the Khorog-Murgab road in the territory of Shugnan District, GBAO
15.02.2019	Avalanche	km 428 of the Dushanbe-Khorog road in the territory of Darvoz District, GBAO
03.03.2019	Avalanche	km 557 of the Dushanbe-Khorog road in the territory of Rushan District, GBAO
03.03.2019	Avalanche	km 576 of the Dushanbe-Khorog road in the territory of Shugnan District, GBAO
04.03.2019	Avalanche	km 638 of the Khorog-Murgab road in the territory of Shugnan District, GBAO
04.03.2019	Avalanche	km 574 of the Dushanbe-Khorog road in the territory of Rushan District, GBAO
28.03.2019	Avalanche	km 465 of the Dushanbe-Khorog road in the territory of Rushan District, GBAO
28.03.2019	Avalanche	km 634-632-675 of the Dushanbe-Khorog-Murgab road in the territory of Shugnan District, GBAO
14.04.2019	Avalanche	km 550 of the Dushanbe-Khorog road in the territory of Rushan District, GBAO
13.02.2019	Landslide	km 362 of the Dushanbe-Khorog road in the territory of Darvoz District, GBAO
13.02.2019	Landslide	km 363 of the Dushanbe-Khorog road in the territory of Darvoz District, GBAO
22.11.2019	Landslide	km 421 of the of the Dushanbe-Khorog road in the territory of Darvoz District, GBAO
28.03.2019	Mudflow	km 448 of the Dushanbe-Khorog road in the territory of Vanch District, GBAO
03.04.2019	Mudflow	km 343 of the Dushanbe-Darvoz-Khorog in the territory of Darvoz District, GBAO
24.04.2019	Mudflow	km 325 of the Dushanbe-Khorog road in the territory of Darvoz District, GBAO
03.02.2019	Rockfall	km 224-225 of the Dushanbe-Kulyab-Sh.Shohin-Badakhshan road in the territory of Sh. Shohin District
17.06.2019	Rockfall	km 228 of the of the Dushanbe-Khorog road in the territory of Sh. Shohin, Khatlon Region
19.08.2019	Rockfall	km 233 of the Dushanbe-Darvoz-Khorog road in the territory of Sh. Shohin District, Khatlon Region
04.01.2019	Avalanche	km 8-12-15-31-34-39-42-46-48-51-52 of the Khorog-Ishkashim road in the territory of Ishkashim District, GBAO
01.02.2019	Avalanche	km 31-34-42-44-51-52-58-62 of the Khorog-Ishkashim road in the territory of Ishkashim District, GBAO
03.02.2019	Avalanche	km 31-32-34-36-42-44-51-52-58-62 of the Khorog-Ishkashim road in the territory of Ishkashim District, GBAO
04.03.2019	Avalanche	km 32-3442-44-48-49-50-51-52-54-55 of the Khorog-Ishkashim rpad in the territory of Ishkashim District, GBAO
08.08.2019	Flooding	km 256 of the Vahdat-Lakhsh road in the territory of Lakhsh District
24.04.2019	Mudflow	km 196-201-202-203 of the Dushanbe-Vahdat-Rasht-Chirgatol road in the territory of Tajikabad District
27.06.2019	Mudflow	km 200 of the Vahdat-Rasht road in the territory of Tajikabad District near the border with the Kyrgyz Republic

01.02.2019	Avalanche	km 17-18-19 of the Rushan-Bartang road in the territory of Rushan District, GBAO
04.02.2019	Avalanche	km 21-27 of the Rushan-Bartang road in the territory of Rushan District, GBAO
25.08.2019	Flooding	km 28 of the Rushan-Bartang road in the territory of Rushan District, GBAO
22.11.2019	Landslide	km 27 of the Rushan-Bartang road in the territory of Rushan District, GBAO

ANNEX B SELECTION OF MITIGATING MEASURES FOR INSPECTION SITES

Table B1 Rock fall mitigation measures

Rock fall				
ID No.	Road name	Road section	Total score	Suggested measures
1	Labijar—Kalaikumb	Sta. 12	1	Flexible rock fall protection barriers
2	Kalaikumb—Khorog	Sta. 365+000 — Sta. 365+250	2	Construct a retaining wall
3	Kalaikumb—Khorog	Sta. 442+000 — Sta. 443+000	2	Construct a retaining wall
4	Kalaikumb—Khorog	Sta. 459+200 — Sta. 460+100	1	Nail grid active system
5	Kalaikumb—Khorog	Sta. 460+470 — Sta. 460+800	2	Construct a retaining wall
6	Kalaikumb—Khorog	Sta. 463+000 — Sta. 464+000	2	Construct a retaining wall
7	Kalaikumb—Khorog	Sta. 575+000 — Sta. 576+000	2	Construct a retaining wall
8	Khorog—Ishkashim	Sta. 16+000 — Sta. 17+000	2	Nail grid active system
9	Khorog—Ishkashim	Sta. 18+000 — Sta. 19+000	2	Construct a retaining wall
10	Khorog—Ishkashim	Sta. 30+000 — Sta. 31+000	2	Construct a retaining wall
11	Khorog—Ishkashim	Sta. 31+000 — Sta. 34+000	1	Construct a retaining wall
12	Khorog—Ishkashim	Sta. 51+000 — Sta. 52+000	1	Nail grid active system
13	Khorog—Ishkashim	Sta. 58+000 — Sta. 68+000	1	Construct a retaining wall
14	Khorog—Ishkashim	Sta. 78+000 — Sta. 79+000	2	Nail grid active system
15	Khorog—Ishkashim	Sta. 89+500 — Sta. 91+000	1	Flexible rock fall protection barriers
16	Rushan—Basid—Savnob	Sta. 16+500 — Sta. 16+800	2	Construct a retaining wall
17	Rushan—Basid—Savnob	Sta. 25+000 — Sta. 25+500	1	Flexible rock fall protection barriers
18	Rushan—Basid—Savnob	Sta. 26+600 — Sta. 26+800	1	Flexible rock fall protection barriers
19	Rushan—Basid—Savnob	Sta. 28+000 — Sta. 29+000	1	Flexible rock fall protection barriers
20	Rushan—Basid—Savnob	Sta. 30+150 — Sta. 30+400	1	Flexible rock fall protection barriers
21	Rushan—Basid—Savnob	Sta. 31+500 — Sta. 32+000	1	Nail grid active system

22	Rushan—Basid—Savnob	Sta. 69+600 — Sta. 70+000	1	Nail grid active system
23	Rushan—Basid—Savnob	Sta. 99+400 — Sta. 100+000	1	Nail grid active system
24	Dushanbe—Ayni	Sta. 60+600 — Sta. 60+700	1	Nail grid active system
25	Dushanbe—Ayni	Sta. 115+300 — Sta. 116+000	1	Flexible rock fall protection barriers
26	Dushanbe—Ayni	Sta. 118+900 — Sta. 122+000	1	Flexible rock fall protection barriers
27	Ayni—Penjakent	Sta. 5+300 — Sta. 5+800	1	Construct a retaining wall
28	Ayni—Penjakent	Sta. 14+700 — Sta. 16+600	1	Nail grid active system
29	Ayni—Penjakent	Sta. 15+650 — Sta. 16+500	1	Nail grid active system
30	Ayni—Penjakent	Sta. 24+950 — Sta. 25+100	1	Flexible rock fall protection barriers
31	Ayni—Penjakent	Sta. 37+700 — Sta. 38+400	1	Nail grid active system
32	Ayni—Penjakent	Sta. 153+000 — Sta. 153+400	1	Flexible rock fall protection barriers
33	Labijar—Karamik	Sta. 233+700 — Sta. 235+500	1	Flexible rock fall protection barriers
34	Labijar—Karamik	Sta. 236+000 — Sta. 236+300	1	Flexible rock fall protection barriers
35	Labijar—Karamik	Sta. 264+900 — Sta. 265+200	1	Flexible rock fall protection barriers
36	Labijar—Karamik	Sta. 290+000 — Sta. 293+000	1	Nail grid active system
37	Labijar—Karamik	Sta. 296+000 — Sta. 296+100	1	Nail grid active system
38	Labijar—Karamik	Sta. 297+300 — Sta. 298+350	1	Nail grid active system
39	Labijar—Karamik	Sta. 305+000 — Sta. 306+080	1	Flexible rock fall protection barriers
40	Labijar—Karamik	Sta. 308+600 — Sta. 308+900	1	Construct a retaining wall
41	Labijar—Karamik	Sta. 310+000 — Sta. 311+000	1	Construct a retaining wall
42	Labijar—Karamik	Sta. 313+400 — Sta. 314+000	1	Flexible rock fall protection barriers

Table B2 Total number of mitigation types

Item	Type of mitigation measures	No.
1	Flexible rock fall protection barriers	15
2	Construct a retaining wall	13
3	Nail grid active system	14
Total		42

Table B3 Flood mitigation measures

Flooding

ID No.	Road name	Road section	Total score	Suggested measures
43	Labijar—Kalaikumb	Sta. 67+300 — Sta. 67+600	2	Stabilize the slope with gabions
44	Rushan—Basid—Savnob	Sta. 16+000 — Sta. 16+500	1	Raise the embankment by 3 m
45	Rushan—Basid—Savnob	Sta. 19+000 — Sta. 20+000	2	Construct a culvert
46	Rushan—Basid—Savnob	Sta. 22+400 — Sta. 23+000	2	Raise the embankment by 3 m
47	Rushan—Basid—Savnob	Sta. 28+000 — Sta. 29+000	2	Raise the embankment by 3 m
48	Rushan—Basid—Savnob	Sta. 38+000 — Sta. 38+500	2	Raise the embankment by 3 m
49	Rushan—Basid—Savnob	Sta. 39+300 — Sta. 40+000	2	Stabilize the slope with gabions
50	Rushan—Basid—Savnob	Sta. 42+000 — Sta. 43+000	2	Raise the embankment by 3 m
51	Rushan—Basid—Savnob	Sta. 48+200 — Sta. 49+000	2	Stabilize the slope with gabions
52	Rushan—Basid—Savnob	Sta. 50+000 — Sta. 51+000	2	Raise the embankment by 3 m
53	Rushan—Basid—Savnob	Sta. 54+200 — Sta. 54+400	1	Raise the embankment by 3 m
54	Khorog—Ishkashim	Sta. 55+200 — Sta. 55+550	1	Raise the embankment by 3 m
55	Khorog—Ishkashim	Sta. 56+900 — Sta. 57+000	1	Raise the embankment by 4 m
56	Khorog—Ishkashim	Sta. 62+000 — Sta. 62+500	1	Raise the embankment by 4 m
57	Khorog—Ishkashim	Sta. 68+400 — Sta. 68+800	2	Raise the embankment by 3 m
58	Rushan—Basid—Savnob	Sta. 69+600 — Sta. 70+000	2	Raise the embankment by 4 m
59	Rushan—Basid—Savnob	Sta. 72+000 — Sta. 72+800	1	Raise the embankment by 3 m
60	Rushan—Basid—Savnob	Sta. 81+000 — Sta. 81+600	2	Raise the embankment by 3 m
61	Rushan—Basid—Savnob	Sta. 83+000 — Sta. 83+500	2	Raise the embankment by 3 m
62	Rushan—Basid—Savnob	Sta. 84+000 — Sta. 86+000	2	Raise the embankment by 3 m
63	Rushan—Basid—Savnob	Sta. 99+400 — Sta. 99+800	1	Raise the embankment by 3 m
64	Rushan—Basid—Savnob	Sta. 100+200 — Sta. 100+700	2	Raise the embankment by 3 m
65	Rushan—Basid—Savnob	Sta. 103+400 — Sta. 104+000	2	Raise the embankment by 3 m
66	Rushan—Basid—Savnob	Sta. 105+000 — Sta. 105+500	2	Raise the embankment by 3 m
67	Rushan—Basid—Savnob	Sta. 106+000 — Sta. 106+500	2	Raise the embankment by 3 m
68	Rushan—Basid—Savnob	Sta. 108+000 — Sta. 109+000	1	Raise the embankment by 4 m
69	Rushan—Basid—Savnob	Sta. 113+000 — Sta. 114+000	2	Raise the embankment by 3 m
70	Labijar—Karamik	Sta. 167+850 — Sta. 168+100	1	Stabilize the slope with gabions
71	Labijar—Karamik	Sta. 175+000 — Sta. 175+500	1	Stabilize the slope with gabions

72	Labijar—Karamik	Sta. 191+500 — Sta. 193+000	1	Stabilize the slope with gabions
73	Labijar—Karamik	Sta. 198+050 — Sta. 199+000	1	Stabilize the slope with gabions
74	Labijar—Karamik	Sta. 255+000 — Sta. 255+300	1	Raise the embankment by 3 m. Slope stabilization

Table B4 Total number of mitigation types

Item	Type of mitigation measures	No.
1	Stabilize the slope with gabions	7
2	Raise the embankment by 3 m	24
3	Construct a culvert	1
Total		32

Table B5 Landslide mitigation measures

Landslide				
ID No.	Road name	Road section	Total score	Suggested measures
75	Kalaikumb—Khorog	Sta. 379+000 — Sta. 379+500	2	Install drainage pathways along the upside of the slope
76	Kalaikumb—Khorog	Sta. 423+000 — Sta. 424+000	1	Construct a gabion retaining wall
77	Kalaikumb—Khorog	Sta. 457+000 — Sta. 457+300	2	Install drainage pathways along the upside of the slope
78	Rushan—Basid—Savnob	Sta. 26+000 — Sta. 26+500	2	Install drainage pathways along the upside of the slope
79	Rushan—Basid—Savnob	Sta. 27+000 — Sta. 28+000	1	Construct a gabion retaining wall
80	Rushan—Basid—Savnob	Sta. 72+300 — Sta. 72+800	1	Construct a gabion retaining wall
81	Rushan—Basid—Savnob	Sta. 85+000 — Sta. 85+300	2	Install drainage pathways along the upside of the slope
82	Rushan—Basid—Savnob	Sta. 89+000 — Sta. 89+250	2	Install drainage pathways along the upside of the slope
83	Rushan—Basid—Savnob	Sta. 92+000 — Sta. 92+500	1	Construct a gabion retaining wall
84	Rushan—Basid—Savnob	Sta. 93+000 — Sta. 93+300	2	Construct a gabion retaining wall
85	Khorog—Ishkashim	Sta. 46+000 — Sta. 47+000	2	Construct a gabion retaining wall
86	Dushanbe—Ayni	Sta. 85+300 — Sta. 85+500	1	Construct a gabion retaining wall

87	Dushanbe—Ayni	Sta. 89+000 — Sta. 89+300	1	Construct a gabion retaining wall
88	Dushanbe—Ayni	Sta. 95+800 — Sta. 96+100	1	Construct a gabion retaining wall
89	Ayni—Istaravshan	Sta. 138+100 — Sta. 139+000	1	Construct a gabion retaining wall
90	Vakdat—Obigarm	Sta. 39+900 — Sta. 40+500	1	Construct a gabion retaining wall
91	Vakdat—Obigarm	Sta. 40+400 — Sta. 40+800	1	Construct a gabion retaining wall
92	Vakdat—Obigarm	Sta. 65+800 — Sta. 67+000	1	Construct a gabion retaining wall
93	Labijar—Karamik	Sta. 299+400 — Sta. 299+700	1	Construct a gabion retaining wall
94	Labijar—Karamik	Sta. 302+800 — Sta. 303+000	1	Construct a gabion retaining wall
95	Labijar—Karamik	Sta. 304+600 — Sta. 304+800	1	Construct a gabion retaining wall
96	Labijar—Karamik	Sta. 305+700 — Sta. 306+000	1	Construct a gabion retaining wall
97	Labijar—Karamik	Sta. 308+050 — Sta. 308+400	1	Construct a gabion retaining wall
98	Labijar—Karamik	Sta. 310+000 — Sta. 310+500	1	Construct a gabion retaining wall
99	Labijar—Karamik	Sta. 312+000 — Sta. 313+000	1	Construct a gabion retaining wall
100	Guliston—Farkhor—Pyanj	Sta. 82+500 — Sta. 83+000	1	Construct a gabion retaining wall
101	Guliston—Farkhor—Pyanj	Sta. 225+000 — Sta. 226+000	1	Construct a gabion retaining wall

Table B6 Total number of mitigation types

Item	Type of mitigation measures	No.
1	Install drainage pathways along the upside of the slope	5
2	Construct a gabion retaining wall	22
Total		27

Table B7 Mudflow mitigation measures

Mudflow				
ID No.	Road name	Road section	Total score	Suggested measures
102	Labijar—Kalaikumb	Sta. 0+000 — Sta. 1+000	1	Construct mudflow protection works
103	Labijar—Kalaikumb	Sta. 2+000 — Sta. 2+100	1	Construct a large-diameter culvert
104	Labijar—Kalaikumb	Sta. 3+000 — Sta. 3+100	1	Construct a large-diameter culvert
105	Labijar—Kalaikumb	Sta. 4+000 — Sta. 4+040	1	Construct a large-diameter culvert
106	Labijar—Kalaikumb	Sta. 7+300 — Sta. 7+400	1	Construct a large-diameter culvert
107	Labijar—Kalaikumb	Sta. 8+000 — Sta. 8+100	1	Construct a large-diameter culvert

108	Labijar—Kalaikumb	Sta. 9+000 — Sta. 9+150	1	Construct a large-diameter culvert
109	Labijar—Kalaikumb	Sta. 23+500 — Sta. 23+700	1	Construct a large-diameter culvert
110	Labijar—Kalaikumb	Sta. 31+000 — Sta. 31+100	1	Bank protection works
111	Labijar—Kalaikumb	Sta. 40+000	1	Construct mudflow protection works
112	Labijar—Kalaikumb	Sta. 49+000 — Sta. 49+150	1	Construct mudflow protection works
113	Labijar—Kalaikumb	Sta. 57+000 — Sta. 58+000	1	Construct mudflow protection works
114	Labijar—Kalaikumb	Sta. 63+100 — Sta. 63+400	1	Construct mudflow protection works
115	Labijar—Kalaikumb	Sta. 65+000 — Sta. 65+100	1	Construct mudflow protection works
116	Kalaikumb—Khorog	Sta. 368+800 — Sta. 369+000	1	Construct mudflow protection works
117	Kalaikumb—Khorog	Sta. 390+000 — Sta. 390+300	1	Construct mudflow protection works
118	Kalaikumb—Khorog	Sta. 416+000 — Sta. 416+100	1	Construct mudflow protection works
119	Kalaikumb—Khorog	Sta. 453+000 — Sta. 453+400	1	Construct mudflow protection works
120	Kalaikumb—Khorog	Sta. 461+000 — Sta. 461+100	1	Construct mudflow protection works
121	Kalaikumb—Khorog	Sta. 489+000 — Sta. 489+300	1	Construct mudflow protection works
122	Kalaikumb—Khorog	Sta. 500+300 — Sta. 500+800	1	Construct mudflow protection works
123	Kalaikumb—Khorog	Sta. 502+000 — Sta. 502+200	1	Construct mudflow protection works
124	Kalaikumb—Khorog	Sta. 574+600 — Sta. 574+800	2	Construct mudflow protection works
125	Kalaikumb—Khorog	Sta. 579+000 — Sta. 579+200	2	Construct mudflow protection works
126	Rushan—Basid—Savnob	Sta. 4+800 — Sta. 5+000	2	Construct mudflow protection works
127	Rushan—Basid—Savnob	Sta. 18+560 — Sta. 19+000	1	Construct mudflow protection works
128	Rushan—Basid—Savnob	Sta. 22+000 — Sta. 22+500	2	Construct mudflow protection works
129	Rushan—Basid—Savnob	Sta. 24+000 — Sta. 24+400	2	Construct mudflow protection works
130	Rushan—Basid—Savnob	Sta. 24+800 — Sta. 25+000	2	Construct mudflow protection works
131	Rushan—Basid—Savnob	Sta. 29+500 — Sta. 30+000	2	Construct mudflow protection works
132	Rushan—Basid—Savnob	Sta. 46+000 — Sta. 46+300	1	Construct mudflow protection works
133	Rushan—Basid—Savnob	Sta. 53+000 — Sta. 53+300	1	Construct mudflow protection works
134	Rushan—Basid—Savnob	Sta. 56+000 — Sta. 56+300	1	Construct mudflow protection works
135	Rushan—Basid—Savnob	Sta. 107+700 — Sta. 108+000	1	Construct mudflow protection works
136	Rushan—Basid—Savnob	Sta. 118+000 — Sta. 119+000	1	Road realignment
137	Khorog—Ishkashim	Sta. 8+000 — Sta. 9+000	2	Construct mudflow protection works
138	Khorog—Ishkashim	Sta. 14+000 — Sta. 14+200	2	Construct mudflow protection works
139	Khorog—Ishkashim	Sta. 19+000 — Sta. 19+200	1	Construct mudflow protection works

140	Khorog—Ishkashim	Sta. 24+000 — Sta. 24+400	2	Construct mudflow protection works
141	Khorog—Ishkashim	Sta. 31+000 — Sta. 32+000	1	Construct mudflow protection works
142	Khorog—Ishkashim	Sta. 38+000 — Sta. 28+200	1	Construct mudflow protection works
143	Khorog—Ishkashim	Sta. 48+000 — Sta. 48+100	1	Construct mudflow protection works
144	Khorog—Ishkashim	Sta. 53+700 — Sta. 53+800	1	Construct mudflow protection works
145	Khorog—Ishkashim	Sta. 65+000 — Sta. 67+000	1	Construct mudflow protection works
146	Khorog—Ishkashim	Sta. 80+000 — Sta. 80+100	1	Construct mudflow protection works
147	Khorog—Ishkashim	Sta. 85+700 — Sta. 86+000	1	Construct mudflow protection works
148	Khorog—Ishkashim	Sta. 99+000 — Sta. 99+500	1	Construct mudflow protection works
149	Khorog—Murgab	Sta. 637+000 — Sta. 639+000	1	Construct mudflow protection works
150	Khorog—Murgab	Sta. 654+300 — Sta. 654+350	1	Construct mudflow protection works
151	Khorog—Murgab	Sta. 657+500 — Sta. 657+600	1	Construct mudflow protection works
152	Khorog—Murgab	Sta. 661+700 — Sta. 662+000	1	Construct mudflow protection works
153	Khorog—Murgab	Sta. 667+200 — Sta. 667+400	1	Construct mudflow protection works
154	Khorog—Murgab	Sta. 673+800 — Sta. 674+100	2	Construct mudflow protection works
155	Khorog—Murgab	Sta. 688+100 — Sta. 688+600	2	Construct mudflow protection works
156	Khorog—Murgab	Sta. 700+100 — Sta. 700+600	1	Construct a large-diameter culvert
157	Khorog—Murgab	Sta. 844+600 — Sta. 844+690	1	Construct a large-diameter culvert
158	Khorog—Murgab	Sta. 845+000 — Sta. 846+000	1	Construct mudflow protection works
159	Khorog—Murgab	Sta. 852+000 — Sta. 853+000	1	Construct mudflow protection works
160	Murgab—Karakul-Kizilart	Sta. 853+000 — Sta. 853+800	1	Construct mudflow protection works
161	Murgab—Karakul-Kizilart	Sta. 35+000 — Sta. 40+000	1	Construct a large-diameter culvert
162	Murgab—Karakul-Kizilart	Sta. 182+000 — Sta. 182+100	1	Construct mudflow protection works
163	Dushanbe—Ayni	Sta. 42+500 — Sta. 42+700	1	Construct mudflow protection works
164	Ayni—Penjakent	Sta. 14+700 — Sta. 15+600	1	Construct a large-diameter culvert
165	Ayni—Penjakent	Sta. 15+650 — Sta. 16+500	1	Construct a large-diameter culvert
166	Ayni—Penjakent	Sta. 19+850 — Sta. 20+050	1	Construct a large-diameter culvert
167	Ayni—Penjakent	Sta. 22+800 — Sta. 22+900	1	Construct a large-diameter culvert
168	Ayni—Penjakent	Sta. 32+600 — Sta. 32+700	1	Construct a large-diameter culvert
169	Ayni—Penjakent	Sta. 47+400 — Sta. 47+800	1	Construct a large-diameter culvert
170	Ayni—Penjakent	Sta. 48+200 — Sta. 48+500	1	Construct a large-diameter culvert
171	Ayni—Penjakent	Sta. 50+950 — Sta. 51+050	1	Construct a large-diameter culvert

172	Ayni—Penjakent	Sta. 51+100 — Sta. 51+150	1	Construct mudflow protection works
173	Ayni—Penjakent	Sta. 52+250 — Sta. 52+350	1	Construct a large-diameter culvert
174	Ayni—Penjakent	Sta. 53+400 — Sta. 53+500	1	Construct mudflow protection works
175	Ayni—Penjakent	Sta. 63+200 — Sta. 63+300	1	Construct mudflow protection works
176	Ayni—Penjakent	Sta. 57+900 — Sta. 58+000	1	Construct a large-diameter culvert
177	Khujand—Asht	Sta. 74+500 — Sta. 74+700	1	Construct a large-diameter culvert
178	Khujand—Asht	Sta. 76+200 — Sta. 76+300	1	Construct a large-diameter culvert
179	Khujand—Asht	Sta. 76+400 — Sta. 76+500	1	Construct mudflow protection works
180	Khujand—Asht	Sta. 77+200 — Sta. 77+400	1	Construct a large-diameter culvert
181	Khujand—Asht	Sta. 78+100 — Sta. 78+200	1	Construct a large-diameter culvert
182	Khujand—Asht	Sta. 78+950 — Sta. 79+000	1	Construct a large-diameter culvert
183	Khujand—Asht	Sta. 80+300 — Sta. 80+400	1	Construct a large-diameter culvert
184	Khujand—Asht	Sta. 80+600 — Sta. 80+700	1	Construct a large-diameter culvert
185	Khujand—Asht	Sta. 83+600 — Sta. 83+800	1	Construct a large-diameter culvert
186	Khujand—Asht	Sta. 117+000 — Sta. 117+100	1	Construct mudflow protection works
187	Khujand—Asht	Sta. 117+500 — Sta. 117+600	1	Construct mudflow protection works
188	Khujand—Asht	Sta. 118+000 — Sta. 118+100	1	Construct mudflow protection works
189	Dehmoy—Konibodom	Sta. 52+300 — Sta. 52+500	1	Construct mudflow protection works
190	Dehmoy—Konibodom	Sta. 53+600 — Sta. 53+800	1	Construct mudflow protection works
191	Dehmoy—Konibodom	Sta. 57+200 — Sta. 57+300	1	Construct mudflow protection works
192	Dehmoy—Konibodom	Sta. 58+500 — Sta. 58+700	1	Construct mudflow protection works
193	Dehmoy—Konibodom	Sta. 64+400 — Sta. 64+600	1	Construct mudflow protection works
194	Dehmoy—Konibodom	Sta. 69+000 — Sta. 69+100	1	Construct mudflow protection works
195	Dehmoy-Konibodom	Sta. 73+950 — Sta. 74+050	1	Construct mudflow protection works
196	Dehmoy—Konibodom	Sta. 86+000 — Sta. 86+100	1	Construct mudflow protection works
197	Konibodom—Isfara	Sta. 5+000 — Sta. 6+000	1	Construct a large-diameter culvert
198	Konibodom—Isfara	Sta. 14+000 — Sta. 14+200	1	Construct a large-diameter culvert
199	Konibodom—Isfara	Sta. 23+600 — Sta. 23+700	1	Construct a large-diameter culvert
200	Vakdat—Obigarm	Sta. 31+000 — Sta. 31+100	1	Construct mudflow protection works
201	Vakdat—Obigarm	Sta. 37+000 — Sta. 37+100	1	Construct mudflow protection works
202	Labijar—Karamik	Sta. 194+500 — Sta. 194+600	1	Construct mudflow protection works
203	Labijar—Karamik	Sta. 195+450 — Sta. 195+600	1	Construct mudflow protection works

204	Labijar—Karamik	Sta. 202+500 — Sta. 202+800	1	Construct a large-diameter culvert
205	Labijar—Karamik	Sta. 203+600 — Sta. 203+800	1	Construct a large-diameter culvert
206	Labijar—Karamik	Sta. 249+000 — Sta. 250+000	1	Construct mudflow protection works
207	Labijar—Karamik	Sta. 261+000 — Sta. 261+050	1	Construct a large-diameter culvert
208	Labijar—Karamik	Sta. 290+000 — Sta. 290+100	2	Construct mudflow protection works
209	Labijar—Karamik	Sta. 310+000 — Sta. 310+500	1	Construct mudflow protection works
210	Khovaling—Vose	Sta. 2+000 — Sta. 2+200	1	Construct mudflow protection works
211	Khovaling—Vose	Sta. 67+700 — Sta. 68+000	1	Construct a large-diameter culvert
212	Guliston—Farkhor—Paynj	Sta. 42+000 — Sta. 43+000	1	Construct a large-diameter culvert
213	Guliston—Farkhor—Paynj	Sta. 43+500 — Sta. 43+700	1	Construct a large-diameter culvert
214	Guliston—Farkhor—Paynj	Sta. 43+800 — Sta. 43+900	1	Construct a large-diameter culvert
215	Guliston—Farkhor—Paynj	Sta. 44+300 — Sta. 44+500	1	Construct a large-diameter culvert
216	Guliston—Farkhor—Paynj	Sta. 44+800 — Sta. 45+100	1	Construct a large-diameter culvert
217	Guliston—Farkhor—Paynj	Sta. 45+200 — Sta. 47+000	1	Construct a large-diameter culvert
218	Guliston—Farkhor—Paynj	Sta. 49+500 — Sta. 49+800	1	Construct mudflow protection works
219	Kulob—Kalaikumb	Sta. 288+000 — Sta. 289+000	1	Construct mudflow protection works

Table B8 Total number of mitigation types

Item	Type of mitigation measures	No.
1	Construct mudflow protection works	76
2	Construct a large-diameter culvert	40
3	Road realignment	1
4	Bank protection works	1
Total		118

Table B9 Avalanche mitigation measures

Avalanche				
ID No.	Road name	Road section	Total score	Suggested measures
220	Kalaikumb—Khorog	Sta. 385+000 — Sta. 385+400	2	Install snow fences on the slope
221	Kalaikumb—Khorog	Sta. 395+000Sta. 395+300	2	Install snow fences on the slope
222	Kalaikumb—Khorog	Sta. 408+000 — Sta. 408+500	2	Install snow fences on the slope
223	Kalaikumb—Khorog	Sta. 442+000 — Sta. 442+100	2	Install snow fences on the slope

224	Kalaikumb—Khorog	Sta. 443+000 — Sta. 443+100	2	Install snow fences on the slope
225	Kalaikumb—Khorog	Sta. 460+000 — Sta. 461+100	2	Install snow fences on the slope
226	Kalaikumb—Khorog	Sta. 466+800 — Sta. 467+100	2	Install snow fences on the slope
227	Kalaikumb—Khorog	Sta. 470+000 — Sta. 471+000	1	Construct an avalanche gallery
228	Kalaikumb—Khorog	Sta. 485+000 — Sta. 485+200	1	Construct an avalanche gallery
229	Kalaikumb—Khorog	Sta. 502+000 — Sta. 502+200	1	Construct an avalanche gallery
230	Kalaikumb—Khorog	Sta. 504+000 — Sta. 504+200	1	Construct an avalanche gallery
231	Kalaikumb—Khorog	Sta. 512+000 — Sta. 512+500	1	Construct an avalanche gallery
232	Kalaikumb—Khorog	Sta. 565+000 — Sta. 565+500	1	Construct an avalanche gallery
233	Kalaikumb—Khorog	Sta. 572+000 — Sta. 572+200	1	Construct an avalanche gallery
234	Kalaikumb—Khorog	Sta. 575+000 — Sta. 575+200	1	Construct an avalanche gallery
235	Kalaikumb—Khorog	Sta. 586+000 — Sta. 586+200	1	Construct an avalanche gallery
236	Rushan—Basid—Savnob	Sta. 8+900 — Sta. 9+000	2	Install snow fences on the slope
237	Rushan—Basid—Savnob	Sta. 10+000 — Sta. 10+500	2	Install snow fences on the slope
238	Rushan—Basid—Savnob	Sta. 11+000 — Sta. 11+400	2	Install snow fences on the slope
239	Rushan—Basid—Savnob	Sta. 12+000 — Sta. 12+500	2	Install snow fences on the slope
240	Rushan—Basid—Savnob	Sta. 13+400 — Sta. 13+840	2	Install snow fences on the slope
241	Rushan—Basid—Savnob	Sta. 15+900 — Sta. 16+000	2	Install snow fences on the slope
242	Rushan—Basid—Savnob	Sta. 19+000 — Sta. 19+500	2	Install snow fences on the slope
243	Rushan—Basid—Savnob	Sta. 20+000 — Sta. 20+300	2	Install snow fences on the slope
244	Rushan—Basid—Savnob	Sta. 21+700 — Sta. 22+000	2	Install snow fences on the slope
245	Rushan—Basid—Savnob	Sta. 23+000 — Sta. 23+500	2	Install snow fences on the slope
246	Rushan—Basid—Savnob	Sta. 27+300 — Sta. 27+500	2	Install snow fences on the slope
247	Rushan—Basid—Savnob	Sta. 28+000 — Sta. 28+500	2	Install snow fences on the slope
248	Rushan—Basid—Savnob	Sta. 29+000 — Sta. 29+500	2	Install snow fences on the slope
249	Rushan—Basid—Savnob	Sta. 30+000 — Sta. 30+500	2	Install snow fences on the slope
250	Rushan—Basid—Savnob	Sta. 34+000 — Sta. 34+200	2	Install snow fences on the slope
251	Rushan—Basid—Savnob	Sta. 39+000 — Sta. 39+500	1	Construct an avalanche gallery
252	Rushan—Basid—Savnob	Sta. 39+600 — Sta. 40+000	1	Construct an avalanche gallery
253	Rushan—Basid—Savnob	Sta. 42+300 — Sta. 42+500	2	Install snow fences on the slope
254	Rushan—Basid—Savnob	Sta. 48+000 — Sta. 48+500	2	Install snow fences on the slope
255	Rushan—Basid—Savnob	Sta. 54+300 — Sta. 54+800	1	Construct an avalanche gallery

256	Rushan—Basid—Savnob	Sta. 56+800 — Sta. 56+900	2	Install snow fences on the slope
257	Rushan—Basid—Savnob	Sta. 57+100 — Sta. 57+300	1	Construct an avalanche gallery
258	Rushan—Basid—Savnob	Sta. 57+400 — Sta. 57+700	1	Construct an avalanche gallery
259	Rushan—Basid—Savnob	Sta. 62+000 — Sta. 62+500	1	Construct an avalanche gallery
260	Rushan—Basid—Savnob	Sta. 83+000 — Sta. 83+500	1	Construct an avalanche gallery
261	Rushan—Basid—Savnob	Sta. 86+600 — Sta. 87+000	1	Construct an avalanche gallery
262	Rushan—Basid—Savnob	Sta. 92+200 — Sta. 92+700	1	Construct an avalanche gallery
263	Khorog—Ishkashim	Sta. 8+000 — Sta. 9+000	1	Construct an avalanche gallery
264	Khorog—Ishkashim	Sta. 10+000 — Sta. 12+000	1	Construct an avalanche gallery
265	Khorog—Ishkashim	Sta. 14+000 — Sta. 14+200	2	Install snow fences on the slope
266	Khorog—Ishkashim	Sta. 15+000 — Sta. 15+300	2	Install snow fences on the slope
267	Khorog—Ishkashim	Sta. 18+000 — Sta. 18+200	2	Install snow fences on the slope
268	Khorog—Ishkashim	Sta. 24+000 — Sta. 24+200	2	Install snow fences on the slope
269	Khorog—Ishkashim	Sta. 30+000 — Sta. 31+000	2	Install snow fences on the slope
270	Khorog—Ishkashim	Sta. 34+000 — Sta. 34+300	2	Install snow fences on the slope
271	Khorog—Ishkashim	Sta. 39+000 — Sta. 39+200	1	Construct an avalanche gallery
272	Khorog—Ishkashim	Sta. 42+000 — Sta. 44+000	2	Install snow fences on the slope
273	Khorog—Ishkashim	Sta. 46+000 — Sta. 46+200	1	Construct an avalanche gallery
274	Khorog—Ishkashim	Sta. 51+000 — Sta. 51+100	1	Construct an avalanche gallery
275	Khorog—Ishkashim	Sta. 61+600 — Sta. 63+000	1	Construct an avalanche gallery
276	Khorog—Murgab	Sta. 634+000 — Sta. 635+000	2	Install snow fences on the slope
277	Khorog—Murgab	Sta. 637+000 — Sta. 639+000	2	Install snow fences on the slope
278	Khorog—Murgab	Sta. 642+000 — Sta. 642+100	1	Construct an avalanche gallery
279	Khorog—Murgab	Sta. 646+600 — Sta. 647+100	1	Construct an avalanche gallery
280	Khorog—Murgab	Sta. 649+000 — Sta. 649+100	1	Construct an avalanche gallery
281	Khorog—Murgab	Sta. 649+700 — Sta. 650+100	1	Construct an avalanche gallery
282	Khorog—Murgab	Sta. 662+600 — Sta. 662+800	1	Construct an avalanche gallery
283	Khorog—Murgab	Sta. 663+000 — Sta. 663+500	1	Construct an avalanche gallery
284	Khorog—Murgab	Sta. 671+000 — Sta. 672+000	1	Construct an avalanche gallery
285	Khorog—Murgab	Sta. 690+000 — Sta. 690+700	1	Construct an avalanche gallery
286	Khorog—Murgab	Sta. 691+200 — Sta. 691+500	1	Construct an avalanche gallery
287	Dushanbe—Ayni	Sta. 48+200 — Sta. 48+350	2	Install snow fences on the slope

288	Dushanbe—Ayni	Sta. 48+350 — Sta. 48+500	1	Construct an avalanche gallery
289	Dushanbe—Ayni	Sta. 58+200 — Sta. 59+100	1	Construct an avalanche gallery
290	Dushanbe—Ayni	Sta. 59+700 — Sta. 60+100	1	Construct an avalanche gallery
291	Dushanbe—Ayni	Sta. 60+300 — Sta. 60+450	1	Construct an avalanche gallery
292	Dushanbe—Ayni	Sta. 60+550 — Sta. 60+750	1	Construct an avalanche gallery
293	Dushanbe—Ayni	Sta. 61+800 — Sta. 62+000	1	Construct an avalanche gallery
294	Dushanbe—Ayni	Sta. 63+000 — Sta. 63+900	1	Construct an avalanche gallery
295	Dushanbe—Ayni	Sta. 64+950 — Sta. 65+300	1	Construct an avalanche gallery
296	Dushanbe—Ayni	Sta. 65+400 — Sta. 67+000	1	Construct an avalanche gallery
297	Dushanbe—Ayni	Sta. 68+200 — Sta. 70+000	1	Construct an avalanche gallery
298	Dushanbe—Ayni	Sta. 71+000 — Sta. 72+000	1	Construct an avalanche gallery
299	Dushanbe—Ayni	Sta. 78+900 — Sta. 79+000	1	Construct an avalanche gallery
300	Dushanbe—Ayni	Sta. 80+050 — Sta. 80+300	1	Construct an avalanche gallery
301	Dushanbe—Ayni	Sta. 120+900 — Sta. 121+100	1	Construct an avalanche gallery
302	Ayni—Istaravshan	Sta. 156+000 — Sta. 157+000	1	Construct an avalanche gallery
303	Ayni—Istaravshan	Sta. 157+900 — Sta. 158+100	1	Construct an avalanche gallery
304	Ayni—Istaravshan	Sta. 159+400 — Sta. 159+800	1	Construct an avalanche gallery
305	Labijar—Karamik	Sta. 246+500 — Sta. 246+700	1	Construct an avalanche gallery
306	Labijar—Karamik	Sta. 249+800 — Sta. 250+000	1	Construct an avalanche gallery
307	Labijar—Karamik	Sta. 256+300 — Sta. 256+700	1	Construct an avalanche gallery
308	Labijar—Karamik	Sta. 290+900 — Sta. 291+000	1	Construct an avalanche gallery
309	Labijar—Karamik	Sta. 291+550 — Sta. 293+000	1	Construct an avalanche gallery
310	Labijar—Karamik	Sta. 293+150 — Sta. 293+300	1	Construct an avalanche gallery
311	Labijar—Karamik	Sta. 297+500 — Sta. 297+700	1	Construct an avalanche gallery
312	Labijar—Karamik	Sta. 303+000 — Sta. 303+600	1	Construct an avalanche gallery
313	Labijar—Karamik	Sta. 306+800 — Sta. 307+000	1	Construct an avalanche gallery
314	Labijar—Karamik	Sta. 307+350 — Sta. 307+500	1	Construct an avalanche gallery
315	Labijar—Karamik	Sta. 308+600 — Sta. 308+900	1	Construct an avalanche gallery
316	Labijar—Karamik	Sta. 310+000 — Sta. 310+500	1	Construct an avalanche gallery
317	Labijar—Karamik	Sta. 311+200 — Sta. 311+800	1	Construct an avalanche gallery
318	Labijar—Karamik	Sta. 313+500 — Sta. 313+700	1	Construct an avalanche gallery
319	Labijar—Karamik	Sta. 313+900 — Sta. 314+000	2	Install snow fences on the slope

320	Labijar—Karamik	Sta. 314+350 — Sta. 314+500	2	Install snow fences on the slope
321	Labijar—Karamik	Sta. 314+800 — Sta. 315+000	2	Install snow fences on the slope
322	Labijar—Karamik	Sta. 315+600 — Sta. 315+800	1	Construct an avalanche gallery

Table B10 Total number of mitigation types

Item	Type of mitigation measures	No.
1	Install snow fences on the slope	38
2	Construct an avalanche gallery	65
Total		103

Table B11 Erosion mitigation measures

Erosion				
Item	Road name	Road section	Total score	Suggested measures
323	Labijar—Kalaikumb	Sta. 6+500	1	Replace soft/swamp material
324	Labijar—Kalaikumb	Sta. 13+700 — Sta. 14+000	1	Replace soft/swamp material
325	Labijar—Kalaikumb	Sta. 17+000 — Sta. 17+800	1	Replace soft/swamp material
326	Rushan—Basid—Savnob	Sta. 24+800 — Sta. 26+100	2	Construct a surface water drain
327	Murgab—Karakul	Sta. 104+000 — Sta. 106+000	2	Construct a surface water drain
328	Labijar—Karamik	Sta. 298+000 — Sta. 298+100	1	Construct a surface water drain
329	Khovaling—Vose	Sta. 8+200 — Sta. 9+000	1	Construct a surface water drain
330	Khovaling—Vose	Sta. 9+300 — Sta. 9+500	1	Replace soft/swamp material
331	Guliston—Farkhor—Pyanj	Sta. 72+900 — Sta. 73+200	1	Raise the embankment by 3 m

Table B12 Total number of mitigation types

Item	**Type of mitigation measures**	**No.**
1	Replace soft/swamp material	4
2	Construct a surface water drain	4
3	Raise the embankment by 3 m	1
Total		9

ANNEX C CALCULATION OF TOTAL TRAFFIC DISRUPTION COSTS

Number	Section	District	Region	Affected by Disasters	Main Type of Disaster	Average delay	VOT Per hour	Traffic AADT	Number of events pa	Total Costs
(РБ 01) Душанбе-Чанок (ба воситаи Хуҷанд-Бӯстон то сарҳади Ҷумҳурии Ӯзбекистон)	11 - 84,5	Varzob	RRS	Y	Avalanche	24.00	19.67	9637	3.375	15,350,775
(РБ 01) Душанбе-Чанок (ба воситаи Хуҷанд-Бӯстон то сарҳади Ҷумҳурии Ӯзбекистон)	84,5-198	Ayni	Sughd	Y	Avalanche	24.00	22.96	5,979	3.375	11,117,757
(РБ 01) Душанбе-Чанок (ба воситаи Хуҷанд-Бӯстон то сарҳади Ҷумҳурии Ӯзбекистон)	198-253,7	Shakristan	Sughd	Y	Avalanche	24.00	22.96	2,320	3.375	4,313,965
(РБ 01) Душанбе-Чанок (ба воситаи Хуҷанд-Бӯстон то сарҳади Ҷумҳурии Ӯзбекистон)	253,7-304,7	Istaravshan	Sughd	N			22.96	5,994	0	0
(РБ 01) Душанбе-Чанок (ба воситаи Хуҷанд-Бӯстон то сарҳади Ҷумҳурии Ӯзбекистон)	274-290	Ch Rasulov	Sughd	N			22.96	8,813	0	0
(РБ 01) Душанбе-Чанок (ба воситаи Хуҷанд-Бӯстон то сарҳади Ҷумҳурии Ӯзбекистон)	244,7-259	Gonchi	Sughd	N			22.96	3,723	0	0
(РБ 01) Душанбе-Чанок (ба воситаи Хуҷанд-Бӯстон то сарҳади Ҷумҳурии Ӯзбекистон)	259-296	Spitamen	Sughd	N			22.96	3,723	0	0
(РБ 01) Душанбе-Чанок (ба воситаи Хуҷанд-Бӯстон то сарҳади Ҷумҳурии Ӯзбекистон)	296	Gafurov	Sughd	Y	Flooding	72.00	22.96	3,723	3.375	20,768,393
(РБ 01) Душанбе-Чанок (ба воситаи Хуҷанд-Бӯстон то сарҳади Ҷумҳурии Ӯзбекистон)	355	Mastchoh	Sughd	N			22.96	3,723	0	0
(РБ 02) Душанбе-Шаҳринав-Турсунзода-сарҳади Ӯзбекистон	8,5-32,5	Gissor	RRS	N			19.67	7,373	0	0
(РБ 02) Душанбе-Шаҳринав-Турсунзода-сарҳади Ӯзбекистон	32,5-53	Shakrinav	RRS	N			19.67	5,839	0	0
(РБ 02) Душанбе-Шаҳринав-Турсунзода-сарҳади Ӯзбекистон	53-66,3	Turzonsade	RRS	N			19.67	4,440	0	0
(РБ 03) Лаби Ҷар-Тавилдара-Қалъаи Хумб	0-102	Tavildara	RRS	Y	Mudflow	120.00	19.67	936	0.75	1,656,173
(РБ 03) Лаби Ҷар-Тавилдара-Қалъаи Хумб	102-136	Darvoz	GBAO	Y	Mudflow	120.00	23.45	3,634	0.75	7,668,858
(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	9,2 - 42	Vakdat	RRS	N			19.67	9,465	0	0

(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	42-68	Norak	Khatlon	N			19.67	7,591	0	0
(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	68-76	Norak	Khatlon	N			19.67	6,753	0	0
(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	76-147	Dangara	Khatlon	N			19.67	5,449	0	0
(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	147-189	Vose	Khatlon	Y	Rockfall	6.00	19.67	3,795	2.6875	1,203,519
(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	189-197	Kulob	Khatlon	Y	Rockfall	6.00	19.67	5,532	2.6875	1,754,119
(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	209-286	Shurobod	Khatlon	N			19.67	2,428	0	0
(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	286-441	Darvoz	GBAO	Y	Avalanche	24.00	23.45	1,923	2.6875	2,908,599
(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	441-481	Vanj	GBAO	Y	Avalanche	24.00	23.45	1,737	2.6875	2,626,422
(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	481-574	Rushan	GBAO	Y	Avalanche	24.00	23.45	1,679	2.6875	2,538,959
(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	574-611	Shugnon	GBAO	Y	Avalanche	24.00	23.45	1,101	2.6875	1,664,955
(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	622-822	Shugnon	GBAO	Y	Avalanche	24.00	23.45	1,060	2.6875	1,602,445
(РБ-04) Душанбе-ағбаи Кулма (ба воситаи Вахдат-Кулоб-Хоруғ-Мурғоб-то сарҳади Ҷумҳурии Халқии Хитой)	822-1023	Murgab	GBAO	Y	Avalanche	24.00	23.45	1,018	2.6875	1,539,179
(РБ 05) Мурғоб-ағбаи Қизиларт-то сарҳади Ҷумҳурии Қирғизистон	0-187	Murgab	GBAO	N			23.45	771	0	0
(РБ 06) Хоруғ-Ишкошим-Тузкул (баромад ба р/а Душанбе-ағбаи Кулма)	0-31	Shugnon	GBAO	Y	Avalanche	24.00	23.45	2,252	2	2,534,814
(РБ 06) Хоруғ-Ишкошим-Тузкул (баромад ба р/а Душанбе-ағбаи Кулма)	31,7-320,4	Ishkashim	GBAO	Y	Avalanche	24.00	23.45	1,072	2	1,206,492

(РБ 07) Ваҳдат-Рашт-Ҷиргатол-то сарҳади Ҷумҳурии Қирғизистон	0-14	Vakdat	RRS	N			19.67	9,236	0	0
(РБ 07) Ваҳдат-Рашт-Ҷиргатол-то сарҳади Ҷумҳурии Қирғизистон	14-62	Faizobod	RRS	Y	Mudflow	120.00	19.67	5,957	0.4375	6,150,645
(РБ 07) Ваҳдат-Рашт-Ҷиргатол-то сарҳади Ҷумҳурии Қирғизистон	62-87	Rogun	RRS	Y	Mudflow	120.00	19.67	4,089	0.4375	4,221,110
(РБ 07) Ваҳдат-Рашт-Ҷиргатол-то сарҳади Ҷумҳурии Қирғизистон	87-142,5	Nurobod	RRS	Y	Mudflow	120.00	19.67	3,780	0.4375	3,902,346
(РБ 07) Ваҳдат-Рашт-Ҷиргатол-то сарҳади Ҷумҳурии Қирғизистон	142,5-193	Rasht	RRS	Y	Mudflow	120.00	19.67	2,701	0.4375	2,788,951
(РБ 07) Ваҳдат-Рашт-Ҷиргатол-то сарҳади Ҷумҳурии Қирғизистон	193-228	Tojikobod	RRS	Y	Mudflow	120.00	19.67	2,346	0.4375	2,421,920
(РБ 07) Ваҳдат-Рашт-Ҷиргатол-то сарҳади Ҷумҳурии Қирғизистон	228-288	Lyaksh	RRS	Y	Mudflow	120.00	19.67	1,910	0.4375	1,971,779
(РБ 07) Ваҳдат-Рашт-Ҷиргатол-то сарҳади Ҷумҳурии Қирғизистон	288-329	Lyaksh	RRS	Y	Mudflow	120.00	19.67	1,784	0.4375	1,841,950
(РБ 08) Гулистон-Фархор-Панҷ-Дӯстӣ	0-13	Kamadoni	Khatlon	N			19.67	2,052	0	0
(РБ 08) Гулистон-Фархор-Панҷ-Дӯстӣ	13-69,4	Farkhor	Khatlon	N			19.67	1,779	0	0
(РБ 08) Гулистон-Фархор-Панҷ-Дӯстӣ	69,4-114,5	Pyanj	Khatlon	Y	Mudflow	120.00	19.67	1,548	0.5	1,826,427
(РБ 08) Гулистон-Фархор-Панҷ-Дӯстӣ	114,5-140,8	Jayhun	Khatlon	N			19.67	1,304	0	0
(РБ 09) Душанбе-Қурғонтеппа-Панҷи Поён (ба воситаи Рӯдакӣ-Ҷ. Румӣ-то сарҳади Ҷумҳурии Афғонистон)	9,8 - 20	Rudaki	RRS	N			19.67	10,420	0	0
(РБ 09) Душанбе-Қурғонтеппа-Панҷи Поён (ба воситаи Рӯдакӣ-Ҷ. Румӣ-то сарҳади Ҷумҳурии Афғонистон)	20-34	Rudaki	RRS	N			19.67	9,480	0	0
(РБ 09) Душанбе-Қурғонтеппа-Панҷи Поён (ба воситаи Рӯдакӣ-Ҷ. Румӣ-то сарҳади Ҷумҳурии Афғонистон)	34-84	Kuroson	Khatlon	N			19.67	8,614	0	0
(РБ 09) Душанбе-Қурғонтеппа-Панҷи Поён (ба воситаи Рӯдакӣ-Ҷ. Румӣ-то сарҳади Ҷумҳурии Афғонистон)	84-107,8	Boktar	Khatlon	N			19.67	8,028	0	0
(РБ 09) Душанбе-Қурғонтеппа-Панҷи Поён (ба воситаи Рӯдакӣ-Ҷ. Румӣ-то сарҳади Ҷумҳурии Афғонистон)	107,8-141,8	Jalilodin	Khatlon	N			19.67	7,007	0	0
(РБ 09) Душанбе-Қурғонтеппа-Панҷи Поён (ба воситаи Рӯдакӣ-Ҷ. Румӣ-то сарҳади Ҷумҳурии Афғонистон)	141,8-181,8	Jayhun	Khatlon	N			19.67	6,021	0	0
(РБ 10) Р/а Қурғонтеппа-Данғара	2,3-8,2	Boktar	Khatlon	N			19.67	5,371	0	0

(РБ 10) Р/а Қурғонтеппа-Данғара	8,2-45,5	Vaksh	Khatlon	N			19.67	4,179	0	0
(РБ 10) Р/а Қурғонтеппа-Данғара	45,5-71	Dangara	Khatlon	N			19.67	3,851	0	0
(РБ 11) Қизилқалъа-Ҷарбуҷа (ба воситаи Қубодиён-Шаҳритус-сарҳади Узбекистон	0-23	Kuroson	Khatlon	N			19.67	1,531	0	0
(РБ 11) Қизилқалъа-Ҷарбуҷа (ба воситаи Қубодиён-Шаҳритус-сарҳади Узбекистон	23-62	Jilikul	Khatlon	N			19.67	1,326	0	0
(РБ 11) Қизилқалъа-Ҷарбуҷа (ба воситаи Қубодиён-Шаҳритус-сарҳади Узбекистон	62-96,5	Quybodin	Khatlon	N			19.67	1,217	0	0
(РБ 11) Қизилқалъа-Ҷарбуҷа (ба воситаи Қубодиён-Шаҳритус-сарҳади Узбекистон	96,5-135,2	Shakritus	Khatlon	N			19.67	1,217	0	0
(РБ 11) Қизилқалъа-Ҷарбуҷа (ба воситаи Қубодиён-Шаҳритус-сарҳади Узбекистон	135,2-168,2	Nosiri Khusav	Khatlon	N			19.67	1,093	0	0
(РБ 12) Шаҳраки Пролетар-Исфана-сарҳади Ҷумҳурии Қирғизистон	0-9,4	Jabbar Rasulov	Sughd	N			22.96	1,814	0	0
(РБ 13) Айнӣ-Панҷакент-сарҳади Узбекистон	0-47	Ayni	Sughd	Y	Landslide	48.00	22.96	722	0.25	198,825
(РБ 13) Айнӣ-Панҷакент-сарҳади Узбекистон	47-112,7	Penjakent	Sughd	Y	Landslide	48.00	22.96	1,316	0.25	362,596
(РБ 14) Конибодом-Деҳмой (баромад ба р/а Душнбе-Чаноқ)	91,0-98,4	Jabbar Rasulov	Sughd	N			22.96	4,659	0	0
(РБ 14) Конибодом-Деҳмой (баромад ба р/а Душнбе-Чаноқ)	56,8-91,0	Gafurov	Sughd	N			22.96	3,292	0	0
(РБ 14) Конибодом-Деҳмой (баромад ба р/а Душнбе-Чаноқ)	0-56,8	Konibodom	Sughd	N			22.96	2,275	0	0
(РБ 15) Истаравшан-Зафаробод (ба воситаи Қуқанд-то сарҳади Ҷумҳурии Ӯзбекистон)	0-21	Istaravshan	Sughd	N			22.96	1,840	0	0
(РБ 15) Истаравшан-Зафаробод (ба воситаи Қуқанд-то сарҳади Ҷумҳурии Ӯзбекистон)	21-28	Zafarobod	Sughd	N			22.96	1,027	0	0
(РБ-16) Исфара-Баткент-сарҳади Ҷумҳурии Қирғизистон	0-10	Isfara	Sughd	N			22.96	902	0	0
(РБ 17) Исфара-Ворӯх-то сарҳади Ҷумҳурии Қирғизистон	0-43,9	Isfara	Sughd	N			22.96	1,005	0	0
(РБ 18) Исфара-Даҳана то сарҳади Ҷумҳурии Узбекистон	0-24,5	Isfara	Sughd	N			22.96	631	0	0
(РБ 19) Б.Ғафуров-Булоқ-Пунгон-то сарҳади Ҷумҳурии Ӯзбекистон	21-28	Gafurov	Sughd	N			22.96	811	0	0
(РБ 19) Б.Ғафуров-Булоқ-Пунгон-то сарҳади Ҷумҳурии Ӯзбекистон	28-122	Asht	Sughd	N			22.96	675	0	0
(РҶ 001) Ба истироҳатгоҳи Хоҷа Оби Гарм	0-5,7	Varzob	RRS	N			19.67	985		0
(РҶ 002) Ба чашмаи Сангхок	0-12,1	Varzob	RRS	N			19.67	412		0
(РҶ 003) ба истироҳатгоҳи "Ҳаватоғ"	0-10,1	Istaravshan	Sughd	N			22.96	572		0

(РҶ 004) Пугус-Такоб-Сафедорак	0-18,3	Varzob	RRS	N			19.67	4,652		0
(РҶ 005) НБО Варзоб-Харангон-истироҳатгоҳи наврасони "Дусти"	0-10,9	Varzob	RRS	N			19.67	2,260		0
(РҶ 006) ба истгоҳи роҳи оҳани Чиптура	0-6	Shakrinav	RRS	N			19.67	1,972		0
(РҶ 007) ба истироҳатгоҳ "Қаратоғ"	0-3,4	Shakrinav	RRS	N			19.67	993		0
(РҶ 008) ба деҳаи Қаратоғ	0-4,5	Shakrinav	RRS	N			19.67	907		0
(РҶ 009) ба ш. Турсунзода	0-3	Turzonsade	RRS	N			19.67	6,738		0
(РҶ 010) ба шаҳраки Ҳисор	0-7	Gissor	RRS	N			19.67	2,838		0
(РҶ 011) ба деҳаи Алмоси	0-12,2	Gissor	RRS	N			19.67	1,823		0
(РҶ 012) ба деҳаи Шоҳамбарӣ	0-8,3	Gissor	RRS	N			19.67	1,131		0
(РҶ 013) ба шаҳри Турсунзода (аз ҷониби Ҷумҳурии Узбекистон)	0-2,8	Turzonsade	RRS	N			19.67	1,091		0
(РҶ 014) Р/а Янги Шаҳар-Янгимазор-Тандиқул	0-22	Lyaksh	RRS	N			19.67	985		0
(РҶ 015) ба роҳи канораи Дарбанд	0-4,2	Nurobod	RRS	N			19.67	977		0
(РҶ 016) Сари Пул-Навобод	0-18,2	Rasht	RRS	N			19.67	915		0
(РҶ 017) ба кони ангишти Назарайлоқ	0-42	Rasht	RRS	N			19.67	782		0
(РҶ 018) ба деҳаи Ҷиргатол	0-4	Lyaksh	RRS	N			19.67	811		0
(РҶ 019) ба деҳаи Ҷиргатол (аз ҷониби Ҷумҳурии Қирғизистон)	0-2	Lyaksh	RRS	N			19.67	896		0
(РҶ 020) ба фурудгоҳи Ляхш	0-1,6	Lyaksh	RRS	N			19.67	899		0
(РҶ 021) Нимич-Сайрон (аз ҳудуди Тоҷикобод)	0-16,7	Tojikobod	RRS	N			19.67	904		0
(РҶ 022) Ваҳдат-Ромит	0-37	Vakdat	RRS	N			19.67	3,378		0
(РҶ 023) деҳаи Чормағзак-д. Хучалонӣ (серпантин)	0-11,1	Norak	Khatlon	N			19.67	333		0
(РҶ 024) Чормағзак-Ёвон (роҳи канора)	9,0-23,0	Yavan	Khatlon	N			19.67	1,781		0
(РҶ 024) Чормағзак-Ёвон (роҳи канора)	0-8,7	Norak	Khatlon	N			19.67	2,494		0
(РҶ 025) ба шаҳри Норак	0-5,3	Norak	Khatlon	N			19.67	3,883		0
(РҶ 026) Данғара-Кангурт-Балҷувон-Ховалинг	0-22	Dangara	Khatlon	N			19.67	3,605		0
(РҶ 026) Данғара-Кангурт-Балҷувон-Ховалинг	22,7-67,4	Temurmalik	Khatlon	N			19.67	1,622		0
(РҶ 026) Данғара-Кангурт-Балҷувон-Ховалинг	22,7-64,4	Balchivon	Khatlon	N			19.67	1,245		0
(РҶ 027) Сомончи-Олимтойи хурд	0-9,8	Farkhor	Khatlon	N			19.67	513		0
(РҶ 028) Комсомол-Шафтолубоғ-Тоҷикистон-Сомончӣ	0-29,2	Farkhor	Khatlon	N			19.67	522		0

(РЧ 029) ба маркази ноҳияи Мир Сайид Алии Ҳамадонӣ	0-13,1	Kamadoni	Khatlon	N			19.67	1,819		0
(РЧ 030) Қурбоншаҳид-Темурмалик	0-21	Vose	Khatlon	N			19.67	992		0
(РЧ 030) Қурбоншаҳид-Темурмалик	21-31,8	Temurmalik	Khatlon	N			19.67	946		0
(РЧ 031)Темурмалик-Кангурт	0-27	Temurmalik	Khatlon	N			19.67	938		0
(РЧ 032) Р/а Восеъ-Ховалинг	0-40	Vose	Khatlon	Y	Avalanche	24.00	19.67	1,217		0
(РЧ 032) Р/а Восеъ-Ховалинг	40-87,7	Khovaling	Khatlon	Y	Avalanche	24.00	19.67	1,131		0
(РЧ 033) Р/а Кулоб-Муъминобод	0-15,8	Kulob	Khatlon	N			19.67	2,078		0
(РЧ 033) Р/а Кулоб-Муъминобод	16-41,8	Muminobod	Khatlon	N			19.67	1,225		0
(РЧ 034) Зираки-Даҳана	0-6,8	Kulob	Khatlon	N			19.67	2,312		0
(РЧ 035) Кулоб-Фурудгоҳ	0-3,5	Kulob	Khatlon	N			19.67	1,521		0
(РЧ 036) Тугарак-Саричашма-Чордара-Шурообод	6-47,5	Shirobod	Khatlon	N			19.67	1,026		0
(РЧ 037) Қалъаи Хумб-фурудгоҳи Дашти Луч	0-6,9	Darvoz	GBAO	N			23.45	970		0
(РЧ 038) ба маркази ноҳияи Ванч-қишлоқи Техарв	0-16	Vanj	GBAO	N			23.45	921		0
(РЧ 039) ба деҳаи Поршнев	0-4,6	Shugnon	GBAO	N			23.45	834		0
(РЧ 040) ба шифохонаи Гармчашма	0-6,2	Ishkashim	GBAO	N			23.45	870		0
(РЧ 041) Хоруғ-Роштқалъа-Тӯқузбулоқ	0-154	Roshkala	GBAO	N			23.45	667		0
(РЧ 042) Душанбе-Чимтеппа	9,4 -21	Rudaki	RRS	N			19.67	7,770		0
(РЧ 043) Рудакӣ-Ёвон-Абдураҳмони Ҷомӣ-Уялӣ	0-23	Rudaki	RRS	N			19.67	6,705		0
(РЧ 043) Рудакӣ-Ёвон-Абдураҳмони Ҷомӣ-Уялӣ	23-75	Yavan	Khatlon	N			19.67	5,066		0
(РЧ 043) Рудакӣ-Ёвон-Абдураҳмони Ҷомӣ-Уялӣ	75-107	Jomi	Khatlon	N			19.67	2,978		0
(РЧ 044) Чимтеппа-Ҳисор	0-6	Rudaki	RRS	N			19.67	6,344		0
(РЧ 044) Чимтеппа-Ҳисор	6-20	Gissor	RRS	N			19.67	4,527		0
(РЧ 045) Лоҳур-Эсамбой-Шуртуғай	0-45	Rudaki	RRS	N			19.67	6,606		0
(РЧ 046) чорсӯи (развязка) Лоҳур	0-2,1	Rudaki	RRS	N			19.67	5,354		0
(РЧ 047) Пойгоҳи борфурории НБО Норак-Қарабулоқ	0-9,9	Vakdat	RRS	N			19.67	1,053		0
(РЧ 048) Душанбе-деҳаи Айнӣ-Ҳисор	0-7,4	Rudaki	RRS	N			19.67	5,177		0
(РЧ 048) Душанбе-деҳаи Айнӣ-Ҳисор	7,4-16,1	Gissor	RRS	N			19.67	1,099		0
(РЧ 049) х/д Россия-х/д Гулистон	9.9	Rudaki	RRS	N			19.67	5,456		0

(РҶ 050) АПФ "Улҷабой"-Х/ф "Қиблаӣ"-и н. Рудакӣ	0-23,9	Rudaki	RRS	N			19.67	3,616		0
(РҶ 051) А. Ҷоми-Қизил Қалъа	0-13,5	Jomi	Khatlon	N			19.67	3,373		0
(РҶ 052) ба ҶСП Корхонаи муштараки Тоҷикистон-Кипр "Кимиё"	0-4,5	Yavan	Khatlon	N			19.67	2,614		0
(РҶ 053) Гирдогирди шаҳри Қурғонтеппа	0-12,4	Boktar	Khatlon	N			19.67	5,282		0
(РҶ 054) Қурғонтеппа - Вахш	0-13,8	Boktar	Khatlon	N			19.67	4,866		0
(РҶ 055) Даромад ба истгоҳи роҳи оҳани ш. Қурғонтеппа	0-0,9	Vaksh	Khatlon	N			19.67	3,457		0
(РҶ 056) Даромад ба ш. Сарбанд	0-2	Vaksh	Khatlon	N			19.67	2,966		0
(РҶ 057) Вахш - Данғара	0-50	Vaksh	Khatlon	N			19.67	1,023		0
(РҶ 058) Узун- Ҷиликул - Мамнунгоҳи "Бешаи Палангон"	0-7	Jalilodin	Khatlon	N			19.67	1,175		0
(РҶ 058) Узун- Ҷиликул - Мамнунгоҳи "Бешаи Палангон"	7-32,5	Jilikul	Khatlon	N			19.67	1,141		0
(РҶ 059) Ҷиликул - Гароути	0-9,2	Jilikul	Khatlon	N			19.67	1,065		0
(РҶ 060) Дусти - Ҷиликул (аз р.а. Қ.теппа - П. Поён)	0-5,7	Jilikul	Khatlon	N			19.67	1,167		0
(РҶ 061) Ҷ. Руми - Ҷиликул (аз р\а Қ.Теппа - П.Поён)	4,8-10,4	Jilikul	Khatlon	N			19.67	1,026		0
(РҶ 061) Ҷ. Руми - Ҷиликул (аз р\а Қ.Теппа - П.Поён)	0-4,8	Jalollidin Balkhi	Khatlon	N			19.67	891		0
(РҶ 062) Комсомол-Пахтакор (аз Ҷамоати "Гулистон"-Қиблаӣ то х/д "Эшонов)	0-8,4	Jayhun	Khatlon	N			19.67	1,017		0
(РҶ 063) Р/а Шурча-мавзолеи Рудакӣ	0-17	Penjakent	Sughd	N			22.96	604		0
(РҶ 064) Р/а Истаравшан-Ғончи	0-7,0	Istaravshan	GBAO	N			23.45	2,519		0
(РҶ 064) Р/а Истаравшан-Ғончи	7-12,6	Gonchi	GBAO	N			23.45	1,050		0
(РҶ 065) ба шаҳри Истаравшан	0-4,2	Istaravshan	GBAO	N			23.45	2,491		0
(РҶ 066) Даромад ба н. Ғончи	0-16,4	Gonchi	GBAO	N			23.45	1,039		0
(РҶ 067) Зафаробод-Ширин-то сарҳади Ҷумҳурии Ўзбекистон	0-25,2	Zafarobod	GBAO	N			23.45	673		0
(РҶ 068) Ёва-Ғафуров-баромад ба р/а Конибодом-Деҳмой	0-17,3	Gafurov	Sughd	N			22.96	3,908		0
(РҶ 069) Р/а Конибодом-Ким-Исфара	0-4,8	Konibodom	Sughd	Y	Mudflow	120.00	22.96	1,724		0
(РҶ 069) Р/а Конибодом-Ким-Исфара	4,8-27	Isfara	Sughd	Y	Mudflow	120.00	22.96	1,085		0
(РҶ-070) Р/а Конибодом-Равот-то сарҳади Ўзбекистон	0-14	Konibodom	Sughd	N			22.96	950		0

(РҶ 071) Булоқ-Чилмаҳрам	0-11	Asht	Sughd	N			22.96	715		0
(РҶ 072) аз деҳаи Оқтеппа ба р/а Конибодом-Деҳмой ва даромади шаҳри Хуҷанд	0-7	Gafurov	Sughd	N			22.96	666		0
(РҶ 073) Б. Ғафуров-Овчи-Қалъача	0-13,6	Gafurov	Sughd	N			22.96	908		0
(РҶ 074) ба р/а Б.Ғафуров-Булоқ-Пунгон-то сарҳади Ӯзбекистон	0-15,2	Gafurov	Sughd	N			22.96	814		0
(РҶ 074) ба р/а Б.Ғафуров-Булоқ-Пунгон-то сарҳади Ӯзбекистон	22-137,2	Asht	Sughd	N			22.96	700		0
(РҶ 075) ба фурудгоҳи Хуҷанд (Б. Ғафуров-Овчи-Қалъача)	0-3,4	Gafurov	Sughd	N			22.96	640		0
(РҶ 076) Даромад ба ПТШ Адрасмон аз 28 км р/а Ғафуров-Булоқ-Пунгон	0-33	Gafurov	Sughd	N			22.96	522		0
(РҶ 077) ба шаҳри Бекобод (сарҳади Ӯзбекистон)	0-6,8	Spitamen	Sughd	N			22.96	1,105		0
(РҶ 078) Даромад ба шаҳраки Шӯроб	0-7	Isfara	Sughd	N			22.96	1,060		0
(РҶ 079) Деҳмой-ба маркази ноҳияи Ҷ.Расулов	0-6,2	Gafurov	Sughd	N			22.96	1,212		0
(РҶ 080) ба деҳаи Яккатол (аз р/а Истаравшан-Зафаробод)	0-1,2	Istaravshan	GBAO	N			23.45	1,972		0
(РҶ 081) аз деҳаи Ҳаштяк ба р/а Зафаробод-Ширин-то сарҳади Ҷумҳурии Ӯзбекистон	0-12,6	Zafarobod	GBAO	N			23.45	358		0
(РҶ 082) Ба истгоҳи роҳи оҳани Конибодом	0-7,1	Konibodom	Sughd	N			22.96	910		0
(РҶ 083) ба истироҳатгоҳи Конибодом	0-4	Konibodom	Sughd	N			22.96	724		0
(РҶ 084) Булоқ-Шайдон	0-11,3	Asht	Sughd	N			22.96	904		0
(РҶ 085) Рушон-Басид-Савнов	0-11,3	Rushon	GBAO	Y	Avalanche	24.00	23.45	851	2	958,047
(РҶ 086) Майхура-Такфон (ба воситаи ағбаи Анзоб)	0-22,5	Varzob	RRS	N			19.67	3,220		0
(РҶ 086) Майхура-Такфон (ба воситаи ағбаи Анзоб)	84,5-124	Ayni	Sughd	N			22.96	949		0
(РҶ 087) ба НБО Сангтуда	0-18	Vaksh	Khatlon	N			19.67	1,201		0
(РҶ 088) Р/а шаҳраки Исоев-шаҳраки Гулистон-шаҳраки Вахш	0-24,2	Jalollidin Balkhi	Khatlon	N			19.67	789		0
(РҶ 088) Р/а шаҳраки Исоев-шаҳраки Гулистон-шаҳраки Вахш	24,2-41,6	Vaksh	Khatlon	N			19.67	1,008		0
(РҶ 089) ба шаҳри Роғун	0-10,75	Rogun	RRS	N			19.67	1,145		0
(РҶ 090) Хуҷанд-Палос (ба р/а Ғафуров-Булоқ-Пунгон)	0-16,6	Gafurov	Sughd	N			22.96	899		0
(РҶ 091) Куркат-Ширин-то сарҳади Ҷумҳурии Ӯзбекистон	0-11,8	Spitamen	Sughd	N			22.96	1,121		0

(РҶ 091) Куркат-Ширин-то сарҳади Ҷумҳурии Ӯзбекистон	135-140	Zafarobod	Sughd	N			22.96	895		0

ANNEX D CALCULATION OF INFLATION

Table D1 Inflation rate in Tajikistan by year

Year	Inflation, %
2017	7.3
2018	3.8
2019	7.8
2020	9.4
Cumulative inflation, 2017—2020	23.8

<u>What is the method to calculate the cumulative inflation, or the inflation for a period?</u>

Assume 1 m3 of concrete cost TJS 100.

In 2017, the inflation was 10%.

In 2018, another 10%.

In 2019, another 10%.

What is the inflation over these years? No, it is not 30%!

In 2017, 1 m3 of concrete cost: TJS 100 + 10% = TJS 110,

In 2018, the price increased by 10%: TJS 110 + 10% = TJS 121.

2019: TJS 121 + 10% = TJS 133.10.

The price increased from TJS 100 to TJS 133.10 over three years, meaning that the cumulative inflation (inflation for a period) for three years is 33.1%.

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