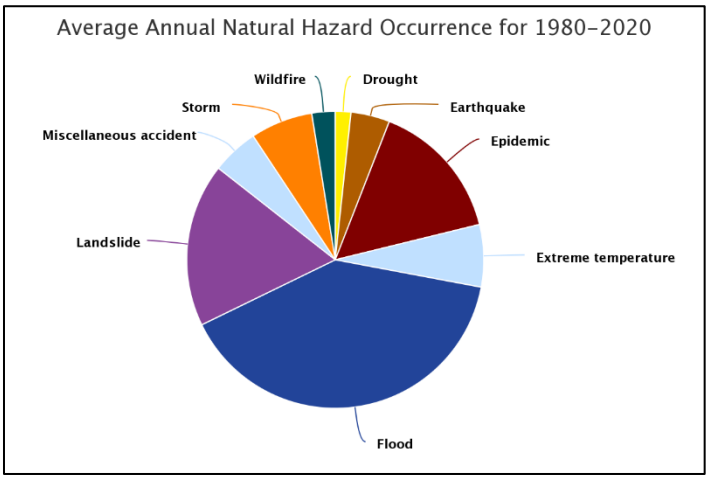
CLIMATE CHANGE TECHNICAL NOTE
NEPAL: PROVINCIAL AND LOCAL ROADS IMPROVEMENT PROGRAM - PHASE- 1 (P171836)

Climate Change Vulnerability Context



Nepal is amongst the most vulnerable countries to climate change in the world and remains at high risk due to the country's extreme hydro meteorological conditions, fragile geological conditions, topographical extremities ranging from mountains to hills and plains, climate-sensitive and subsistence livelihoods of its people, its low adaptive and coping capacity, and its economy dependency on climate-sensitive sectors[1]. With the gradual increase in temperature[2] and increases in the occurrence of erratic rainfall patterns, Nepal is facing challenges from both extreme and slow-onset climate-related hazards.

Nepal's diverse geo-climatic system, which combines heavy monsoons, steep terrain, and remoteness, renders the country vulnerable to natural hazards including earthquakes. In addition to natural factors, extremely low governance capacity at the local level, unplanned settlements and lack of resilient infrastructure, inadequate hydrometeorological networks, and limited resources for disaster preparedness and response mechanisms have sustained several shocks in the recent past (floods in 2017, COVID-19 pandemic in 2020) are key drivers of Nepal's climate vulnerability. According to the long-term Climate Risk Index[3], Nepal ranks 10th in the world as a country most affected by past climate hazards, recording nearly 200 significant events between 2000-2019. Approximately 80 percent of the country's population is at risk from natural and climate-induced hazards, including extreme heat stress, and flooding[4]. Additionally, with the gradual increase in temperature[5] and the occurrence of erratic rainfall patterns, Nepal is facing challenges from both extreme and slow-onset climate-related hazards. Mountains are warming faster than the plains[6] triggering the melting of ice and permafrost and increasing the risk of glacial lake outburst floods and landslides in the country.[7] Flood events and landslides are also triggered by extreme, torrential rainfall episodes in the foothills during the monsoon season (June-September) (relevant for all three provinces under Phase I).

The future climate in Nepal is expected to be warmer and sparsely wetter[8] which is predicted to affect people, economy, and the environment. Mean annual temperatures throughout Nepal are projected to

[1] Government of Nepal (2020). Second Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Nepal%20Second/Second%20Nationally%20Determined%20Contribution%20(NDC)%20-%202020.pdf
[2] https://gain.nd.edu/our-work/country-index/rankings/
[3] https://germanwatch.org/sites/default/files/Global%20Climate%20Risk%20Index%202021_1.pdf
[4] MoHA. (2018). Nepal Disaster Report 2017: The Road to Sendai. Kathmandu, GoN.
[5] https://gain.nd.edu/our-work/country-index/rankings/
[6] Annually mean maximum temperature has been increasing by 0.056°C. Observed Climate Trend Analysis in the Districts and Physiographic Zones of Nepal (1971-2014). Government of Nepal, MoPE, DoHM, June 2017
[7] https://climateknowledgeportal.worldbank.org/sites/default/files/2021-05/15720-WB_Nepal%20Country%20Profile-WEB.pdf
[8] Climate Change Scenarios for Nepal for National Adaptation Plan (NAP), Ministry of Forests and Environment, Kathmandu

increase between 0.5°C and 2.0°C by the 2030s under emission scenarios of shared socioeconomic pathways (SSPs) 4.5[9]. Rises in maximum and minimum temperatures are expected to be stronger than the rise in average temperature, likely amplifying the pressure on human health, livelihoods, and ecosystems. Though rainy days are expected to decrease in the future, intense precipitation events are likely to increase in frequency, and with increased extremely wet days and very wet days the probability of more water-related hazards in the future upsurge. It is projected that average annual precipitation is likely to increase by 2-6% between 2016-2045 and by 8-12% between 2036-2065 with more rainfall in the higher regions of Karnali and Sudurpaschim Provinces as compared to Province 1[10]. Projections shows the risk of flooding in the river basins of the non-Himalayan region due to 14 to 40 percent increase in the monsoonal precipitation by the 2030s. Furthermore, the return period of the floods is expected to fasten with a 1 in 100-year flow becoming a 1 in 50-year or 1 in 25-year event, increasing the population at high risk of extreme floods[11].

Impacts of Climate Change on the Transport Sector

Nepal's rural population is dependent on a relatively limited network of roads (63,500 km provincial and local roads network[12]) for goods, trade, and basic access to health, education, and job opportunities. According to the New Rural Access Index, 47 percent of the rural population is estimated to be living beyond 2 km of the nearest road in good condition[13]. This is because only about one-fourth (1/4th) of these roads provide all-weather connectivity; less than 30 percent of these roads are either black-top or gravel roads, and the remaining is earthen roads.

Transport infrastructures including roads and bridges are already affected by changing climate such as temperature variations (heat waves, droughts, snow, etc.); higher rainfall causing severe flash- and seasonal floods; earthquakes; and landslides, mudflow, debris flow, and rock-falls, impeding access to jobs and critical services. Moreover, recurring disruption caused by climate-induced hazards in transport flows and services have been worsening development challenges that converge to an increased cost of trading, lack of access to basic services, limiting mobility, and compromising key economic sectors that exacerbate the vulnerability of low-income residents, women, children, and people with disabilities.

Damaged road infrastructure has a significant impact on the country's economic growth, leading to disruption of access and supply chains for agriculture and manufacturing. Disaster-related closures and damage to roads lead to reduced access to jobs, health care, education, and employment; decreased profitability of businesses – particularly, micro, small, and medium businesses are at risk as they have low financial coping capacity and knowhow of climate and disaster risk. The direct cost of climate to the transport sector is estimated at US$25-50 million over the next 10 years and the indirect impacts would add 50-75 percent to these costs[14]. Currently, the government spends approximately US$8 million annually to repair the damage caused by climatic disruption on the strategic road network only[15]. Thus, it is not unusual for repairs to be delayed significantly or not to take place at all for provincial and rural roads. For example, the flooding of the Koshi River in 2008 caused a major obstruction to the East-West

[9] https://climateknowledgeportal.worldbank.org/country/nepal/climate-data-projections
[10] Climate Change Scenarios for Nepal for National Adaptation Plan (NAP), Ministry of Forests and Environment, Kathmandu
[11] Climate Risk Country Profile: Nepal (2021)
[12] Nepal- Country, Climate and Development Report, World Bank, September 2022; https://openknowledge.worldbank.org/bitstream/handle/10986/38012/FullReport.pdf?sequence=11
[13] New Rural Access Index: Main Determinants and Correlation to Poverty, WB Policy Research Working Paper 7876, 2015; https://openknowledge.worldbank.org/handle/10986/25676
[14] Nepal Country Climate and Development Report 2022
[15] Based on Department of Roads data and The Nepal Infrastructure Sector Assessment, by World Bank, 2019.

Highway, which took one year to be restored, severely affecting trade along this corridor. Similarly, the newly built Jabdighat Bridge over the Babai River which collapsed in 2017 due to floods, severely disrupting access in the Bardiya District, has not been repaired since[16].

Further, the impact of climate change is expected to be profound across roads and transport sectors in the future as they are susceptible to floods, landslides, flash floods, debris flow, and sedimentation in the rivers. Given the context of increasing extreme weather and climatic events, the roads and bridges need to be built with appropriate climate-resilient designs incorporating nature-based solutions given the projected intensity and frequency of floods and other hazards.

Contributions to the Country's Climate Objectives

The Project is 100% aligned with the World Bank Group's Climate Change Action Plan 2021–2025[17], while supporting the country's priority development objectives and GRID agenda. Forging a shared understanding of integrated climate and development priorities as part of Nepal's GRID pathway, PLRIP as a program adapts a life-cycle approach of integrating both mitigation and resilience measures starting from planning, engineering designs, business processes, construction, asset management, institutional structures, and associated capacity building. Furthermore, the project is aligned with the Nepal Country Climate and Development Report's key recommendations on pursuing Green, Resilient, and Inclusive Development through strengthening low-carbon resilient connectivity. The Project is in full compliance with the country's 15th Periodic Plan[18], its 2nd Nationally Determined Contribution to UNFCCC[19], National Climate Change Policy, 2019 (NCCP)[20], and the provisions included in the country's National Adaptation Plan (NAP)[21], and Nepal 2019-23 Country Partnership Framework's (CPF's); Focus Area 3 (Inclusion and Resilience) by strengthening climate-resilient and low carbon solutions to the transport sector that prevent and reduce climate risks during planning, construction, operation and maintenance of the Project.

Statement of the Project's Intent to Enhance Climate Resilience and Reduce GHG Emissions

The Project activities are defined and prioritized with the core objective of enhancing resilience of the communities towards identified climate and disaster-related vulnerabilities risks and sustainability challenges by providing all-weather and resilience road and bridge access to services, markets and providing relief during natural calamities. Therefore, maximizing the investment by financing strategies, measures, and activities to increase its climate resilience is of paramount importance. Considering the high climate change vulnerability and risks in the country, and recent severe climate-related disruptions/damages in the transport infrastructures, this project has been carefully designed to fully support climate and disaster-resilient provincial and local road networks (PLRN) that serve as the backbone for connectivity and socio-economic growth.

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[16] Nepal- Country, Climate and Development Report, World Bank, September 2022.

[17] World Bank Group. 2021. World Bank Group Climate Change Action Plan 2021–2025: Supporting Green, Resilient, and Inclusive Development. World Bank, Washington, DC. © World Bank. URL: https://openknowledge.worldbank.org/handle/10986/35799 License: CC BY 3.0 IGO

[18] Strategic Pillar 2: Investment Promotion clearly outlines "Promotion of Green Infrastructure Policy" as an action under the strategy "Policy Advocacy for Improvement of Investment Policies and Systems". This Project directly addressed related KPIs "Study the best practices related to green and climate-resilient infrastructure" and "workshops/meetings organized on green and climate-resilient".

[19] Government of Nepal (2020). Second Nationally Determine Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Nepal%20Second/Second%20Nationally%20Determined%20Contribution%20(NDC)%20-%202020.pdf

[20] Government on Nepal (2019). National Climate Change Policy, 2076. URL: https://mofe.gov.np/downloadfile/climatechange_policy_english_1580984322.pdf

[21] Government of Nepal (2021). National Adaptation Plan. URL: https://www.mofe.gov.np/uploads/documents/nap-book-finalpdf-1278-504-1700479041.pdf

Intent to enhance Climate Resilience

Component 1 & 2: The component 1 and 2 focus on improving efficiency of the service delivery of the existing network, enhancing climate resilience of the provincial and local roads and bridges, and strengthening the community resilience through all-weather road access to services and markets. This will be undertaken through integrating climate and disaster risk information and mainstreaming suitable measures into project life cycle i.e., planning, designing, construction, maintenance as well as asset management along with enhancing institutional capacity for the same. Climate-resilient engineering measures against flooding, landslide, and temperature risks are incorporated in the design and construction of all road and bridge infrastructure supported in the right of way under this project (sub-components 1.1, 1.2, 1.3, and 2.1. These include but are not limited to:

- **Planning:** selection/prioritization of roads from the long list of roads based on accessibility and the climate risk; specifically at the planning stage, the project would undertake vulnerability assessment of provincial and local roads and bridges specifically at flood and landslide affected areas and help prepare suitable area-specific adaptation measures applying where possible nature-based solutions.

- **Designing & Construction**: The designs of all civil works, including for maintenance activities, will be prepared to climate resilient standards to enhance the resilience of rural communities and reduce their vulnerability to climate events. Further, designs will be prepared based on detailed surveys and investigations through a combination of historical data as well as projected climate change scenarios, and climate change vulnerability and risk profiles. The construction will include: (i) upgradation of existing earthen and gravel roads to paved surfacing (asphalt, concrete or blocks) with adequate culvert/ cross-drainage structures, shoulders and bridge structures (planned for 100 years return period); (ii) slope stabilization measures including bio-engineering to prevent slope failure, landslides and debris flow, (iv) raising the road embankment in specific situations; (v) submersible road structures in areas prone to flooding such as hard concrete causeways and vented fords for stream crossings; (vi) providing additional length of both lined and natural side drains, increasing the capacity and spacing of cross drains and culverts to respond to the increase in storm intensity; frequency and reduce water logging by considering higher return period; designing causeways for streams; (vii) use as wildlife crossings; and (viii) high category of asphalt binder standard such as VG-30 or higher, to withstands rising temperatures and improve surface life of pavement and prevent premature deterioration/ failure; (ix) sealing of sections experiencing higher volume traffic to avoid further deterioration due to intense rainfall; (x) geometric improvement of roads to enhance road safety and improve gradient; and (xi) pedestrian and non-motorized transport infrastructure. Accordingly, all roads (under component 1.1 and 2.1) will be covered by the mandatory provision of five-years of maintenance in the construction contracts in addition to the defect liability period, as per the Model Bid Document

- **Maintenance**: In addition, to reduce vulnerability and mitigate risk, improve service life and quality of the existing network, periodic and routine will be undertaken as part of component 1.2 and 1.3 through performance and output-based maintenance contracts and community-based routine maintenance groups to be mobilized with preference to fifty or more participation of women respectively. In addition to regular activities, the project will specifically include (i) periodic maintenance – providing adequate size/capacity and balancing of culverts, crack sealing, surface treatment, patching, adequate camber, erosion control, vegetation & debris clearing and slope stabilization measures, including bio-engineering, low-cost surface sealings, grass seedling, safety features (markings, signage, etc.) and; (ii) routine maintenance – revised maintenance schedules

with increased frequency of cleaning and maintenance of drainage systems, patching potholes, removing of storm damage, cleaning of roads, pruning of brushes and snow and ice removal, debris removal, safety features, repairing guardrails etc. Additional adaption measures will be undertaken such as early warning systems, incident deduction and handling systems/ protocols, weather stations, road load censors and other location-specific measures as necessary.

- **Complimentary Infrastructure**: The Sub-component 1.4 will also support in building community resilience through the construction of cold storage and warehouses and help enhance the supply-chain efficiency for agriculture produce, Medium, Small and Micro-Enterprise (MSMES) and industries. This will help in storage of agriculture produce in case of the disruption of the roads due to extreme events by constructing climate-smart complementary/ associated infrastructure through community-led initiatives. This will include market sheds, market centres, public-toilets, bus-station, bus-bys, non-motorized transport access infrastructure to health centres, schools, community buildings and markets, cold storage and warehouses, collection/processing/ packaging centre by using energy and resource-efficient techniques and materials such solar lightening, waste construction, debris or hill-cutting material etc.

Component 3: This will support laying a strong sector foundation for provincial and local roads by improving the governance systems and strengthening the capacity of the participating governments thus assisting in developing the adaptation and the mitigation potential. This includes support for enhancing the capacity of staff/officials of the PLGs through specialized training courses on climate-resilient road infrastructure design and development. Furthermore, under this component will undertake: (i) a vulnerability and risk assessment of the existing 500 km road and bridge infrastructure in the three participating provinces that will also identify the potential adaptation & mitigation measures that will be incorporated into the road construction design and maintenance. The availability of the current and future climate risk could lead to reduced anticipated impacts of climate change; (ii) preparation and adoption of a climate resilient and green growth strategy to ensure mainstreaming and institutionalization of resilient and low-carbon development of provincial and local roads infrastructure; (iii) capacity building of the road agency staff at all three tiers of the government which will foster the harmonization of the road and bridge standards, specifications, norms, and provincial and municipal transport master plan for a green and resilient transport sector development; (iv) building a centre of excellence for building climate resilient and disaster risk management of provincial and local road network infrastructure and maintenance; and (v) developing road asset management system with risk and hazard database to undertake risk predictive investments prioritization and maintenance.

Similarly, **Component 4** supports climate adaptation as it includes an assessment of existing road safety measures and management capacity, including engineering, enforcement, education/awareness, and emergency response on provincial and local roads, and implementation of road safety measures based on the findings of such assessment.

Component 5, with contingent emergency response to the climatic or non-climatic crisis, will help in reducing the severity of the possible impact and in one- or another support adaptation.

Overall, five components of this operation focus on the upgradation, rehabilitation, construction and improvement of provincial & local roads and maintenance of existing roads and bridges infrastructure to ensure that the mobility infrastructure can withstand and are well functioning during time of climatic or geophysical hazards, crisis, or emergency conditions. These components will increase all-weather and resilient access by enhancing the standard of the roads and hence the adaptive capacity of the people, livelihood, or sector. Project components support the adaptation goal by developing an inclusive approach

for developing climate-resilient infrastructure, strengthening the capacity of the government, and carrying out hazard risk assessment to design all-weather roads and bridges and mainstreaming suitable measures in the construction/ upgradation/ rehabilitation and maintenance of road and bridge infrastructure in Nepal.

Intent to reduce GHG Emissions

Furthermore, the project will employ a resource efficient approach to enhance Greenhouse Gas (GHG) mitigation from road construction/ upgradation and maintenance.

Component 1 and 2.1: To reduce GHG emissions and promote resource/energy-efficient construction, site-specific measures as applicable, will be undertaken, including, but not limited to: (i) reduction in aggregate and asphalt quantities by maximizing the use of local/ alternative construction material/ technology, and stabilization (cement, lime); (ii) adopting design standards for pavements that enhance pavement life and requires less maintenance work and use of nature-based solutions including use of hill cut material for embankment filling and pavement layers, use of waste products, recycling (asphalt and granular pavement), mass balancing, bio-engineering, dumping and quarry sites' reinstatement and protection works), where possible avoiding tree felling and adopting alternative alignment; (iii) water conservation (redevelopment/enhancement of ponds, water harvesting structures, water channelization structures to protect stream beds and store storm runoff water); (iv) borrow area development and re-use of extraction sites; (v) dust and noise control; (vi) carbon sink in public areas; and (vii) landscape management and biodiversity.

Component 2.2: This will support undertaking pilot to improve non-motorized modes of transport infrastructure including pedestrian infrastructure and alternative means of access through community timber bridges for providing access to very remote non-accessible locations in the mountainous regions. These will collectively lead to a reduced carbon footprint across the project's operational life.

Component 3: on the other hand, focuses on the institutional strengthening and the capacity development of the relevant government entity. This will foster an understanding of energy efficiency improvement or low carbon-intensive transportation, in the long run assisting the mitigation targets. The sub-component 3.6 will also support in developing program for cost-effective and resilient low-carbon/ low-emission including electric vehicles rural passenger and freight transportation services investment in the country.

Component 4: 'road safety management' by undertaking safety audits and preparing and adopting province-level road safety action plans including adopting measures that address safety risks due to climate-related hazards and road vehicle accidents. The assessment from Sub-component 4.3 emphasizes updating road design standards/ manual for integrating road safety engineering measures while 4.5 highlights training the trainers and the safety auditors.

Based on the current and future traffic forecasts, emission reductions due to the project implementation are estimated using HDM-4 modeling as follows:

Emissions during the economic lifetime (CO_2 in ton) (2024-4343)				
	Annual Vehicle km Million	**Without project**	**With project**	**Savings**
73,354Tonnes	8.50	73,354	57,972	15,383

Tonnes/Million Vehicle Km	8.50	8,628.36	6,818.96	1809.40

Thus, the above-mentioned program measures will result in the development of climate-resilient, low-carbon provincial and local road networks as well as: (i) significant extension of road service life due to enhanced resilience and material mix; (ii) reducing energy intensity and therefore carbon-footprint of road construction and promoting sustainable growth of infrastructure; (iii) optimized life cycle costs and minimizing losses in asset value from premature failure during extreme events; and (iv) reduction in unit cost of construction due to the optimization of pavement layers and materials. In all, as can be seen from the above, the program is aligned with Nepal's Kathmandu Declaration on Green, Resilient, and Inclusive Development.

Table 1 – Project Financing Breakdown

Component No.	Total IDA Financing (US$ million)	Further Cost Break-up (US $ million)		Activity	Mitigation	Adaptation
Component1: Enhancing efficiency and resilience of Provincial Roads	65.09	56.22	1.1	Preparation, upgradation, rehabilitation, improvement, supervision, and quality assurance of 200 km of selected Provincial Roads and Bridges to ensure that they are all-weather, climate-resilient, resource-efficient and meet required safety standards, and include carriageway matching traffic needs along with approach roads and five-years post-construction maintenance	**YES (cf. above) Please see the detailed reduction in the GHG emissions analysis provided above**	**YES (More Adaptation Co-benefit (cf. above)**
		7.31	1.2	Periodic maintenance of 300 km of existing Provincial Roads and Bridges for the preservation of existing infrastructure and retrofitting these infrastructures to make them climate resilient.	**Partially (cf. above)**	**YES (More Adaptation Co-benefit (cf. above)**
		0.56	1.3	Routine and recurrent rehabilitation of 2500 km of existing Provincial Roads and Bridges to enhance their durability and resilience to climate and geophysical disasters through community-led road maintenance groups which include the participation of women.	**Partially (cf. above)**	**YES (More Adaptation Co-benefit (cf. above)**
		1.00	1.4	Development of community-led complementary/associated climate-smart infrastructure facilities along the roadside.		**YES (More Adaptation Co-benefit (cf. above)**
Component 2: Enhancing all-weather connectivity and access to Municipalities	26.26	25.26	2.1	Preparation, construction, upgradation, supervision, and quality assurance of 100 km all-weather Local Roads and Bridges to ensure they are all-weather, climate and disaster resilient, resource-efficient and meet required safety standards, and include carriageway matching traffic needs along with approach roads and five-years post-construction maintenance, in order to provide connectivity to prioritized unconnected very remote/ remote Local Level centers and villages.	**YES (cf. above) Please see the detailed reduction in the GHG emissions analysis provided above**	**YES (More Adaptation Co-benefit (cf. above)**
		1.00	2.2	Undertaking of pilots to improve access in very remote/remote locations through non-motorized transport and alternative means of access, thereby mitigating greenhouse gas emissions in the rural transport sector.	**YES (cf. above)**	**YES (cf. above)**

Component 3: Institutional Strengthening and Capacity Development	5.25	0.50	3.1	Business Systems and Processes: Development and implementation of institutional strengthening and modernization plan.	**Partially (cf. above)**	**YES (cf. above)**
		0.80	3.2	Program Management: Development and implementation of a Program monitoring and management system and a road asset management system, including an accident reporting module and a risk and hazard database to undertake predictive prioritization and investments.	**Partially (cf. above)**	**YES (cf. above)**
		1.90	3.3	Implementation Support: Project implementation support to DoLI, Provincial and local Governments, and Local Levels including hands-on implementation support for the environment and social risk management, for harmonization of climate-resilient road and bridge standards, specifications, and norms; development of provincial and local transport masterplans; gender disaggregated road-user satisfaction surveys; an outcome monitoring study to measure the results of resiliency; and Project supervision, quality assurance, technical audit, monitoring and evaluation.	**Partially (cf. above)**	**YES (cf. above)**
		1.05	3.4	Capacity Building: Training and capacity building of DoLI, Provincial, and local Governments, through the development and implementation of a capacity-building strategy and an implementation plan, including the establishment of technical centers of excellence for building a climate and disaster-resilient provincial and local road and bridge network.	**Partially (cf. above)**	**YES (cf. above)**
		0.30	3.5	Climate Resilience: Carrying out hazard risk assessments on 500 km of existing all-weather roads and bridges in the Participating Provinces; and the adoption and implementation of a climate resilience and green growth strategy.	**Partially (cf. above)**	**YES (cf. above)**
		0.70	3.6	Rural Transportation Services: assessment of gaps for strengthening low-emission rural passenger and freight transportation services, including electric vehicles.	**Partially (cf. above)**	**YES (cf. above)**
Component 4: Road Safety management	3.40		4.1	Undertaking a safety audit of 100 km of the provincial and local road network and implementing the audit findings on prioritized 30 km in the participating provinces.		**YES (cf. above)**
			4.2	Preparing and adopting province-level road safety action plans including adopting measures that address safety risk due to climate-related hazards.	**Partially (cf. above)**	**YES (cf. above)**
			4.3	Updating road design standards/ manual for integrating road safety engineering measures driven by a predictive approach to climate and disaster resilience for low-volume roads.	**Partially (cf. above)**	**YES (cf. above)**
			4.4	Adopting community and work zone safety guidelines.	**Partially (cf. above)**	**YES (cf. above)**
			4.5	Training trainers and road safety auditors.	**Partially (cf. above)**	**YES (cf. above)**
			4.6	Strengthening road safety enforcement capacity and post-crash care through equipment and training support.	**Partially (cf. above)**	**YES (cf. above)**
CERC	0			Contingent Emergency Response Component	**Partially (cf. above)**	**YES (cf. above)**

Total	100					