SUMMARY ECONOMIC AND FINANCIAL ANALYSIS

I. INTRODUCTION

1. The Landslide Risk Management Sector Project has three outputs: (i) implement landslide mitigation engineering measures in around 15–20 high risk sites, (ii) improve on-site monitoring for 20 sites and pilot a national satellite-based landslide monitoring system, and (iii) strengthen capacity for landslide risk management. Key expected economic benefits are the avoidance of deaths and injuries, damage to assets and infrastructure, disruptions to economic activities, and permanent resettlement costs. The project is estimated to directly benefit 4,700 people and avoid damage to about 650 hectares (ha) of land, 60 kilometers of linear infrastructure, and 14 community buildings.

II. DEMAND ANALYSIS

2. Disasters triggered by natural hazards affect about 5% of gross domestic product (GDP) and about 5% of the population to some degree every year.[1] After earthquakes, landslides are the most economically damaging disaster in the country.[2] The government has prioritized managing landside risks in its national strategies.[3] Landslide risk management is hampered by (i) limited experience of the Ministry of Emergency Situations (MES) in landslide mitigation, (ii) limited capacity for modern landslide monitoring, and (iii) lack of community risk management. Resettlement has been a primary response to landslide risk in rural communities, however it is costly and has had limited effectiveness because of the high number of returning households. According to a conservative estimate by the MES, permanent resettlement of 4,000 households (about 20,000 people) currently at risk from landslides would cost around $140 million. More effective implementation incorporating international best practices will likely increase the costs.

III. APPROACH

3. The project applies the sector lending modality. Subprojects for engineering measures (output 1) or on-site monitoring (output 2) will be selected, assessed, and implemented during project implementation. To confirm economic viability of the project, a feasibility study has been prepared for a major representative subproject for engineering measures in Ayusai, Ayu village, Osh *oblast* (province), including geotechnical, geophysical, and topographic survey.[4] Subsequent sites will be selected from a long list of 46 prospective sites prepared by the MES. Preliminary quantitative analysis has been undertaken for each to categorize the hazard level, at-risk elements, and expected mitigation requirements.[5] Additional subprojects will be selected and prepared in line with eligibility criteria and procedures detailed in the project administration manual. The economic internal rate of return (EIRR) is required ideally to be above 9%, with a

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[1] Global Facility for Disaster Reduction and Recovery. 2015. Country Profile: Kyrgyz Republic.

[2] World Bank and United Nations International Strategy for Disaster Reduction. 2009. *Central Asia and Caucasus Disaster Risk Management Initiative Risk Assessment for Central Asia and Caucasus: Desk Study Review.* Washington, DC.

[3] Government of the Kyrgyz Republic. 2018. *The Development Program of the Kyrgyz Republic for the Period 2018–2022: Unity. Trust. Creation*. Bishkek; and Government of the Kyrgyz Republic. 2018. *Strategy for the Comprehensive Protection of the Population and the Territory of the Kyrgyz Republic from Emergency Situations for 2018–2030*. Bishkek.

[4] Technical Feasibility Study: Ayusai Subproject (accessible from the list of linked documents in Appendix 2 of the report and recommendation of the President).

[5] Landslide Risk Assessment (accessible from the list of linked documents in Appendix 2 of the report and recommendation of the President).

minimum of 6%.[6] The approach is justified given the similarities in landslide volumes and soil characteristics across the identified high-risk sites. Financial sustainability analyses of the overall project was conducted. These analyses serve as an indicator of the expected economic viability and financial sustainability of the project overall, and will also serve as models for economic analysis of subsequent subprojects selected for financing.

IV. ECONOMIC ANALYSIS OF THE AYUSAI REPRESENTATIVE SUBPROJECT

A. Subproject Description

4. **Technical rationale.** The technical rationale of the Ayusai subproject is the need to protect residents from the risk of landslides. The subproject will implement a range of engineering measures to largely eliminate the landslide hazard. This will significantly reduce landslide risk for 39 ha of nearby agricultural and residential land and benefit 38 households (about 190 people). A landslide early warning system (EWS) will be installed to reduce risks during civil works. The unloaded soil will be deposited on the nearby site of a 2017 landslide and on the banks of nearby rivers, resulting in increased arable land. The proposed civil works will require temporary resettlement of 11 households and temporary loss of agricultural land for 24 households, with associated temporary housing, compensation, and training to be provided under the project.

5. **Economic rationale.** The economic rationale of the subproject is the need to avoid large-scale losses caused by landslides, including deaths and injuries, disruption of livelihoods, destruction of physical assets, and costs of resettlement of surviving households. The involvement of the public sector is justified because protection of the public from natural hazards is unlikely to be financed by the private sector. The technical, financial, social, and logistical barriers to preemptive permanent resettlement strengthen the economic rationale of the proposed engineering approach. A preliminary economic analysis of alternative project designs (ranging from full resettlement with no engineering works to the use of alternative engineering options) was conducted, with all four yielding negative economic returns.[7]

6. **Without-project scenario.** The without-project scenario is continued landslide risk and possible damaging landslide events at Ayu village. The return time of a landslide event at the site is estimated at 7 years, equating to an estimated 53% chance of landslide occurring by 2027 and 75% by 2031. This return time estimate is based on a sample of 1,583 landslides in southern Kyrgyz Republic during 1990–2013.[8] According to the climate change risk and vulnerability assessment carried out under the technical assistance, by 2050 the site is expected to experience increased soil infiltration, thereby reducing the return period. It is difficult to quantify the associated change in return period, but it strongly suggests an increase in the subproject benefits over time (footnote 7).

B. Methodology and Assumptions

7. The following are the key methodology and design assumptions used in estimating economic viability. Additional assumptions are provided in the detailed analysis (footnote 7).

(i) Subproject economic life is estimated at 20 years.

[6] Project Administration Manual (accessible from the list of linked documents in Appendix 2 of the report and recommendation of the President).

[7] Detailed Economic and Financial Analysis (accessible from the list of linked documents in Appendix 2 of the report and recommendation of the President).

[8] Landslide Risk Assessment (accessible from the list of linked documents in Appendix 2 of the report and recommendation of the President).

(ii) Domestic price numeraire is used for economic pricing, with a shadow exchange rate conversion factor of 1.03 applied to the financial price of tradeable items (both costs and benefits).[9]

(iii) A discount rate of 6% is applied in line with ADB guidelines for disaster risk reduction projects.[10]

(iv) An exchange rate of $1 = Som82.84 (the exchange rate on 31 December 2020) is used for conversion of financial prices between international and domestic currencies.[11] All prices are expressed in 2021 constant terms.

(v) A shadow wage rate factor of 1 is applied to estimates of labor costs in economic budgets to reflect prevailing levels of un- and underemployment in rural southern Kyrgyz Republic in 2020.[12]

(vi) The population of Ayu village and average per capita income of its inhabitants are assumed to remain constant during the subproject economic life (2022 to 2041).[13]

(vii) The estimated proportions of tradeables' costs and domestic resource costs by major subproject cost categories are reflected in the estimates of subproject economic costs.

(viii) In the without-subproject scenario, the return time of a landslide event at the Ayusai site is estimated at 7 years.[14] The probability of a landslide in year t is therefore calculated as $(1/7) \times (1–1/7)^{t}$.[15]

(ix) In the without-subproject scenario, land at risk from a landslide (39 ha) falls under one of three hazard classes: (i) H3, land which will be detached during a landslide (about 10 ha); (ii) H2, land which will be buried by a landslide (about 16 ha); and (iii) H1, land which will be significantly impacted by a landslide (mud flows, etc.) (about 13 ha). The landslide vulnerability of land and moveable and nonmoveable assets in H3 and H2 is 100%, and in H1 70%, where 100% equates to complete destruction of land and assets (footnote 5).

(x) The agricultural and residential land, households, and physical assets at risk were identified via physical asset and social safeguard surveys conducted in July–August 2020 and the subsequent landslide risk assessment. The average household size in the area is five people.[16]

(xi) The value of land and replacement cost of infrastructure were obtained from a range of sources, including recent ADB and World Bank studies, the MES, local news sources, and personal communications. The average value of household possessions at risk was calculated using market prices of major household goods.

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[9] Shadow exchange rate conversion factor was calculated using latest World Bank data (https://data.worldbank.org/).

[10] ADB. 2017. *Staff Instruction on Business Processes for Economic Analysis of Projects.* Manila.

[11] XE. Currency Exchange Rates (accessed 4 March 2021).

[12] ADB. 2018. *Report and Recommendation of the President to the Board of Directors: Proposed Loan and Grant to Kyrgyz Republic for the Climate Change and Disaster Resilient Water Resources Sector Project.* Detailed Economic Analysis (accessible from the list of linked documents in Appendix 2). Manila.

[13] During 2015–2019, Osh *oblast* experienced average annual population growth of 2.2% and annual average real per capita income growth of 6.2% (http://www.stat.kg/ru/). However, because of the coronavirus disease (COVID-19) pandemic, the national GDP is expected to drop by 10% in 2020 (ADB. 2020. *COVID-19 in the Kyrgyz Republic: Socioeconomic and Vulnerability Impact Assessment and Policy Response.* Manila.), which is also likely to impact population growth. The decision to assume no changes in population and income levels to 2041 was made because of difficulties in making projections in such an unstable environment.

[14] This estimate is based on secondary literature and will be confirmed during detailed design. See Landslide Risk Assessment (accessible from the list of linked documents in Appendix 2 of the report and recommendation of the President).

[15] Holcombe E. et al. 2011. An integrated approach for evaluating the effectiveness of landslide risk reduction in unplanned communities in the Caribbean. *Natural Hazards*, 61(2): 351–85.

[16] ADB. 2021. *Landslide Risk Management Sector Project: Poverty, Gender, and Social Assessment.* Consultant's report. Manila (TA 9726-KGZ).

(xii) In an event of a landslide (the without-subproject scenario), 38 households (190 people) at risk would experience 26 weeks of economic inactivity because of complete destruction of their assets, subsequent relocation, retraining, etc. Another 119 nearby households would experience 1 week of economic inactivity because of temporary damage to road, water, and power infrastructure.

(xiii) In an event of a landslide, 40% of 190 people at risk are expected to suffer serious injuries, 40% minor injuries, and 20% escape unharmed. Consequent economic losses are calculated based on income lost, with major injuries equating to 8.52 months of lost income and minor injuries equating 0.28 months of lost income.[17]

(xiv) In an event of a landslide, 38 households at risk would undergo subsequent resettlement to a new, currently uninhabited area.[18] This would require construction of a new village, provision of temporary housing while the village is being built, and other related costs (transportation, allowances for vulnerable groups, etc.). The resettled households would receive occupational training by local authorities that would allow them to engage in nonagriculture employment.[19]

(xv) In an event of a landslide, around 500 meters of the main village road would be buried. The replacement road would need to be diverted around the landslide, resulting in an extra 300 meters of travel. Consequent increases in travel time costs and vehicle operating costs (VOCs) were calculated using estimates of daily local car and foot traffic (collected during physical asset surveys) and VOC estimates for a range of vehicles in the Kyrgyz Republic.[20]

(xvi) The engineering measures proposed under the subproject would largely eliminate the landslide hazard. However, because 100% hazard reduction can never be guaranteed, a conservative estimate of 95% is used (to be further confirmed during detailed design). Hazard reduction would reflect the progress of civil works, with a (very roughly estimated) 20% reduction during year 1, 55% during year 2, and 80% during year 3. An EWS proposed under the subproject would reduce the residual hazard during years 1–3 for moveable assets (people, livestock, and household possessions) by 50%.[21]

(xvii) The current subproject design includes safely depositing the unloaded soil on the nearby site of a 2017 landslide and on the banks of the Zerger River, resulting in an additional 12 ha of arable land. The annual benefit of this additional land was calculated using gross margins for hay (the main crop cultivated in Ayu village, $600/ha/year).

(xviii) Because of the nature of planned works and equipment installation, long-term operation and maintenance (O&M) costs are expected to be modest with limited complexity. Landslide soil removal, reshaping, and drainage works are largely permanent and do not require significant further O&M.

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[17] R. Mechler. 2005. *Cost–Benefit Analysis of Natural Disaster Risk Management in Developing Countries*. Vienna.

[18] If resettlement involves only a few households, they are usually placed within an existing village. However, for a larger resettlement, the government typically builds a new village in a valley because of lack of suitable land for housing and agricultural livelihoods in mountainous areas.

[19] Sewing, dressmaking, and construction and maintenance of agricultural equipment and vehicles (tractors, cars) were mentioned as desirable occupations by Ayu inhabitants during subproject surveys.

[20] VOCs of $0.53 for a primary road covered in the study were increased by 50% to include additional cost of travelling on a secondary road. See: ADB. Economic and Financial Analysis. Additional Financing of CAREC Corridor 1 (Bishkek-Torugart Road) Project 3.

[21] EWSs are ineffective for landslides triggered by single strong seismic activity because of the very quick response time required, but are very effective for landslides triggered by snowmelt, low continuous small seismic shakes, and prolonged rain periods. In the absence of reliable information on shares of landslide hazard represented by these triggers at the Ayusai site, a midway point (50%) figure was used.

C. Subproject Costs

8. The total subproject cost (including physical and price contingencies) is $3.65 million. The economic cost of the subproject is $3.25 million (Table 1). The economic cost was obtained by multiplying the cost of tradeable goods and services by the shadow exchange rate conversion factor (1.03) and subtracting taxes and duties (average 12%) from domestic goods and services. Component two (unloading works) accounts for 71.8% of total base costs because of the substantial civil works associated with slope unloading and soil deposition. Soil excavation and transportation account for over 50% of total capital costs, for which conservative cost assumptions are used based on local market surveys.

Table 1: Economic Costs and Benefits of the Representative Subproject
($ million)

Year	Calendar Year	Economic Costs	Economic Benefits	Net Benefits
1	2022	(0.966)	0.250	(0.716)
2	2023	(1.284)	0.487	(0.797)
3	2024	(0.839)	0.587	(0.252)
4	2025	(0.032)	0.588	0.556)
5	2026	(0.032)	0.505	0.473
6	2027	(0.032)	0.434	0.403
7	2028	(0.032)	0.417	0.385
8	2029	(0.003)	0.322	0.319
9	2030	(0.003)	0.277	0.274
10	2031	(0.003)	0.238	0.236
11	2032	(0.003)	0.205	0.203
12	2033	(0.003)	0.177	0.175
13	2034	(0.003)	0.153	0.150
14	2035	(0.003)	0.132	0.129
15	2036	(0.003)	0.114	0.112
16	2037	(0.003)	0.099	0.096
17	2038	(0.003)	0.086	0.083
18	2039	(0.003)	0.075	0.072
19	2040	(0.003)	0.065	0.062
20	2041	(0.003)	0.057	0.054
Total		**(3.249)**	**5.268**	**2.018**

( ) = negative.
Source: Asian Development Bank.

D. Unquantified Subproject Benefits

9. The subproject provides several benefits that are difficult to quantify. These are excluded from economic analysis calculations. First, the key benefit of the subproject is avoided deaths of up to 190 people at direct risk, including 37 women and 114 children (footnote 16). In the event of a landslide, it is likely that many if not all people at risk will not have time to escape and would be buried. In the 2017 landslide in the village, 24 people were killed.[22] The without-subproject

[22] *Aljazeera.* 2017. Massive landslide kills 24 in Kyrgyzstan's Osh. 29 April. https://www.aljazeera.com/news/2017/04/29/massive-landslide-kills-24-in-kyrgystans-osh/.

scenario used in this analysis assumes an alternative scenario with no deaths; instead, it is presumed that 40% of people at risk will suffer serious injuries, 40% suffer minor injuries, and 20% escape unharmed. For this reason, the obtained EIRR is likely to be conservative in this category. In addition, the current landslide hazard has a deterrent effect on both private and municipal development projects.[23] Consequently, landslide risk reduction is likely to result in greater investor confidence, leading to higher rates of infrastructure investments and increased living standards in the village.

E. Quantified Subproject Benefits

10. Benefits quantified and included in the economic analysis calculations are those arising from (i) avoided destruction of about 39 ha of residential and agricultural land; (ii) avoided destruction of physical assets including buildings, roads, water and power infrastructure, household possessions, livestock, and productive trees; (iii) avoided nonasset losses from a landslide, including loss of income because of post-landslide economic inactivity, economic losses from injuries, and costs of subsequent resettlement of 38 households; (iv) avoided additional travel time and VOCs caused by diversion of the village road; (v) additional agricultural land created by deposition of unloaded soil on previously unproductive areas; and (vi) resale value of an EWS installed under the subproject after 6 years of service.

F. Estimated Economic Returns and Sensitivity Analysis

11. The base-case estimate of economic returns to the subproject investment is an EIRR of 13.17% and an economic net present value of $0.73 million at a discount rate of 6% (Table 2). Avoided nonasset losses account for 65% of net present value benefits, primarily stemming from the avoided cost of post-landslide resettlement.

Table 2: Base Case Analysis for the Representative Subproject

Item	Economic Cost ($ million)	EIRR (%)	ENPV[a] ($ million)
Subproject results	3.25	13.17	0.73

EIRR = economic internal rate of return, ENPV = economic net present value.
[a] At 6% discount rate.
Source: Asian Development Bank.

12. The subproject's economic returns are sensitive to its overall costs. Economic costs would have to rise by 26% (to $4.1 million) for the EIRR to fall below 6%. The subproject's economic viability is also sensitive to the estimated landslide return period (currently at 7.0 years, unviable at 13.8 years). The subproject also becomes economically unviable if the landslide vulnerability of zone H1 (currently 70%) is reduced to 29% or lower. This highlights the importance of accurate hazard assessments, which will be undetaken for all subprojects. Soil excavation costs (estimated at $1.18 per cubic meter [$m^3$]) would need to rise to $3.5/$m^3$ or higher for the subproject to become economically unviable. The cost of transporting excavated soil to disposal sites needs to rise from $3.7/$m^3$ to $6.0/$m^3$ for the subproject to become unviable, meaning that subproject viability is sensitive to prevailing fuel prices. The economic analysis has used conservative assumptions for

[23] The following activities and proposed investments were halted following the 2017 landslide: (i) the operation of a 250-person school; (ii) a proposed project to provide drinking water; (iii) proposed construction of a medical point, a kindergarten, additional roads, an irrigation network, and power lines; and (iv) house construction on 28 private plots, including eight plots where construction was completed and 12 plots with completed foundations. In another example, the nearest school to the subproject site is 5 kilometers away, resulting in long daily travel for local children (which is particularly hard in winter when the temperature can drop to -20^0 Celsius).

key costs and physical parameters, thereby limiting the risk that the project is unviable at implementation. Sensitivity analysis of the subproject is presented in Table 3.

Table 3: Sensitivity Analysis for the Representative Subproject

Item	Base Case	Change (%)	EIRR (%)	ENPV ($ million)	Switching Value (% change)
Project economic cost	$3.25 million	+20	7.25	0.16	25.6
Total project benefits	$5.27 million	(20)	6.11	0.01	(20.3)
Landslide return period	7 years	+5	7.36	0.19	97.6
Area of high vulnerability	70%	(20)	9.58	0.38	(58.6)
Effectiveness of mitigation	95%	(20)	8.45	0.24	(31.6)
Soil excavation cost	$1.18/m^3	+20	12.24	0.66	196.6
Soil transport cost	$3.70/m^3	+20	10.44	0.50	62.8
Avoided resettlement costs	$3.92 million	(20)	9.25	0.34	(37.2)

( ) = negative, EIRR = economic internal rate of return, ENPV = economic net present value, m^3 = cubic meter.
Source: Asian Development Bank.

V. ESTIMATED BENEFITS OF THE PROJECT

13. The total estimated benefits of engineering measures under output 1 are (i) avoiding deaths of around 2,550 people and (ii) preventing destruction of about $37.2 million of assets. This is based on applying the results of the Ayusai subproject analysis the 19 most densely populated of the 46 total long-listed landslide sites. For output 2, the estimated benefits of 20 on-site landslide monitoring and EWSs are (i) landslide risk reduction for an estimated 2,175 people and (ii) landslide risk reduction for $42.9 million worth of assets. Additional benefits will be provided nationally by the satellite-based monitoring and stakeholder capacity building.

VI. FINANCIAL SUSTAINABILITY OF THE PROJECT

14. Financial sustainability of the project depends on adequate funding and implementation of long-term O&M of all landslide mitigation measures and equipment installed in the project. These O&M costs are estimated at about Som20.65 million (around $0.25 million) per year (Table 4). The O&M costs would be borne by the MES under budget lines 453-01 (Implementation of priority preventative, restoring, and defense measures; construction and maintenance of engineering measures to protect villages), 452-01 (Monitoring and analysis of natural resources, man-made processes and phenomena; carrying out research work in certain hazardous areas) and 452-03 (Government investments in disaster risk reduction). These costs equate to 0.9% of the total MES budget for 2020 (Som2.19 billion) and 3.3% of relevant budget lines (Som632.2 million) and are thus deemed reasonable. Under normal circumstances, the government has the capacity to increase the MES budget by around 5% per year in real terms as per the long-run average GDP growth in the country. The GDP contracted 8.6% in 2020 because of the ongoing COVID-19 pandemic and the country has an external financing gap estimated at $500 million.[24] However, GDP growth is expected to rebound to 4% in 2021.[25]

[24] National Statistical Committee of the Kyrgyz Republic. *National Accounts: Gross Domestic Product* (accessed 4 March 2021) and ADB and United Nations Development Progamme. 2020. *COVID-19 in the Kyrgyz Republic: Socioeconomic and Vulnerability Impact Assessment and Policy Response.* Biskek

[25] ADB. 2020. Asian Development Outlook 2020 Update - Wellness in Worrying Times.

Table 4: Long-Term Annual Operation and Maintenance Costs of the Project
(Som)

Item	Output 1 Engineering Measures	Output 2 On-Site Monitoring	Output 2 InSAR System	Output 3 GIS Platform	Total
Annual cost	3,997,655	12,988,331	3,288,754	378,806	20,653,546
MES budget line	453-01	452-01		452-03	
Allocated MES budget (2020)	351,622,300	14,543,700		266,049,700	632,215,700
O&M as % of budget line	1.0	89.0	23.0	0.0	3.0
O&M as % of overall MES budget	0.2	0.6	0.1	0.0	0.9

GIS = geographical information system, InSAR = Interferometric Synthetic Aperture Radar, O&M = operation and maintenance.
Source: Ministry of Emergency Situations.

VII. FINANCIAL AND ECONOMIC RISKS AND MITIGATING MEASURES FOR THE PROJECT

15. The overall project is expected to economically viable given that (i) the Ayusai representative subproject is demonstrated to be viable and robust to alternative assumptions, (ii) subsequent subprojects are expected to have very similar mitigation measures and risk profiles, and (iii) further subprojects will be required to meet the EIRR threshold for eligibility. The key economic risk of the project is that landslide risks at subproject sites are overestimated and/or project costs are underestimated. To mitigate this risk, economic analysis of the representative subproject has used conservative assumptions, and risk assessment and surveys of each subsequent site will be conducted using best practices and advanced technologies. On-site monitoring will be installed at sites not deemed as at immediate risk, preventing unnecessary civil works. Economic analysis includes physical contingency. More accurate costs will be confirmed during detailed design as part of project implementation.

16. Sustainability of the project will depend on adequate financing and management of O&M because of limited scope for cost recovery. However, long-term O&M costs are expected to be modest with limited complexity because of the nature of planned works and equipment installation. Landslide soil overburden removal, reshaping, and drainage works are largely permanent and do not require significant maintenance. Long-term O&M costs have been estimated at about Som20.7 million (about $0.25 million) per year, around 3% of MES's current annual budget for disaster monitoring, prevention, and management. Project financial sustainability risk is *substantial* because of low O&M annual budget allocations, heavy dependency on central government support, and limited capacity to manage and plan O&M. To mitigate risks, the project will develop and update asset management and O&M plans for each site including budget and assignment of roles and responsibilities. ADB has secured government assurance that adequate finance and resources will be provided to implement these plans. Local communities will be engaged and trained in the planning, design, and capacity-building phases to support project effectiveness and long-term operation of the installed systems. MES staff will be trained in O&M and financial management of O&M to strengthen their internal asset management systems, records, and safeguards.