PROJECT CLIMATE RISK ASSESSMENT AND MANAGEMENT

I. Basic Project Information

Project Title: CAREC Corridors 1 and 3 Connector Road
Project Budget: $114.35 million (2016 ADB-financed section only - Epkin–Bashkugandy)
Location: Kyrgyz Republic
Sector: Transport
Theme: Inclusive economic growth, environmentally sustainable growth, and regional integration
Brief Description: The proposed Central Asia Regional Economic Cooperation (CAREC) Corridors 1 and 3 Connector Road (the project) will improve national and regional connectivity by rehabilitating of road sections connecting the CAREC Corridors 1 and 3 in the center of the Kyrgyz Republic. The project will: (i) reduce the cost of transporting passengers and cargo between the southern and northern regions by providing safer and faster access; (ii) provide a more direct transit route between Kazakhstan, Tajikistan, and beyond; (iii) stimulate trade; and (iv) improve road maintenance practices in the country: (i) Balykchi to kilometer-post 43 (Km 0 to Km 43), approximately 43 km; (ii) Kochkor to Bashkugandy (Km 64 to Km 159), approximately 93 km; and (iii) Aral to CAREC Corridor 3 via the Suusamyr valley (Km 195 to Km 286), approximately 91 km. The Climate Change Assessment covers climate risks for the project, estimation of greenhouse gas levels with and without the project, and recommendations for project design.

II. Summary of Climate Risk Screening and Assessment

A. Sensitivity of project component(s) to climate/weather conditions and sea level	
Project component 1. Construction of the Road base on section 3. 2. Construction of a road pavement on section 3. 3. Pavement widening on section 3. 4. Reconstruction of river-crossing bridges. 5. Pavement Rehabilitation on the entire study road. 6. Road side drainage improvement/ construction. 7. River bank stabilization works on section 3. 8. Slope stabilization works. 9. There is an avalanche hazard at the Suusamyr valley close to the project section 3. The section 3 does not, however, cross the highest mountains most at risk of avalanches. Rising winter temperatures can in the future increase the risk of unpredictable avalanches, as temperature changes can be more sudden.	Sensitivity to climate/weather conditions and sea level 1. Winter and summer temperature contrast, annual mean temperature 2. Flooding 3. Precipitation-induced landslides, avalanches 4. Freeze-thaw cycles 5. Ice phenomena such as sludge ice, shore ice, and floating shapes on the waterways
B. Climate Risk Screening	
Risk topic 1. Temperature increase 2. Flood increase 3. Increase in number of freeze-thaw cycles 4. Increase in frequency of landslides and rock slides	Description of the risk 1. Increase of mean and extreme temperature may lead to faster pavement rutting due to increase of plasticity of bitumen in the wearing course; 2. Landslides, avalanches, and flood events may affect bridge/road access, performance, and longevity; 3. Increase in freeze-thaw cycles may leads to premature pavement degradation 4. The estimated increase in extreme temperatures and drought impact

most drastically the environment and livelihoods, but especially the rise in temperatures contributes also to the road condition and lifecycle. Possible surface damage that can occur on pavements includes rutting, cracking, potholes, and fretting. One of the factors contributing to surface damage is high road surface temperatures. The low albedo of road surfacing means that it is an efficient absorber of sun radiation, and the increasing frequency of extreme temperatures entails more prevalent damage.

5. On the mountainous part of the road section 3, there is a medium risk for landslides, as well as rockslides. As precipitation is not expected to increase in the area, the risk is not likely to increase significantly, but should, however, be taken into account in the road planning. On the section 3, there is also a risk of flooding, as the road is located very close to the Kokomerin River.
6. Potential landslide risk areas along the road are: Km 10–Km 12, Km 90–Km 120, Km 130–Km 135, and Km 215–Km 225.
7. Avalanche prone areas are at the Kiz Art Pass from Km 200 to Km 240 (Section 3).

Climate Risk Classification **Medium**

Climate Risk Assessment

A climate risk and vulnerability assessment (CRVA) was undertaken during project preparation. The draft final CRVA report is attached.

The main hazards identified include:

(i) River floods and water logging in spring, due to more intense rainfall. This will mainly affect lower altitudes and areas susceptible to flooding;
(ii) Heat stress in the summer, especially at lower altitudes;
(iii) Mudslides related to more intense rainfall in the spring at medium altitudes (and in a lesser degree also high altitudes); and
(iv) Flash floods in the summer especially at higher altitudes, related to higher temperatures together with the increase in winter, spring and autumn rainfall (snow at higher altitudes).

Analysis of climate simulations by IFAD[1] indicates that the CAREC Corridors 1 and 3 Connector Road is located at an area with low vulnerability risk as compared with the north of Chuy Oblast and other high altitude areas. Vulnerabilities identified for the project are mainly related to increased heat stress at the project areas with low altitudes and mudslides at medium altitudes.

Hazards	***Road Section 1***	***Road Section 2***	***Road Section 3***
Landslides, precipitation	*Low risk*	*Low risk*	*Medium risk*
Landslides, earthquakes	*Low risk*	*Low risk*	*Medium risk*
Avalanches	*Very low risk*	*Very low risk*	*Medium risk*
Floods	*Low risk*	*Low risk*	*Medium risk*
Strong winds	*Very low risk*	*Very low risk*	*Very low risk*
Extreme temperature	*Medium risk*	*Medium risk*	*Low risk*
Drought	*Medium risk*	*Medium risk*	*Low risk*

[1] IFAD. Climate Change Impact on Pastures and Livestock Systems in Kyrgyzstan. Summary Report, 2013.

III. Climate Risk Management Response within the Project

The CRVA has identified and recommended the following climate change adaptation measures, which have been incorporated into the feasibility-level design.

The estimated costs for improved asphalt layers based on the estimated quantity of polymer modified bitumen and has been calculated as follows:

Road Section	Unit	Estimated Quantity	Unit Rate (USD)	Amount (USD)
Km 0–Km 43 (Balykchi–Km-post 43)	Ton	475	2,100	997,500
Km 62–Km 89 (Kochkor–Epkin)	Ton	310	2,100	651,000
Km 89–Km 159 (Epkin–Bashkugandy)	Ton	987	2,100	2,072,700
Km 195–Km 274 (Aral–Too-Ashuu)	Ton	801	2,100	1,682,100
Total				**5,403,300**

The adaptation cost estimate for extended drainage system based on the civil works cost estimate for drainage works.

Road Section	Total Drainage Costs (USD)	Assumed 20% Adaptation Costs (USD)
Km 0–Km 43 (Balykchi–Km-post 43)	3,872,050	774,410
Km 62–Km 89 (Kochkor–Epkin)	1,638,121	327,624
Km 89–Km 159 (Epkin–Bashkugandy)	3,433,442	686,688
Km 195–Km 274 (Aral–Too-Ashuu)	6,056,755	1,211,351
Total		**3,000,074**

Risk	Adaption responses in design
Flooding	• Increasing size and number of drainage structures • Raising embankment height to avoid over-flooding • Realigning natural water courses • Update design for drainage systems • Slope stability studies in an attempt to minimise landslides and mudflows as a result of increased precipitation • Measures to enhance slope stability and prevent landslides and rock fall
Increased temperatures and head waves will result in pavement deformation and deterioration	• Improved pavement material specifications • Consideration of polymer-modified bitumen • Advanced construction technologies
Temperature increase will result in increasing number of frost-thaw cycles and increase the risk for avalanches	• Implementation of snow fences, preferable living snow fences • Artificial anti-avalanche structures, like galleries

It is estimated that incorporating the recommended climate change adaption measures increased the civil works cost above the no-climate baseline design by approximately $8.4 million of the total civil works cost. The Government has agreed to take account of these recommendations in the detailed design.

Climate Change Impact Assessment

TA 8887-KGZ
June 2016

KGZ: CAREC Corridors 1 and 3 Connector Road

Prepared by Kocks Consult GmbH in joint venture with Central Asian Consulting Center and Finnish Overseas Consultants Ltd for the Asian Development Bank.

Climate Change Assessment: CAREC Corridors 1 and 3 Connector Road Project, TA-8887 KGZ

Contents

I. Introduction and Background

1. The proposed Central Asia Regional Economic Cooperation (CAREC) Corridors 1 and 3 Connector Road (the project) will improve regional and national connectivity by rehabilitating of road sections connecting the CAREC Corridors 1 and 3 in the center of the Kyrgyz Republic. The project will: (i) reduce the cost of passenger and cargo transportation between southern and northern regions by providing direct access, (ii) provide a more direct transit route between Kazakhstan and Tajikistan, and (iii) help stimulate trade. The project will cover three sections:

(i) Balykchi to Kilometer-post 43 (Km 0 to Km 43), approximately 43 km;
(ii) Kochkor to Bashkugandy (Km 64 to Km 159), approximately 93 km; and
(iii) Aral to CAREC Corridor 3 via the Suusamyr valley (Km 195 to Km 286), approximately 91 km.

2. The Climate Change Assessment covers climate risks for the project, estimation of GHG levels with and without the project, and recommendations for project design.

3. According to both national and international estimates, [1] the Kyrgyz Republic will face considerable environmental degradation, humanitarian stress and economic loss due to current climate variability and future climate change impacts. The impacts include an increase in mean annual air temperature of 4.6°C by 2100; an increase in the variability of rainfall patterns, with average seasonal rainfall likely to increase during winter and decrease during summer; and an increase in extreme weather events as well as intensity and frequency of climate-related disasters, including floods, mudflows, droughts and landslides.

4. In climatic terms, the Kyrgyz Republic is characterized by wide variety. The significant complexity of the terrain—deep roughness, various expositions of mountain slopes for sun and airflows cause a wide variety of climate characteristics. There are four notably different climatic zones:[2]

(i) Valley-piedmont zone/belt (from 500–600 up to 900–1,200 m) characterized by hot summer (up to 28°C), moderate cool and snowless winter with high precipitation deficit;
(ii) Mid-mountain zone/belt (from 900–1,200 up to 2,000–2,200 m) has typical moderate climate with warm summer and moderate - cool snowy winter;
(iii) High-mountain zone/belt (from 2,000–2,200 up to 3,000–3,500 m) is characterized by cool summer and cold, sometimes heavy snowy winter;
(iv) Nival zone/belt (from 3500 m and more) is characterized by sever, very cold climate.

5. The project sections 1 and 2 are located in the mid-mountain zone, while the elevation rises at section 3 going to Suusamyr with elevation of 2000–2600 m and surrounding peaks of up to 4,500 m.

[1] Second National Communication to the UN Framework Convention on Climate Change, Republic of Kyrgyzstan, 2009. And Hijioka, Y., E. Lin, J.J. Pereira, R.T. Corlett, X. Cui, G.E. Insarov, R.D. Lasco, E. Lindgren, and A. Surjan, 2014: Asia. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1327–1370.

[2] Ministry of Emergency Situations of the Kyrgyz Republic. Newsletter: Current climate status and change in the Kyrgyz Republic. 2015.

6. The GHG emissions contribution of Kyrgyz Republic to the total global GHG emissions from fossil fuel combustion was 0.023% in 2010, while the population was 0.079% of the world's total population. This means that per capita GHG emission in the Kyrgyz Republic is less than one-third of the world average.3 The total GHG emissions were 12,017.1 Gg CO_2 equivalent in 2005.4 However, the planned economic development is expected to lead to sharp increase in emissions. Accordingly, the Kyrgyz Republic has set emission reduction targets limiting the per capita GHG emissions to maximum of 1.23 t/ CO_2 , or 1.58 t/ CO_2 in 2050 to achieve the below 2°C objective, with a probability of 66% and 50%, respectively.5

7. The timeframe for emission reduction targets is 2020-2030 and 2050. The scope of reductions is energy; industrial processes; solvents and other product use; agriculture, land use, land use change and forestry; and waste. Climate change mitigation efforts are ambitious for the Kyrgyz Republic, since the low emission level is largely due to 90% of the total electricity being supplied by hydroelectric power plants. However, the expected climate change impacts will decrease the water flow, reduce the hydropower resources potential, and require new energy solutions. As a lower middle income country, the Kyrgyz Republic will need international funding to achieve the climate mitigation targets.[6]

8. Although the national emissions are small, the Kyrgyz Republic is highly vulnerable to climate change due to its geography and topography. Adaptation needs to be done in three different categories: structural / physical, social and institutional. Structural options include solutions for engineered and built environment, such as transport and infrastructure adaptation; technological options like hazard mapping and monitoring technology; ecosystem based options like adaptive land use management; and services, for example, enhanced emergency medical services. Social adaptation category includes education options, like awareness raising and integrating into education gender equity in education; informational solutions, for example, hazard and vulnerability mapping, and systematic monitoring and remote sensing; behavioral options, like soil and water conservation. Finally, institutional category includes economic options like financial incentives; laws and regulations; and government policies and programs, like national, regional and sectoral adaptation plans.[7]

9. Road design, construction, and maintenance in Kyrgyz Republic are governed by guidelines that do not explicitly account for changes in future temperature and precipitation. This could jeopardize the expected benefits from road transport investments. Therefore, climate change assessment was undertaken to identify key climate risks and adaption needs for the project road sections.

II. Vulnerability of the Project to Climate Change

[3] The Kyrgyz Republic. Intended Nationally Determined Contribution, the UN Framework Convention on Climate Change, 2015.

[4] Emissions Summary for Kyrgyzstan. United Nations Climate Secretariat, no date. Emissions without Land Use Change and Forestry (LUCF).

[5] The Kyrgyz Republic. Intended Nationally Determined Contribution, the UN Framework Convention on Climate Change, 2015.

[6] Ibid.

[7] Noble, I.R., S. Huq, Y.A. Anokhin, J. Carmin, D. Goudou, F.P. Lansigan, B. Osman-Elasha, and A. Villamizar, 2014. Adaptation needs and options. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 833-868.

10. Road infrastructure is the backbone of the society. Citizens, companies and governments rely on uninterrupted availability of transport. It is generally understood that the climate is changing and that this will have significant effects on the road infrastructure. Since road infrastructure is vital to society, climate change calls for timely adaptation.

11. For the project road impacts are anticipated due to expected changes in the frequency and intensity of extreme weather events, increased precipitation and temperature changes. Greater rainfall intensity will affect the capacity of drainage and overflow systems to deal with stronger or faster velocity of water flows. The increase in intense precipitation events increase the potential of road damages due to landslides and mudflows. Higher peak temperatures require asphalt better to withstand softening. Softening of asphalt could cause rutting and deterioration of the pavement integrity. Later onset of seasonal freeze and earlier onset of seasonal thaw results in pavement deterioration due to increased freeze-thaw conditions.

III. CAREC Corridors 1 and 3 Connector Road Project Description

12. The Connector Road Project consists of three segments:

(i) Balykchi to Kilometer-post 43 (Km 0 to Km 43), approximately 43 km;
(ii) Kochkor to Bashkugandy, (Km 64 to Km 159), approximately 93 km; and
(iii) Aral to CAREC Corridor 3 via the Suusamyr valley (Km 195 to Km 286), approximately 91 km.

13. In late 2015, it was emphasized that another section was to be included in the study, particularly for the safeguards component, which is the:

(iv) Bashkugandy to Kyzyl-Zhyldyz (Km 159 to Km 183), approximately 24 km.

14. At section 4 the focus of studies is mainly on the Bypass road Chaek to Chyldyk, and the section is not discussed in this report. However, the characteristics of the section are similar to that of section 2.

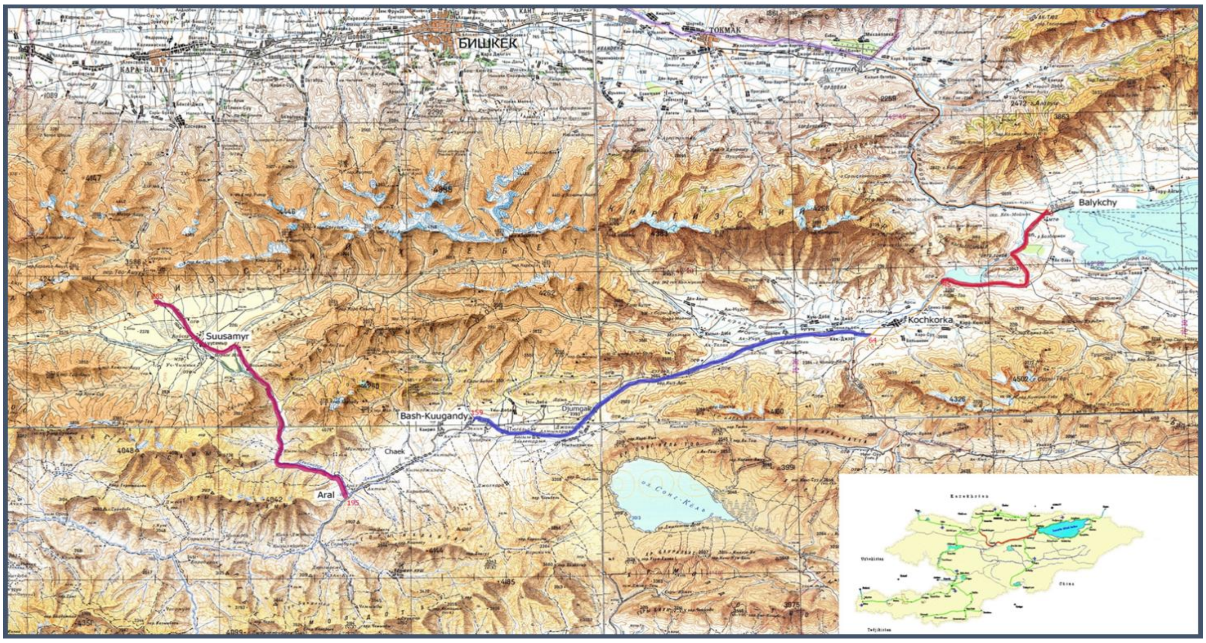


Figure 1: Project Area Map (Sections 1–3).

15. The project environment is generally characterized by rural settings, semi-arid steppe landscapes (mostly middle of Section 2), farmlands and graze lands, and rugged terrain (Section 3). At the mountainous part of section 3, the mountains are prone to rock and landslides, as well as erosion. A number of villages are found along the road, primarily in Section 2, with Chaek as the main commercial administrative focal village.

16. The project area has numerous rivers, including the River Chu, River Naryn, River Kokomeren and their tributaries. Snow fields and glaciers are the main feeding sources for the rivers, while the collection of water in river basins can broadly be divided in three categories: 1. Seasonal snow melt from lower and middle mountain ranges, 2. Melting of high altitude snow, snow-drifts and glaciers during the hottest period of the year, 3. Low water period characterized by relatively small water discharge. [8]

17. The project area is prone to earthquakes that will in many areas contribute to the movement of talus, formation of landslides, and impact the roadbed and road construction covering artificial structures.[9]

18. The road sections cross three oblasts (Issyk-Kul, Naryn, and Chuy) and four raions.

Table 1: Road Sections, Villages, and Local Population

	Section 1	**Section 2**		**Section 3**
Name	Balykchy (Km 0)–Km 43)	Kochkor (Km 64)–Epkin (Km 89)	Epkin (Km 89–Bashkugandy (Km 159)	Aral (Km 195)–Too Ashuu/Bishkek–Osh Road (Km 286)
Length (km)	43	25	70	91
Oblast(s)	Issyk-Kul (c. 34 km)	Naryn	Naryn	Naryn (c. 10 km)
	Naryn (c. 9 km)			Chuy (c. 81 km)
Raion(s)	Issyk-Kul: Ton	Kochkor	Kochkor	Naryn: Jumgal
	Naryn: Kochkor		Zhumgal	Chuy: Jayil
Villages	Orto-Tokoi Ak-Olon	Chikildek Kok-Dyar Cholpon Ara-Kel Osoviahim Tuz Akuchuk	Zhumgal Lama Kyzart Djany-Aryk Bazar-Turuk Kyzyl-Emgek Kuiruchuk Tugyol-Sai Tugyol-Sai Epkin Bash-Kuugandy (Bashkugandy)	Suusamyr Tunuk Pervoe Maya Kojomkol Kaisar Kyzyl Oi
Local Population	[2303][2]	11,808 (2,382 HH)	15,878 (3,112 HH)	7,048 (1,320 HH)

[1 and 2] Villages located more than five (5) km from the project road section.

Section 1

[8] Feasibility Study of Alternative Road North–South: Balyktchy T.–Jalal-Abad T. Kyrgyz Republic. MOTR (MOTR). 2013.

[9] Feasibility Study of Alternative Road North–South: Balyktchy T.–Jalal-Abad T. Kyrgyz Republic. MOTR. 2013.

19. The section 1 is mainly located at the Issyk-Kul region that has complex and varied nature and climate conditions, topography and geology. The climate is sharply continental, but mitigated by the Issyk-Kul Lake. The total length of the lake is 240 km and the width is 70 km. The main water arteries in the Issyk-Kul basin are about 80 rivers and streams flowing into Lake Issyk-Kul. Deep non-freezing lake and the high mountain ranges surrounding it on all sides create the conditions for the moderate seasonal temperatures drop and an abundance of sunny days. Rainfall is uneven: in the eastern zone 800 mm, while in the region of Balykchy, where the section 1 begins from, rainfall amounts to 100–200 mm.[10] In Balykchy town itself, there is virtually no rainfall during the year. The average annual temperature is 4.9 °C and precipitation averages 150 mm.[11]

20. The road section 1 begins from the outskirts of Balykchy with five stores and some industrial establishments located by the road. The road also crosses a railway line. The road continues from the populated area to agricultural and graze lands that are fairly flat. From Km 16 onwards, the road follows the foothills of the northern slope of Yrymdymazar Mountain, and then it goes by the bottom of dry ravine, cutting the afore-said mountain. The width of the ravine is from 50 m to 150 m, and slopes of the dry ravine are flat. There is very little infrastructure on the sector and no villages besides Balykchy, and road sides are mostly barren with some grazing land.

21. The road follows the Chui River from Km 8 to Km 14.5, and meets it again by the Orto Toko Reservoir. The Chui River originates from the southern flanks of the Kyrgyz Range north of Naryn, with 1,070 km course ending in Kazakstan. The ridges composing the catchment area of the Chui River have the highest point of 4,501 m, and exceed 4,000 m for a considerable distance. The Chui basin is characterized by less precipitation in winter and more in summer due to the predominance of summer rainfall in the upper reaches of the Chu. This contributes to the low specific water content of the upper reaches of the river.[12]

Figure 2: Project Road at Section 1.

22. At Km 32, the road turns towards the Orto-Tokoi reservoir and is laid on northern foothill loop of Tegerek Mountain. Slope of the section is directed to the North– to Orto-Tokoi reservoir. The surface of the loop is faintly parted by mudflow ejections, which should be

[10] Feasibility Study of Alternative Road North–South: Balyktchy T.–Jalal-Abad T. Kyrgyz Republic. MOTR. 2013.
[11] Climate-data.org. Balykchy. Available at: http://en.climate-data.org/location/25236/
[12] Feasibility Study of Alternative Road North–South: Balyktchy T. – Jalal-Abad T. Kyrgyz Republic. MOTR. 2013.

taken into consideration in draining.[13] The Orto-Tokoi Reservoir was built in 1956, covering an area of 25 m^2. After reaching the Orto Tokoi Reservoir, the road section enters the Naryn Oblast for final kilometers. All of the section 2 is located in the Naryn Oblast, the characteristics of which are described in the following chapter.

Section 2

23. A considerable part of the Naryn oblast, in which the section 2 is located, is ridges. The climate is continental with cold, long winters, and short and cool summer. Several climatic zones can be observed in the oblast: at the height of 1,400–1,600 m above sea level there is a desert, 1,600–1800 m – semi desert, 1,800–2,000 m – steppes, 2,500–4,000 m - subalpine and alpine zones, above 4,000 m - zone of perpetual snow. For example, the average annual temperature in Kochkor, located on the existing road, is 4.1 °C and the average rainfall is 228 mm. Kochkor is influenced by the local steppe climate.[14] Section 2 is located in the Kochkor Valley area.

24. Naryn oblast is an important agricultural area. There are over 93,000 horses, 91,6000 sheep, and 134,000 heads of cattle in the oblast. Large numbers of livestock graze in the valley surrounding the road sector. There is also industry in the oblast, but it is not located by the project area.[15]

Figure 3: Project Road at Section 2.

25. The section 2 crosses two districts of Kochkor and Jumgal. There are several villages located by the road: Kok-Dzar, Chikildek, and Akuchuk in the Kochkor District; and Jumbal, Kuruchuk, Tugulsay, Bashkugandy, Bayzak, Chaek and Kyzyl–Zyldyz in the Jumbal District. The infrastructure at villages (water supplies, facilities, etc.) will be updated according to other studies done for the CAREC Corridors project.

26. The longest river in the Kyrgyz Republic, the Naryn River, is located in the oblast. There are more than 5,000 rivers and streams in the Naryn oblast. Highest parts of the ridges are occupied by glaciers, which give rise to many rivers, stretching far beyond the oblast. Glaciers are located at an altitude of over 4,000 m.

Section 3

[13] Feasibility Study of Alternative Road North–South: Balyktchy T. – Jalal-Abad T. Kyrgyz Republic. MOTR. 2013.
[14] Climate-data.org. Kochkor. Available at: http://en.climate-data.org/location/26029/
[15] Feasibility Study of Alternative Road North–South: Balyktchy T. – Jalal-Abad T. Kyrgyz Republic. MOTR. 2013

27. The section 3 is located in a mountainous terrain in two oblasts, Naryn in the South and Chui in the North. The section begins from the junction with the Aral–Kazarman road passing through rugged and winding terrain along the right bank of the Kokomerin River until it crosses it after Kyzyl-Oi Village. The left side of road straddles the foothills of mountains prone to rock and landslides. Mountains are also prone to erosion. A recently built powerline follows the road for some kilometers on mountainsides.

28. After Kyzyl-Oi Village, the road crosses the Kokomeren by a bridge and then follows the left bank of the River until crossing it to reach Kojomkol Village. The road crosses Suusamyr valley, which has a total area of 4673 km^2. The altitude of the valley lies within about 2,100 to 3,000 meters ASL. The valley is formed by the two catchments of the Suusamyr river and Karakol river flowing from East and West, respectively, which then join to form the Kokomeren river and flow south to the Naryn river.[16] Kokomeren river belongs to the group of rivers with intermittent freeze-up. The typical ice phenomena include sludge ice, shore ice, and floating shapes.[17]

Figure 4: Project Road and Kokomeren River at Section 3.

29. The final section of road after the Kojomkol village is located on flatter land used for agriculture and graze lands. The road passes the villages of Suusamyr and Tunuk, and crosses a bridge over Karakol River.

30. Suusamyr Valley has some of the highest ranked risk for landslides in Kyrgyzstan, and climate change creates new risk in this respect. The thawing of higher altitude areas of tundra or permafrost reduces the ability of plants to hold the soil on upper, steep slopes with soil sloughing off. Overgrazing or even any grazing on these areas can cause landslides or lead to conditions that are ripe for landslides. The loss of pastures due to landslides poses serious challenges for pasture management and to human health and safety.[18] However,

[16] Climate Risk Management in Kyrgyzstan. United Nations Development Programme Country: Kyrgyzstan. No date, Available at: http://www.kg.undp.org/content/kyrgyzstan/en/home/operations/projects/environment_and_energy/climate-risk-management-in-kyrgyzstan.html

[17] Feasibility Study of Alternative Road North–South: Balyktchy T. – Jalal-Abad T. Kyrgyz Republic. MOTR. 2013.

[18] Climate Risk Management in Kyrgyzstan. United Nations Development Programme Country: Kyrgyzstan. No date, Available at:

it should be noted that the landslide and avalanche risks are biggest on the higher mountains that are not located by the road.

31. Overall, the section 3 up till the Kojomkol village seems at highest risk of climate related hazards like heavy rains, flooding, land, and rock slides. The road would need to be considerably widened with safety measures to mitigate the risks. As the Kokomeren River meanders alongside the road, there is limited space for the road.

IV. Climate Change in the Kyrgyz Republic

4.1.1 Observed Trends in Air Temperature and Precipitation

32. Due to insufficient meteorological information, the national climate change analysis is based on transformation of the initial series of observations. In UNDP's climate study, certain series of observations were consistently differentiated, followed by averaging differentiated series and then integrating into the summary series. The results show a significant change in temperatures. The observed increase is almost the same at all climatic zones, except for the Issyk-Kul Region. [19]

Table 2: Changes in Temperature between 1991 and 2010 (°C) with Breakdown by Regions Compared to the Baseline Period[20]

Region Indicator	Batken	Jalal-Abad	Issyk-Kul	Naryn	Osh	Talas	Chui
Mean 1961–1990 (Baseline)	9,45	8,11	3,04	-0,34	6,32	6,13	5,11
Mean 1991–2010	10,13	9,00	3,36	0,11	7,16	6,66	5,65
The difference between the mean values	0,67	0,89	0,32	0,46	0,84	0,53	0,54
Increase from 1991 to 2010	1,61	1,42	0,88	1,57	1,36	1,39	1,22

33. Between 1976–2014, the observed trend of air temperature change is likewise positive with the average annual temperature change amounting to 0,18°C. The highest changes are observed in the spring period when temperature rise amounts to 0,42°C in 10 years; and in autumn period, when temperature rise is 0,24°C/10 years.[21]

34. According to the UNDP study[22], the precipitation trends show that the overall mean annual precipitation slightly increased (by 0.847 mm/year), but during the last 50 years this increase significantly reduced (to 0.363 mm/year), and over the last 20 years there is a significant tendency to its decrease (-1.868 mm/year). This entails a definite aridization of the country's climate.

http://www.kg.undp.org/content/kyrgyzstan/en/home/operations/projects/environment_and_energy/climate-risk-management-in-kyrgyzstan.html

[19] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.

[20] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.

[21] Ministry of Emergency Situations of the Kyrgyz Republic. Newsletter: Current climate status and change in the Kyrgyz Republic. 2015.

[22] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.

Table 3: Results of Comparing Mean Annual Precipitations during the Baseline Period (1961–1990) and the Last 20 Years (1991–2010), mm[23]

Region Indicator	Batken	Jalal-Abad	Issyk-Kul	Naryn	Osh	Talas	Chui
Mean 1961–1990 (baseline)	367,7	535,4	457,8	297,2	371,2	366,9	522,3
Mean 1991–2010	386,8	574,1	461,5	295,1	387,2	309,4	502,9
The difference between the mean values	19,1	38,6	3,73	-2,10	16,03	-57,5	-19,4
Increase from 1991 to 2010	-297,1	-0,18	0,13	-0,49	-0,20	-0,38	0,12

35. Observations for the period 1976–2014[24] show an upward trend in the annual precipitation (by 2.9% for the period of 10 years) in the Kyrgyz Republic as a whole, with the largest growth observed in summer and winter. However, the trends in precipitation vary between regions and there are some local areas with observed reduction in precipitation. These areas include the Suusamyr basin located by the project area.

36. The change of the amount of summer precipitation is extremely uneven. Moving from the west eastwards, the level of precipitation increase reaches negative values of 0–7% for 10 years in the east of Issyk-Kul Oblast, where the project is located. There are also local areas of precipitation reduction in Chui Oblast–Ala-Archa Stow-5.9% for 10 years, Suusamyr Meteorological Station-5.2% for a 10-year period.

37. The location of observation points is shown in the map below. The meteorological posts at the project area are located in Balykchy, Chaek and Suusamyr in addition to an agrometeorological post in Kochkor.

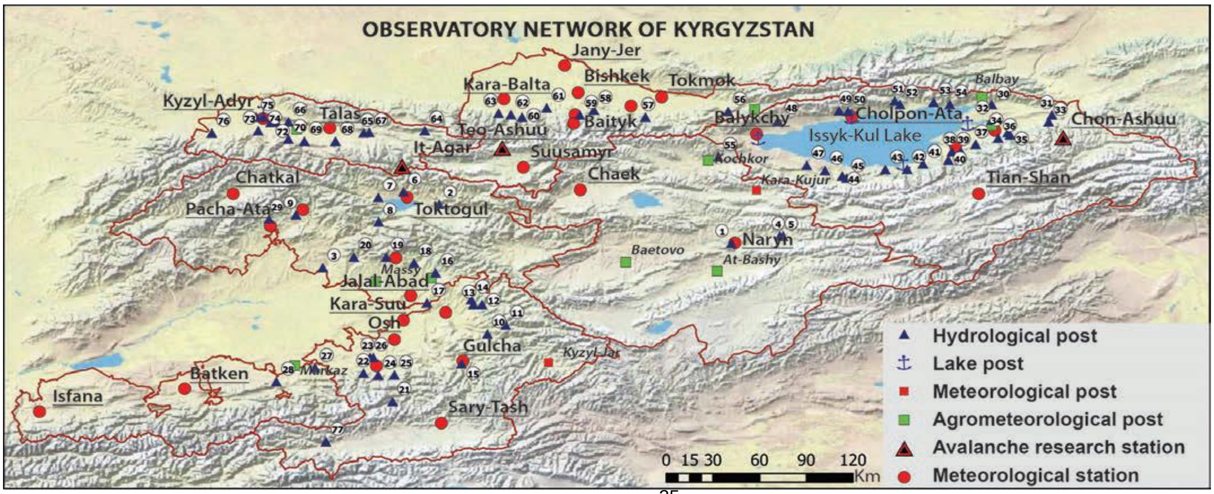


Figure 5: Observatory network of Kyrgyz Republic.[25]

4.2 Future Climate Change Projections

38. The climate change scenarios used in the Kyrgyzstan National Communication to the United Nations[26], and for national climate strategies were developed with

[23] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.
[24] Ministry of Emergency Situations of the Kyrgyz Republic. Newsletter: Current climate status and change in the Kyrgyz Republic. 2015.
[25] Ministry of Emergency Situations of the Kyrgyz Republic. Newsletter: Current climate status and change in the Kyrgyz Republic. 2015.
[26] Second National Communication to the UN Framework Convention on Climate Change, Republic of Kyrgyzstan, 2009.

MAGICC/SCENGEN program using the A2 and B2 families of following GHG emission scenarios:

(i) A2-ASF - scenario that gives the maximal value of CO2 concentration by year 2100 among scenarios of A2 family (among scenarios A2 with more moderate economic and demographic parameters); and

(ii) B2-MESSAGE - scenario that gives the minimal value of CO2 concentration by year 2100 among scenarios of B2 family (among B2 scenarios with more moderate economic and demographic parameters).

39. The A2 and B2 emission scenarios were selected, because they have more moderate social and economic indexes and describe the development conditions with focus on preservation of local originality and local solution of problems of economic, social, and ecological sustainability.

40. The calculations were performed for three estimate areas. The first estimate area covers Talas and Chui oblasts. The second estimate area covers Issyk-Kul and Naryn oblasts, and a part of Jalal-Abad oblast. The third area covers the larger part of Batken and Osh oblasts. The project road section one is located in the first estimate area and road sections two and three in the second estimate area. The maps below illustrate the average annual changes in temperatures.

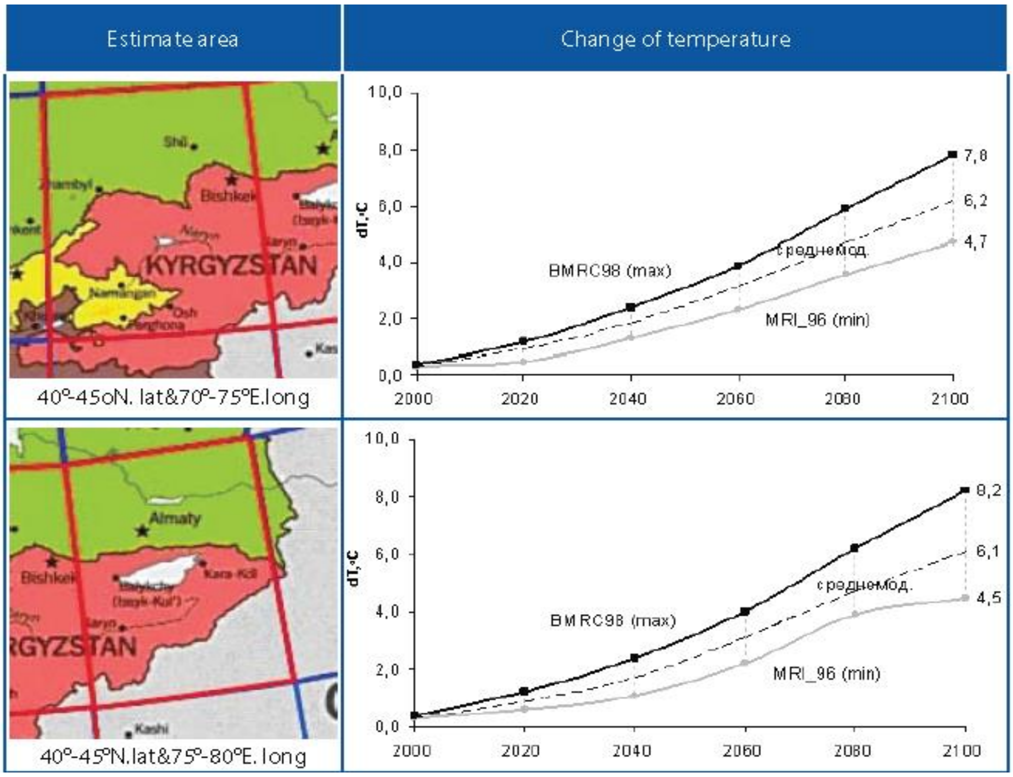


Figure 6: Averaged Annual Changes of Temperatures in Relation to the Base Period of 1961–1990. A2-ASF Emissions Scenario[27]

[27] Second National Communication to the UN Framework Convention on Climate Change, Republic of Kyrgyzstan, 2009.

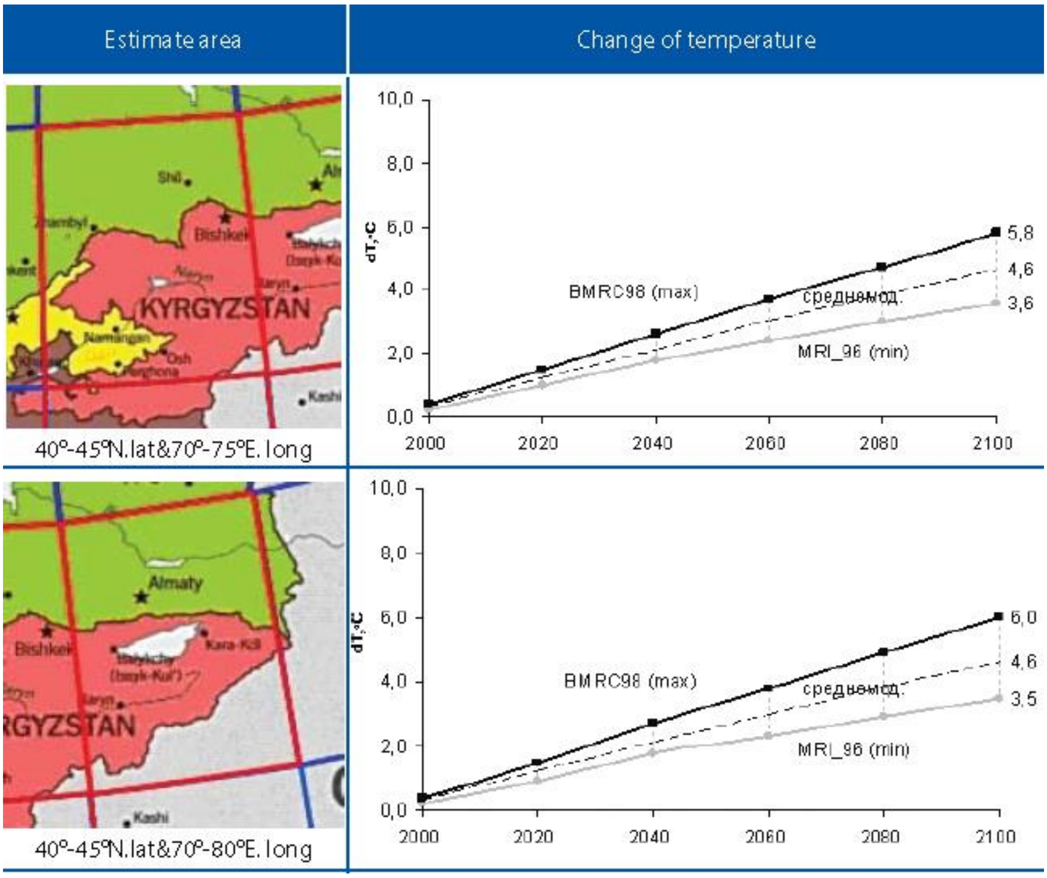


Figure 7: Averaged Annual Changes of Temperatures in Relation to the Base Period of 1961–1990. B2 MESSAGE Emissions Scenario[28]

41. The scenarios indicate the growth of averaged-annual temperatures in all estimate areas. The values of seasonal temperature changes by year 2100 anticipate a greater increase of summer temperature in comparison to other seasons, and the minimum increase is predicted for the winter period.

42. The more recent UNDP Climate Profile study calculations[29] were made using the A2 emissions scenario that provides for the highest greenhouse gas emissions and, consequently, the greatest warming from the scenarios, and all the climate models approved by IPPCC at the time. The results also show a significant increase in temperatures with no significant regional difference. In contrast to the observed trends, the expected temperature variability was found to be approximately the same for all months.[30]

[28] Second National Communication to the UN Framework Convention on Climate Change, Republic of Kyrgyzstan, 2009

[29] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.

[30] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.

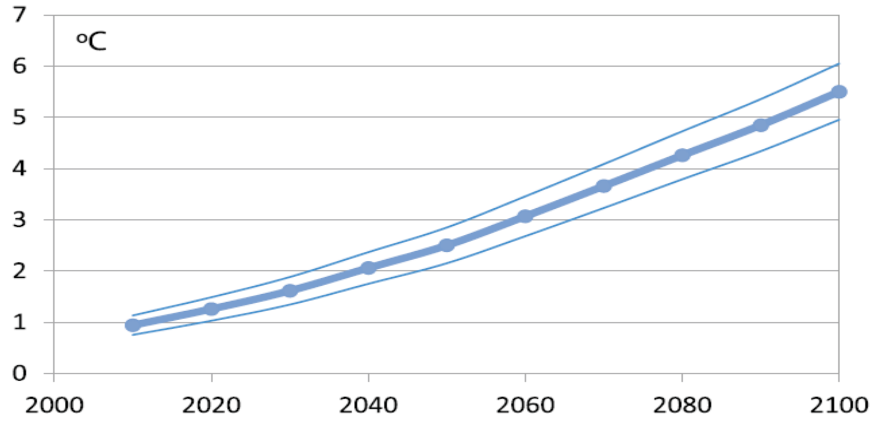


Figure 8: Estimate of the Expected Mean Temperature, °C (thin lines outline the area of uncertainty estimated on the basis of models).[31]

43. Similar calculations were performed for the annual precipitation. In the Kyrgyz Republic Second National Communication[32], the calculations indicate some increase of precipitation in the northern part of the country (1.3 - 2.1 percent compared to the base period irrespective of any scenario), and for the southern part some decrease is assumed (from -2.0 to -3.1 percent compared to the base period for scenarios A2 and B2 accordingly). The seasonal fluctuations can be significant, with most essential decrease of precipitation during the summer season and the greatest increase during winter season.

[31] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.
[32] Second National Communication to the UN Framework Convention on Climate Change, Republic of Kyrgyzstan, 2009.

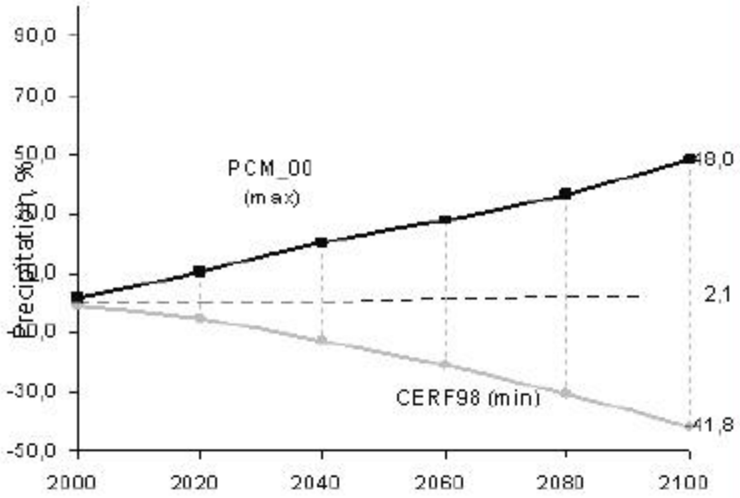
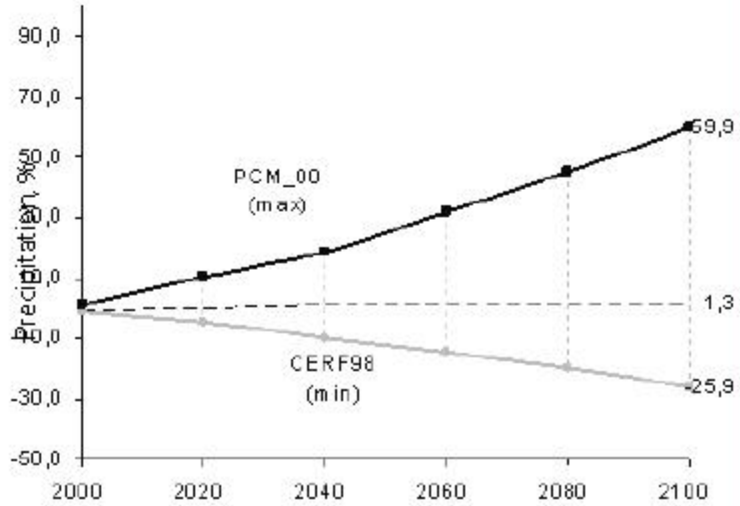
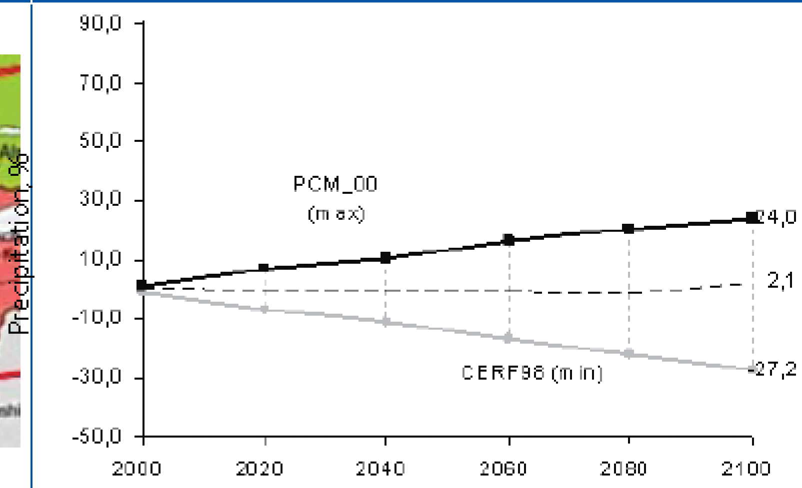
Estimate area	Change of precipitation amount
 40°-45° N.lat&70-75° E.long	
 40°-45° N.lat&75-80° E.long	

Figure 9: Changes of Annual Precipitation amounts Compared to the Base Period of 1961–1990. A2-ASF Emission Scenario[33]

[33] Second National Communication to the UN Framework Convention on Climate Change, Republic of Kyrgyzstan, 2009.

<table>
<tr><th>Estimate area</th><th>Change of precipitation amount</th></tr>
<tr><td>

40°-45° N.lat&70-75° E.long</td><td>
</td></tr>
<tr><td>

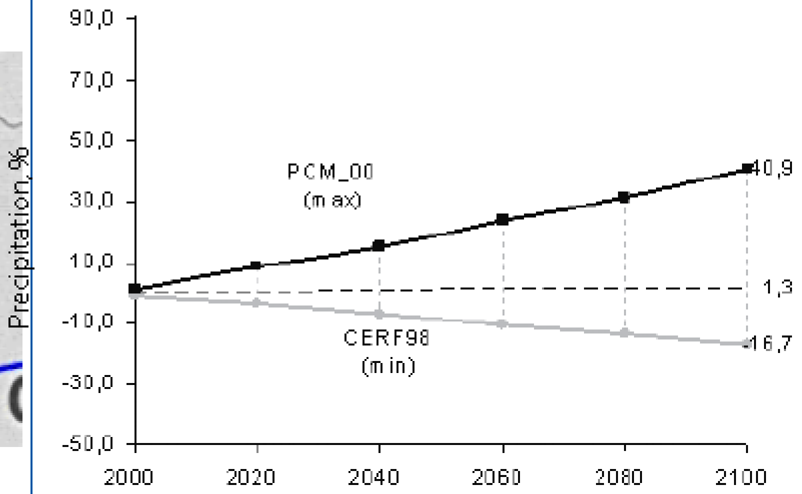
40°-45° N.lat&70-80° E.long</td><td>
</td></tr>
</table>

Figure 10: Changes of Annual Precipitation amounts Compared to the Base Period of 1961–1990. B2-MESSAGE Emission Scenario[34]

44. For the UNDP Climate Profile[35], the expected annual precipitation was also estimated for the A2 scenario and the ensemble of climate models. According to the results, the annual precipitation decreases, but at a lower rate (-0.0677 mm/year) than observed during the past fifty years. It is expected that the amount of precipitation will vary over time, in contrast to the monotonically changing temperature. The expected seasonal distribution of precipitation is generally equal to those observed in recent decades.

[34] Second National Communication to the UN Framework Convention on Climate Change, Republic of Kyrgyzstan, 2009.

[35] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.

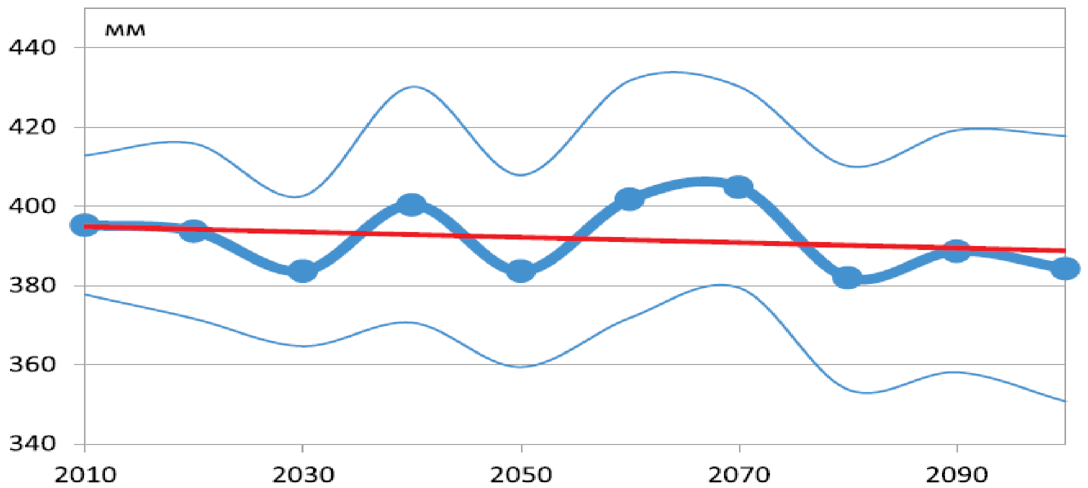


Figure 11: Estimation of the expected mean annual precipitation (the red line is a linear tendency, while thin lines are the uncertainty estimate for scattered models).[36]

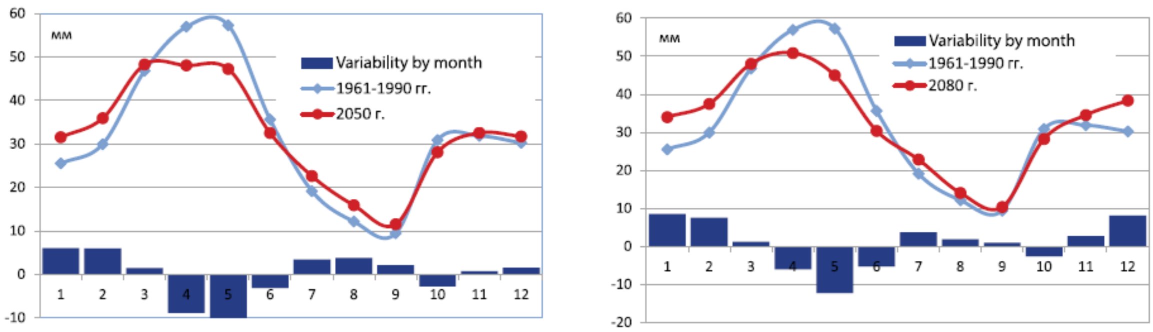


Figure 12: Distribution of the Monthly Precipitation.[37]

V. Estimated Impacts of Climate Change in the Kyrgyz Republic and the Project Area

45. In the Kyrgyz Republic Second Communication to the UN Framework on Climate Change,[38] the sectors identified especially vulnerable to climate change are:

(i) Water resources (indicators of vulnerability: glacier parameters, volume of superficial runoff, lakes parameters);
(ii) Health (indicators of vulnerability: morbidity and mortality rate);
(iii) Agriculture (indicators of vulnerability: heat availability, productivity of various types of crops and pastures);
(iv) Emergency climate situations (indicators of vulnerability: mud-flows, landslides, lake breakout, avalanches occurrence).

46. The Kyrgyz Republic has more than 8,500 glaciers spanning an area of 8,000 km. A total of 3103 rivers and 800 lakes in the high mountains are considered at risk for flooding

---

[36] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.
[37] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.
[38] Second National Communication to the UN Framework Convention on Climate Change, Republic of Kyrgyzstan, 2009.

from heavy rains and snowmelt.[39] Glaciers play an essential role in Kyrgyzstani water systems, as river flow regimes are mostly dominated by snow and glacier melt. The general trend related to perceived warming is that river flows increase in the short term, as the glaciers retreat, but the flows decline once the glaciers continue shrinking and ultimately disappear. For example, at Aksu River Basin, 80 % of the annual discharge occurs in the warm season from April to September. In the cold season, the flow of the river can be very low. River flows are also impacted by glacial lake outburst floods, which cause peaks in river discharge.[40]

47. A study published in 2015 concluded that glaciers in Tien Shan Mountains bordering the Kyrgyz Republic, northwest China and Kazakhstan, have lost more than a quarter of their total mass over the past 50 years. The analysis indicates that the combination of positive degree days and annual precipitation explains as much as 93% of the variance in the Tien Shan glaciers yearly mass budgets. This reflects the importance of summer air temperature, and highlights the vulnerability of the Tien Shan with respect to temperature changes. It is suggested that the glacier decline is driven primarily by summer melt and, possibly, linked to the combined effects of general climatic warming and circulation variability over the north Atlantic and north Pacific. The researchers estimated that half of the remaining ice in the glaciers can disappear by 2050. [41]

48. Climate-related disasters affecting the Kyrgyz Republic are a combination of dynamic (e.g. landslides and mudslides) and slow onset (such as reduced glacial melt). The Kyrgyz Republic is characterized by high cyclical variability of floods, often accompanied by mudflows and droughts.[42] There are 5,000 potentially active landslide sites, with more than 10,000 homes located in landslide prone areas, the majority of which are found in the south. Intense rainstorms trigger landslides within minutes, as do snowmelts.[43]

49. According to an UNDP study[44], there is a significant correlation between climate change and the occurrence of emergency situations (ES). The ES studied included mudflows and floods, landslides, avalanches, flooding, rainstorms, hurricane winds, hail and snowfall. The study was partly restricted by the lack of data, but during 1990 – 2010, the increase in the number of all the above ES throughout country was observed. The increase rate for ES varies, but the highest is for mudflows and floods.

50. There is, however, no generally accepted uniform quantitative indicator for assessing the changes. The UNDP study utilized the mean annual temperature as the indicator, with extrapolation of results for coming 5-15 years. The study also underlined the need for sectoral analysis, which are hindered by the lack of statistical data and no previous research.[45]

---

[39] World Bank. Vulnerability, Risk Reduction, and Adaptation to Climate Change in Kyrgyz Republic, 2011.

[40] Kundzewicz, Z., Merz, B., Vorogushyn, S., Hartmann, H., Duethmann, D., Wortmann, M., Huang, Sh., Su, B., Jiang, T., Krysanova, V. Analysis of changes in climate and river discharge with focus on seasonal runoff predictability in the Aksu River Basin. Environmental Earth Sciences, 2015, Vol.73(2), pp.501-516

[41] Substantial glacier mass loss in the Tien Shan over the past 50 years. D. Farinotti, L. Longuevergne, G. Moholdt, D. Duethmann, T. Mölg, T. Bolch, S. Vorogushyn and A. Güntner. Nature Geoscience. Vol. 8, September 2015.

[42] Climate Risk Management in Kyrgyzstan. United Nations Development Programme. Environment Protection for Sustainable Development. Kyrgyzstan Component of the Central Asian Climate Risk Management Programme. 2010.

[43] World Bank. Vulnerability, Risk Reduction, and Adaptation to Climate Change in Kyrgyz Republic, 2011.

[44] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.

[45] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013

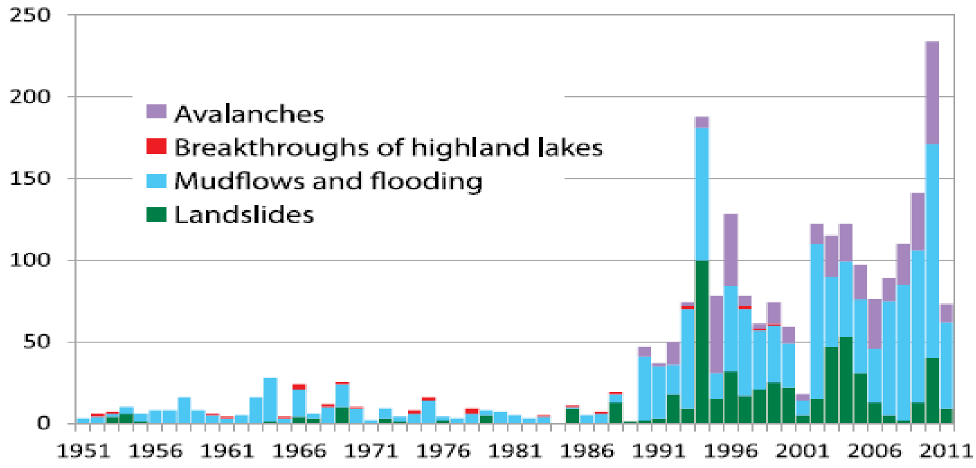


Figure 13: The number of major emergencies recorded in Kyrgyzstan[46]

51. The study also estimated the increase in the number of ES due to temperature increase by 1^{o}C. The results are shown in the table below.

Table 4: The Increase in ES Number due to Temperature Change[47]

ES type	The increasing ES number for 1990 – 2010	The increase in ES number due to temperature increase by 1oC
Mudflows and floods	50,57	34,4
Landslides	1,896	1,23
Avalanches	26,728	18,2
Flooding	5,376	3,65
Rainstorms	4,416	3,00
Hurricane winds	23,062	15,7
Hail	2,832	1,92
Snowfalls	6,026	4,09

52. It should also be noted that ES such as landslides are linked to earthquakes. The Tien Shan is particularly prone to earthquake-triggered landslides or slope failures caused by combined seismic and climatic factors. It is assumed that most large mapped mass movements at Tien Shan were triggered by major earthquakes, possibly in combination with climatic factors. The Suusamyr earthquake that took place in 1992 triggered the massive Belaldy rock avalanche and caused possibly over 30 casualties.[48]

53. The table below indicates the number of observed ES in the project area.

[46] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.
[47] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.
[48] Tien Shan Geohazards Database: Earthquakes and landslides. H.B. Havenith, A. Strom, I. Torgoev, A. Torgoev, L. Lamair, A. Ischuk, K. Abdrakhmatov. Geomorphology 249 (2015) 16–31.

Table 5: Emergency Situation Data from Issyk-Kul, Naryn, and Chui Oblasts[49]

	Issyk-Kul oblast		Naryn oblast		Chuy oblast		Total	
Emergency Situations	**Number**	**Casualties**	**Number**	**Casualties**	**Number**	**Casualties**	**Number**	**Casualties**
2000								
Landslides	0	0	0	0	0	0	0	0
Avalanches	1	0	0	0	0	0	1	0
Mudflows and floods	2	0	0	0	0	0	2	0
Flooding	0	0	0	0	0	0	0	0
Rainstorms	0	0	0	0	0	0	0	0
Hurricane winds	0	0	3	0	4	0	7	0
Hails	0	0	0	0	0	0	0	0
Snowfalls	2	0	0	0	1	0	3	0
2002								
Landslides	1	0	0	0	8	0	9	0
Avalanches	2	0	2	1	3	0	7	1
Mudflows and floods	3	0	1	0	7	0	11	0
Flooding	1	0	0	0	18	0	19	0
Rainstorms	0	0	0	0	1	0	1	0
Hurricane	1	0	0	0	3	0	4	0
Hails	2	0	1	0	12	0	15	0
Snowfalls	0	0	0	0	1	0	1	0
2004								
Landslides	0	0	3	0	6	0	9	0
Avalanches	4	12	3	0	3	0	10	12
Mudflows and floods	1	0	2	0	4	0	7	0
Flooding	0	0	0	0	0	0	0	0
Rainstorms	0	0	0	0	1	0	1	0
Hurricane	0	0	0	2	0	0	0	2
Hails	0	0	0	0	0	0	0	0
Snowfalls	1	0	0	0	0	0	1	0
2006								
Landslides	5	0	0	0	1	0	6	0
Avalanches	4	4	4	2	5	1	13	7
Mudflows	8	0	2	0	3	0	13	0
Flooding	0	0	0	0	0	0	0	0
Rainstorms	4	0	3	0	1	0	8	0
Hurricane	0	0	0	0	0	0	0	0
Hails	1	0	0	0	0	0	1	0
Snowfalls	1	0	0	0	1	0	2	0
2008								
Landslides	0	0	0	0	0	0	0	0
Avalanches	2	5	3	0	1	0	6	5
Mudflows	7	3	3	0	0	0	10	3
Flooding	0	0	0	0	0	0	0	0
Rainstorms	1	0	0	0	0	0	1	0
Hurricane	12	1	2	0	4	0	18	1
Hails	0	0	0	0	1	0	1	0
Snowfalls	0	0	0	0	1	0	1	0
2010								
Landslides	0	0	4	0	0	0	4	0
Avalanches	12	1	11	0	8	0	31	1
Mudflows	4	0	7	0	12	0	23	0
Flooding	0	0	0	0	0	0	0	0
Rainstorms	1	0	0	0	0	0	1	0
Hurricane winds	13	0	1	0	8	0	22	0
Hails	0	0	0	0	0	0	0	0
Snowfalls	1	0	4	0	0	0	5	0
2014								
Landslides	0	0	0	0	0	0	0	0
Avalanches	0	0	0	0	8	1	8	1
Mudflows	3	0	3	0	2	0	8	0
Flooding	0	0	0	0	3	0	3	0
Rainstorms	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hurricane winds	4	0	0	0	4	1	8	1
Hails	3	0	0	0	0	0	3	0
Snowfalls	1	0	1	0	0	0	2	0

[49] Data for years 2000-2010: Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013. Data for 2014: Ministry for Emergency Situations.

5.1 Climate Change Impacts at the Project Area

54. The assessment of climate change impacts at CAREC Corridors project area is based on climate modelling by The International Fund for Agricultural Development and UNEP's Global Risk Platform data. The socioeconomic profile of the project area with components for each of the road sections is used for the vulnerability assessment. The socioeconomic data based on surveys, statistical inputs etc. will be available in March 2016.

55. The International Fund for Agricultural Development[50] has assigned climate change simulations to identify vulnerabilities and to define adaptation strategies for rural regions in Kyrgyzstan. The methodology used included the utilization of six climate models used by the IPCC in its Fifth Assessment Report, gathering historical observations from available monitoring stations, and adaptation and application of a statistical downscaling methodology.

56. The main hazards identified include:

(i) River floods and water logging in spring, due to more intense rainfall. This will mainly affect lower altitudes and areas susceptible to flooding;
(ii) Heat stress in the summer, especially at lower altitudes;
(iii) Mudslides related to more intense rainfall in the spring at medium altitudes (and in a lesser degree also high altitudes); and
(iv) Flush floods in the summer especially at higher altitudes, related to higher temperatures together with the increase in winter, spring and autumn rainfall (snow at higher altitudes).

57. Climate simulations by IFAD indicate that the CAREC Corridors project area is located at an area with low or very low vulnerability risk as compared with the north of Chuy Oblast and other high altitude areas. Vulnerabilities identified by IFAD are mainly related to increased heat stress at the project areas with low altitudes and mudslides at medium altitudes (road section 3). The vulnerability of different areas was defined in four categories: very high, high, low and very low as shown in the map below.

[50] IFAD. Climate Change Impact on Pastures and Livestock Systems in Kyrgyzstan. Summary Report, 2013.

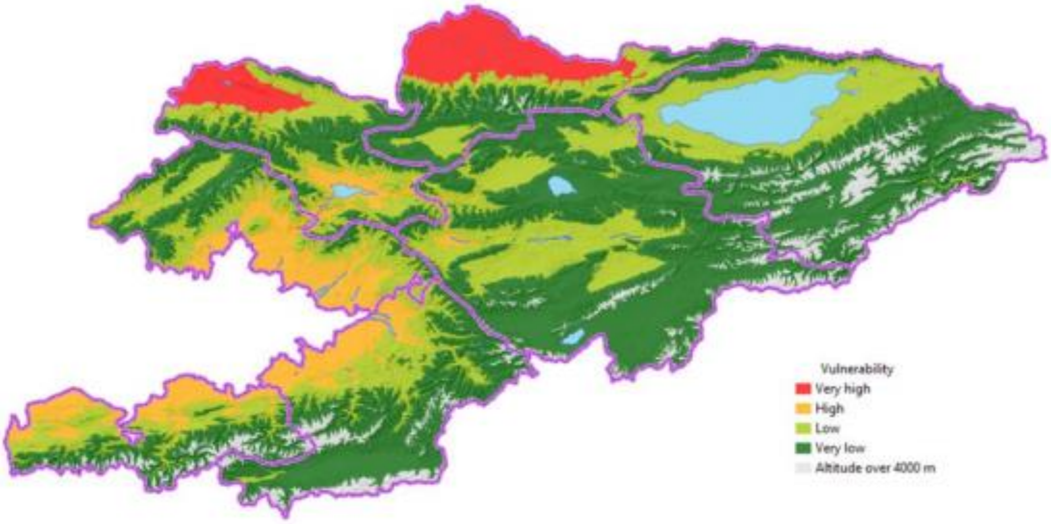


Figure 14: Levels of vulnerability to the climate change[51]

58. Very limited information on the occurrence of extreme rainfall was found, but with relation to emergency situations, there is a tendency of reduction of rainstorms in all regions excluding Talas.[52]

59. Hazards related to flooding have been studied at UNEP's Global Risk Data Platform. The hazards modeling was developed by a large team of experts selected by the World Meteorological Organization (WMO) and the United Nations Education and Scientific Cultural Organization (UNESCO). The Platform follows all standards for Spatial Data Infrastructures. According to the data, the flood hazard will increase along major rivers in the Central Asia region, but Kyrgyzstan and the project area is less influenced by this than the neighboring countries.

[51] IFAD. Climate Change Impact on Pastures and Livestock Systems in Kyrgyzstan. Summary Report, 2013.
[52] Climate profile of the Kyrgyz Republic – Sh. Ilyasov, O. Zabenko, N. Gaydamak, A. Kirilenko, N. Myrsaliev, V. Shevchenko, L. Penkina. - B. 2013.

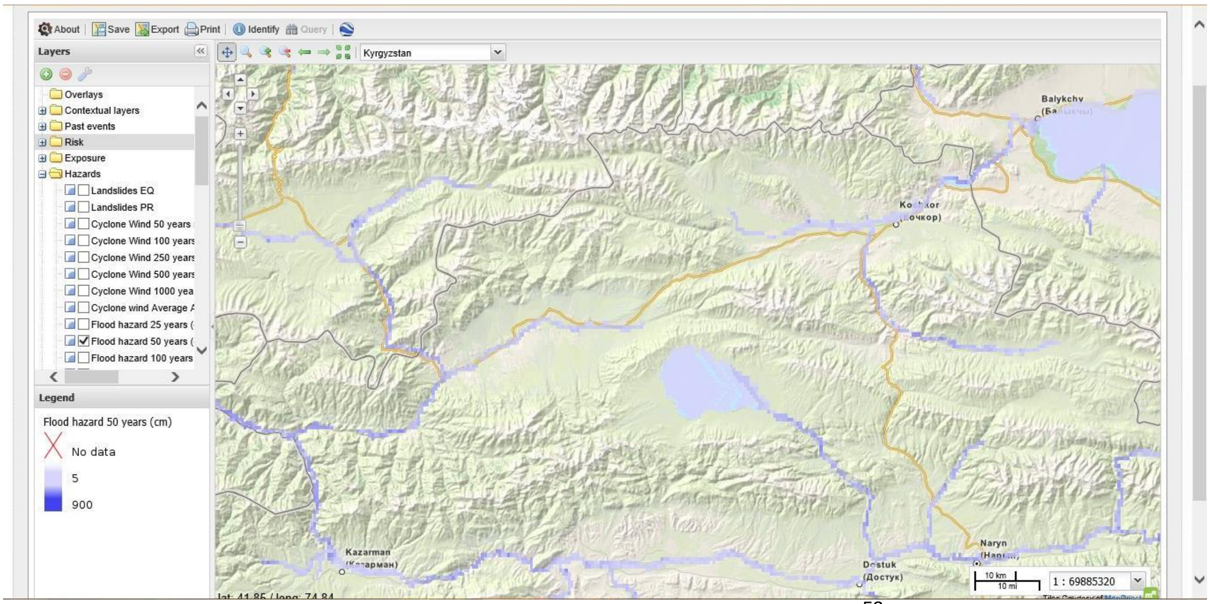


Figure 15: Flood hazard estimation for 50 years in the project area[53]

60. According to the Global Risk Data Platform modelling, the risk of landslides triggered by increased precipitation will increase in Kyrgyzstan. The project area is located in areas of low risk, whereas the risk increases at higher altitudes. The project area is, however, subject to the risk of landslides caused by earthquakes. Especially the project section 3 is subject to the risk of landslides.

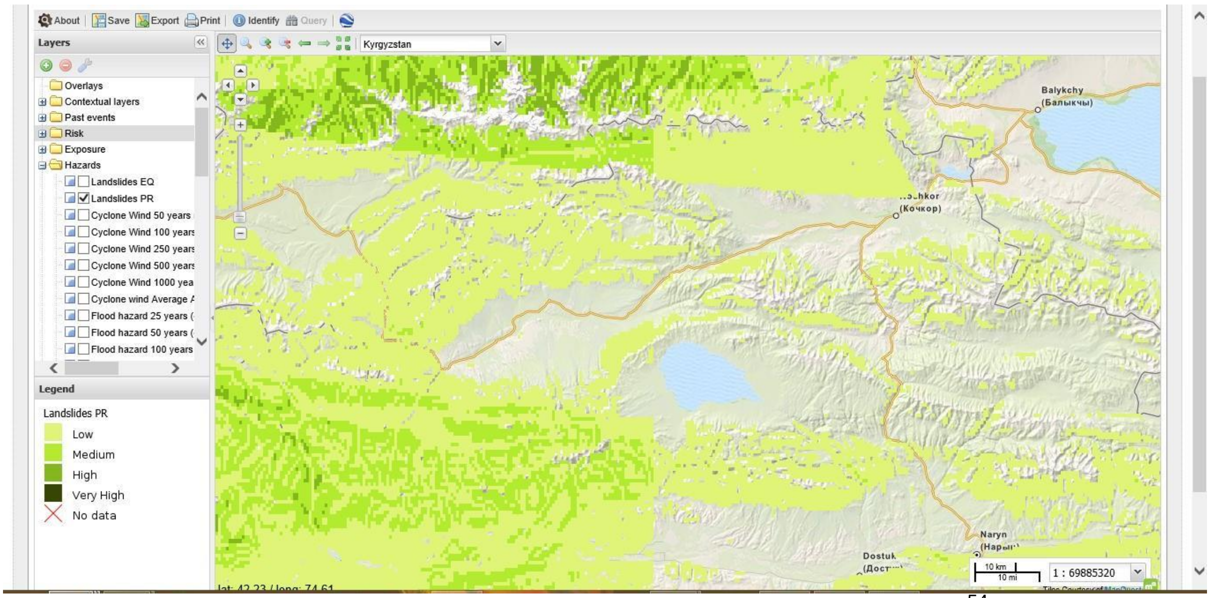


Figure 16: Landslides hazard, precipitations estimation for the project area[54]

53 Global Risk Data Platform. http://preview.grid.unep.ch/index.php?preview=map&lang=eng
54 Global Risk Data Platform. http://preview.grid.unep.ch/index.php?preview=map&lang=eng

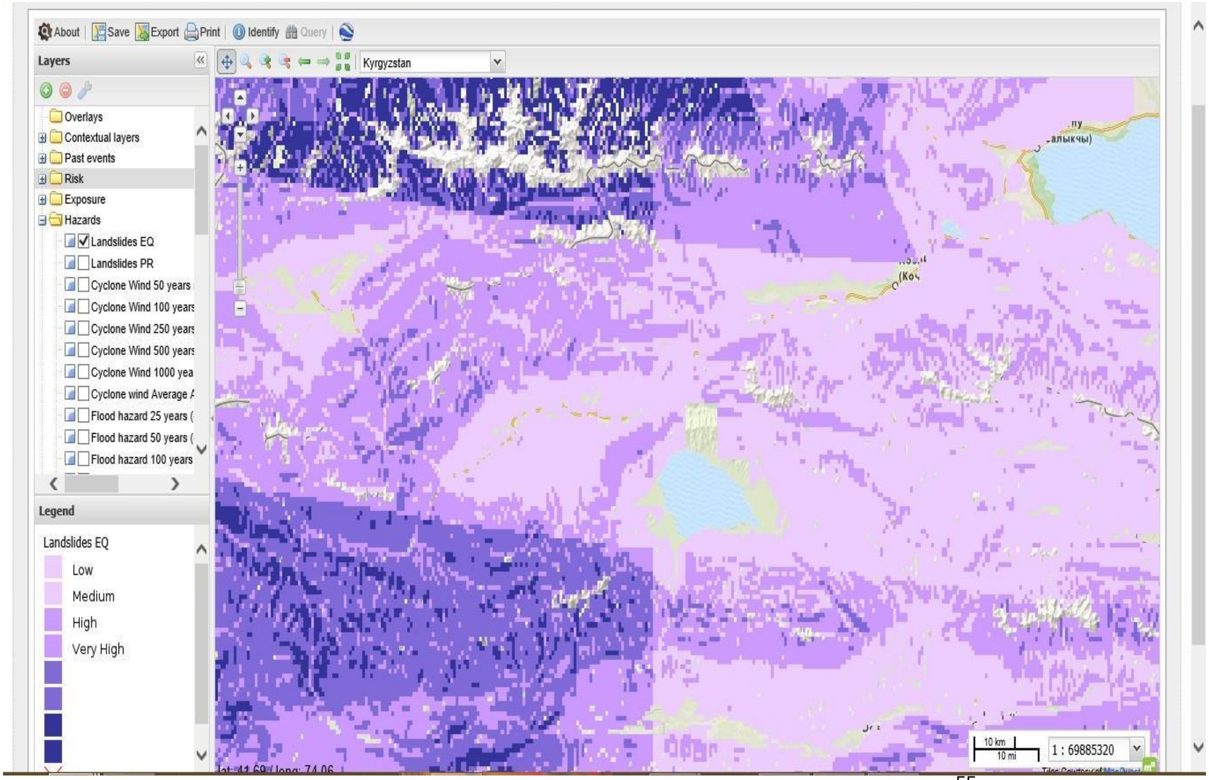


Figure 17: Landslides hazard, earthquakes estimation for the project area[55]

61. In addition to landslides, avalanches occur frequently in the Kyrgyz Republic. More than one - half of the territory of the Republic is exposed to the avalanche hazard. The geomorphological structure of deeply cut mountain relief determines intensive avalanche activity in case of active precipitation and presence of a steady deep snow cover. The highest avalanche activity takes place in the basins of the following rivers: Chandalash, Chychkan, Uzun-Akmaт, Chatkal and Suusamyr.[56] Of these rivers, Suusamyr is the tributary to Kokomerin river at the road section 3.

62. As evidenced by the UNISDR map below[57], there is an avalanche hazard at the Suusamyr valley close to the project section 3. The section 3 does not, however, cross the highest mountains most at risk of avalanches. Rising winter temperatures can in the future increase the risk of unpredictable avalanches, as temperature changes can be more sudden.[58]

[55] Ibid.
[56] Second National Communication to the UN Framework Convention on Climate Change, Republic of Kyrgyzstan, 2009.
[57] The United Nations International Strategy for Disaster Reduction (UNISDR). In-depth Review of Disaster Risk Reduction in the Kyrgyz Republic. 2010.
[58] Kyrgyzstan: Warmer World Raises Avalanche Risk. Eurasianet.org. March 20, 2015.

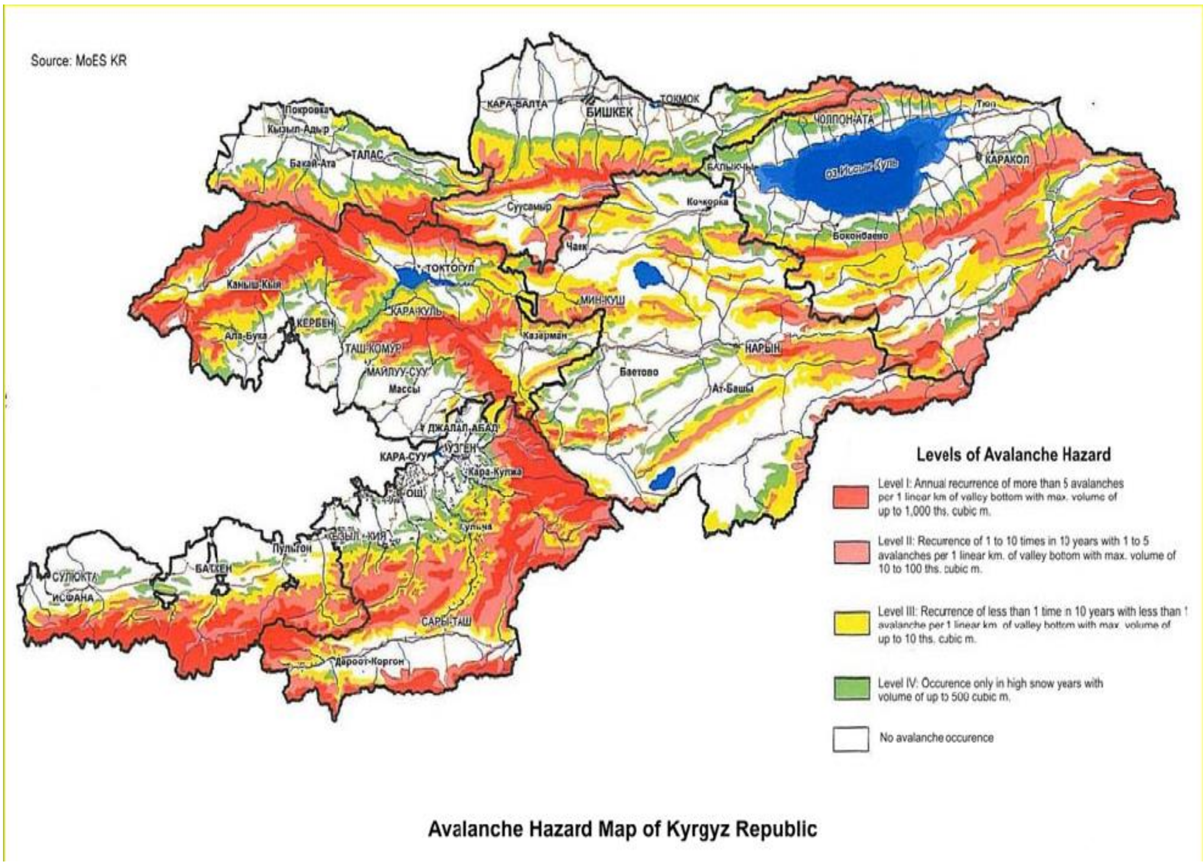


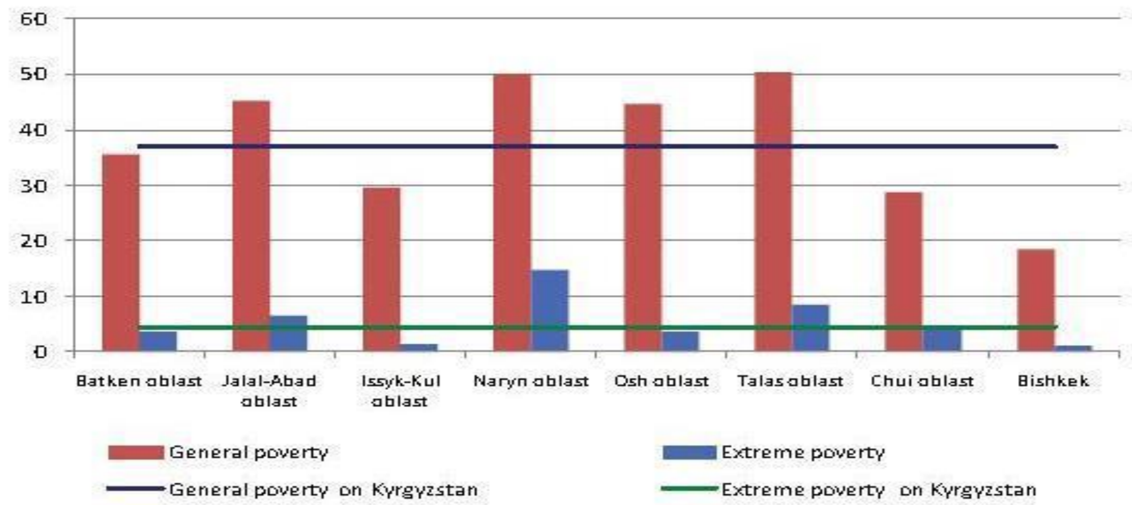
Figure 18: Avalanche hazard in the Kyrgyz Republic.[59]

5.2 Climate Hazard Vulnerability in the Project Area

63. The Kyrgyz Republic is facing challenges with persisting poverty, the disparity in the level of development of different regions and slow economic growth. Climate change and environmental degradation aggravate economic challenges, especially as agriculture is the main source of livelihood for rural population. According to the Ministry of Economy,[60] 80% of agricultural land is liable to degradation and desertification.

64. In year 2013, 37% of total population was living below the income poverty line, and 73,6% of them were rural citizens. At the project area, the poverty rate in the Naryn Province is 43,8%, in the Issuk-Kul 39,5% and in Chui Province 23,6%.[61] It should be noted, however, that the Chui Province poverty rate reflects more the situation in Bishkek than in the rural project area.

[59] The United Nations International Strategy for Disaster Reduction (UNISDR). In-depth Review of Disaster Risk Reduction in the Kyrgyz Republic. 2010.
[60] Ministry of Economy of the Kyrgyz Republic. Human Dimension of the Sustainable Development in the Kyrgyz Republic. 2016.
[61] Ibid.



Source: National Statistical Committee of the Kyrgyz Republic

Figure 19: Poverty rate by oblast[62]

65. The gender impact of climate change has been little studied in the Kyrgyz Republic, but it has been noted that with regard to poverty, vulnerable rural women (divorced, low-income, and single women) are in the most precarious situation. Employment opportunities for women are often limited as they lack experience and adequate qualifications. Poverty also has a more severe impact on women than men, due to the fact that increased workload on women is combined with household keeping duties. The socio-economic and legal status of women oblige them to engage in economic activities under unequal conditions and with low income.[63]

5.3 Climate Hazard Matrix for the Project Area

66. The climate risk assessment of road sections is based on climate change and hazard data presented in previous chapters. The risk is evaluated according to its estimated frequency and impact, as shown in the table below.

Table 6: Climate Risk Assessment Matrix: Frequency and Hazard[64]

		Impact		
		Low	**Medium**	**High**
Frequency	**Low**	Very low risk	Low risk	Medium risk
	Medium	Low risk	Medium risk	Hig risk
	High	Medium risk	High risk	Very high risk

67. The risk assessment includes hazards influenced by climate change; landslide caused by precipitation, avalanches, floods, strong winds, extreme temperature, drought and also landslides related to earthquakes.

[62] UN Kyrgyzstan. The Kyrgyz Republic: Third report on progress towards achieving the Millennium Development Goals. 2013.

[63] UN Kyrgyzstan. The Kyrgyz Republic: Third report on progress towards achieving the Millennium Development Goals. 2013.

[64] Adapted from ADB. Climate Change Assessment. Republic of Tajikistan: Building Climate Resilience in the Pyanj River Basin.

Table 7: Climate Risk Assessment for the Project

	Road Section 1	Road Section 2	Road Section 3
Landslides, precipitation	Low risk	Low risk	Medium risk
Landslides, earthquakes	Low risk	Low risk	Medium risk
Avalanches	Very low risk	Very low risk	Medium risk
Floods	Low risk	Low risk	Medium risk
Strong winds	Very low risk	Very low risk	Very low risk
Extreme temperature	Medium risk	Medium risk	Low risk
Drought	Medium risk	Medium risk	Low risk

68. The estimated increase in extreme temperatures and drought impact most drastically the environment and livelihoods, but especially the rise in temperatures contributes also to the road condition and lifecycle. Possible surface damage that can occur on pavements include rutting, cracking, potholes and fretting. One of the factors contributing to surface damage is high road surface temperatures. The low albedo of road surfacing means that it is an efficient absorber of sun radiation, and the increasing frequency of extreme temperatures entails more prevalent damage.

69. On the mountainous part of the road section 3, there is a medium risk for landslides, as well as rockslides. As precipitation is not expected to increase in the area, the risk is not likely to increase significantly, but should, however, be taken into account in the road planning. On the section 3, there is also a risk of flooding, as the road is located very close to the Kokomeren River.

70. Potential landslide risk areas along the road are: Km 10–Km 12, Km 90–Km 120, Km 130–Km 135, and Km 215–Km 225

71. Avalanche prone areas are at the Kiz Art Pass from Km 200 to Km 240 (Section 3).

VI. Climate Change Adaptation

6.1 Adaptation Options

72. Adaptation to climate change involves actions to help reduce vulnerability to the effects of climate change. In relation to the project roads, adaptation involves actions that ensure that the infrastructure can better withstand the physical impacts of climate change.

73. *A pro-active* approach to climate adaptation in transport implies a conscious decision to invest in measures in the face of climate change impacts. This option appears to also be challenging, not only due to costs but also because it cannot be easily replicated in all environments and is not a ‘one-size fits all` exercise.

74. Climate change will certainly impact on the infrastructure, operations, safety and maintenance of the road systems. Main impacts include both direct (e.g., pavement deterioration and deformation, general structural damage, traffic disruption and) and indirect (economic, environmental, demographic, and spatial planning). Road infrastructure will also suffer from asphalt rutting and/or melting, thermal expansion of bridge joints, landslides and bridge scouring or undermining. Consequently it is crucial to prepare for such effects.

75. Adaptation options for the anticipated climate change road projects can generally be divided into engineering (structural) options (material specifications, drainage and erosion,

and protective engineering structures), and non-engineering options (maintenance planning and early warning, alignment, master planning and land use planning, and environmental management). Adaption strategies also targeting two objectives (i) reduce the likelihood of impacts, and (ii) reduce the consequences of impacts.

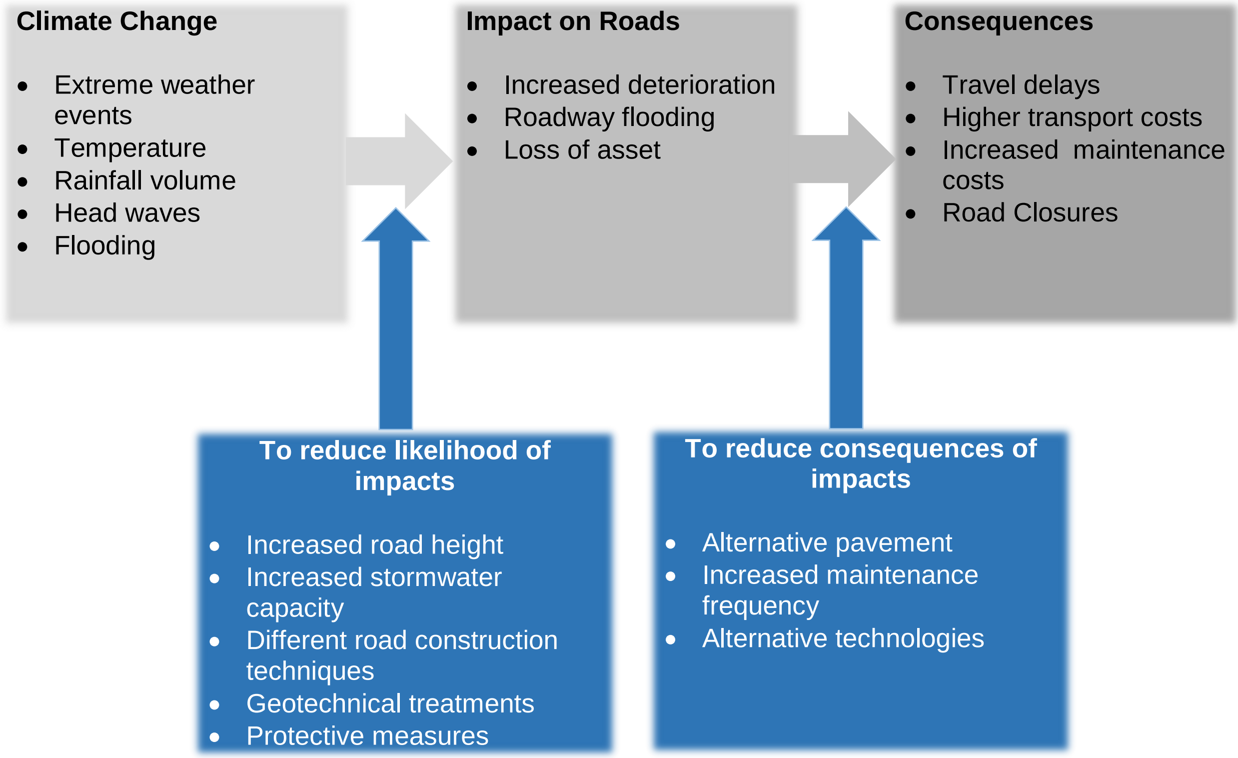


Figure 20: Adaptive Strategies
Source: Adapted from Climate Change Risk Assessment, 2015, Vicroads.

76. Principle engineering climate change adaptions options for the project roads are summarized in the Table below.

Table 8: Potential Adaption Measures

Risk	Potential adaption responses
Increase in precipitation	• Increasing size and number of drainage structures • Raising embankment height to avoid over-flooding • Realigning natural water courses • Update design for drainage systems • Slope stability studies in an attempt to minimise landslides and mudflows as a result of increased precipitation • Measures to enhance slope stability and prevent landslides and rock fall
Increased temperatures and head waves will result in pavement deformation and deterioration	• Improved pavement material specifications • Consideration of polymer-modified bitumen • Advanced construction technologies
Temperature increase will result in increasing number of frost-thaw cycles and increase the risk for avalanches	• Implementation of snow fences, preferable living snow fences • Artificial anti-avalanche structures, like galleries

77. These potential adaption options have been assessed and recommendation for adaption measures to be included in the preliminary design has been prepared.

6.2 Recommendations for Climate Change Adaptation

78. Climate proofing and adaptation on the transport sector requires different scale measures, such as, resurfacing of roads with more durable materials, re-routing or flood protection. Adaptation calls for additional investment and also creates new logistical needs. The future choice of freight and passenger traffic modes can become more responsive to the relative sensitivity to extreme weather events.[65]

79. In the project area, the main adaptation needs are related to the increase in temperatures at sections 1 and 2, and rock and debris slides, as well as flooding especially on the section 3. However, as rainfall or rainstorms are not expected to increase in the area, the risks of flooding and rock slides will neither significantly increase.

80. The impact of increased and extreme temperatures, as well as temperature fluctuation, should be taken into account in the pavement design. Higher peak temperatures require asphalt able to withstand softening or melting, which can be improved through adjusting the binder composition of the asphalt.

81. The risk of landslides and debris flow onto the road need to be taken into account especially at the road section 3 between Km 215 and Km 225. The possibilities of slope stabilisation through vegetation should be studied to contribute to long-term sustainability. Besides the positive impact on slope stability, forestation also contributes to CO_2 absorption.

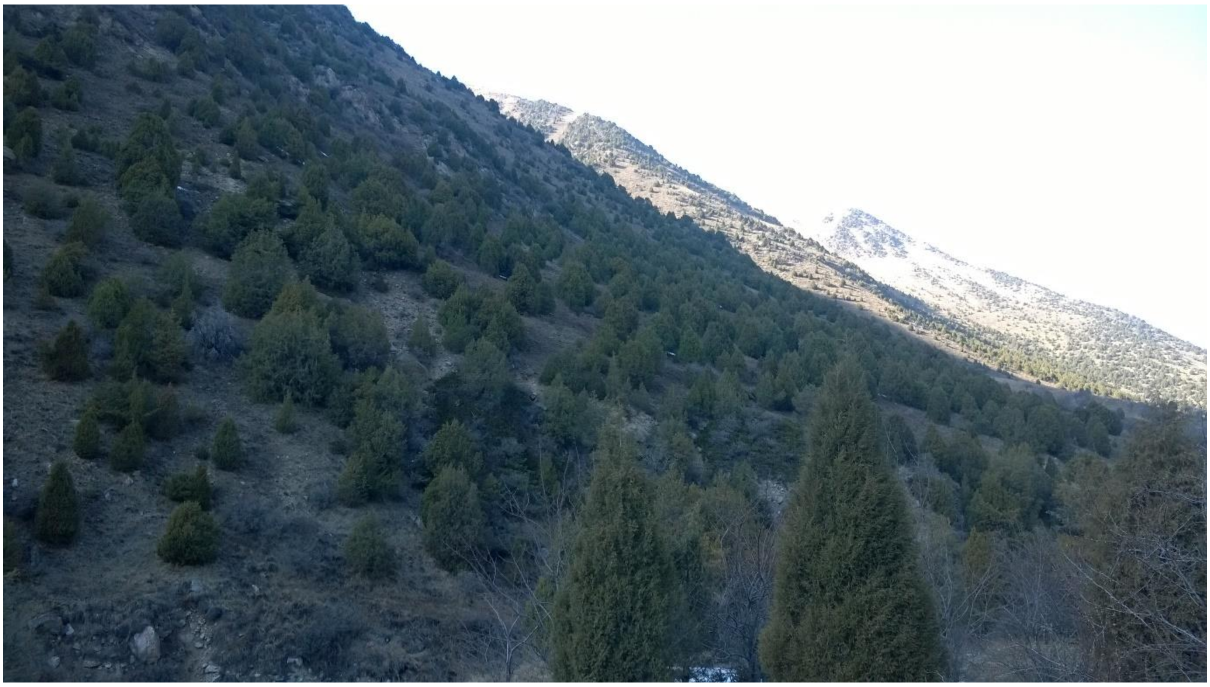


Figure 21: Forested slopes at Ala Archa National Park.

[65] Sims R., R. Schaeffer, F. Creutzig, X. Cruz-Núñez, M. D'Agosto, D. Dimitriu, M. J. Figueroa Meza, L. Fulton, S. Kobayashi, O. Lah, A. McKinnon, P. Newman, M. Ouyang, J. J. Schauer, D. Sperling, and G. Tiwari, 2014: Transport. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

82. The risk of flooding need to be taken into account especially at the road section 3, including the design of bridges. No significant increase in number of rainstorms (see figures 22 and 23) or maximum annual rainfall is estimated in the project area, but the drainage should be designed so as to ensure adequate capacity, also in the event of a heavy peak rain.

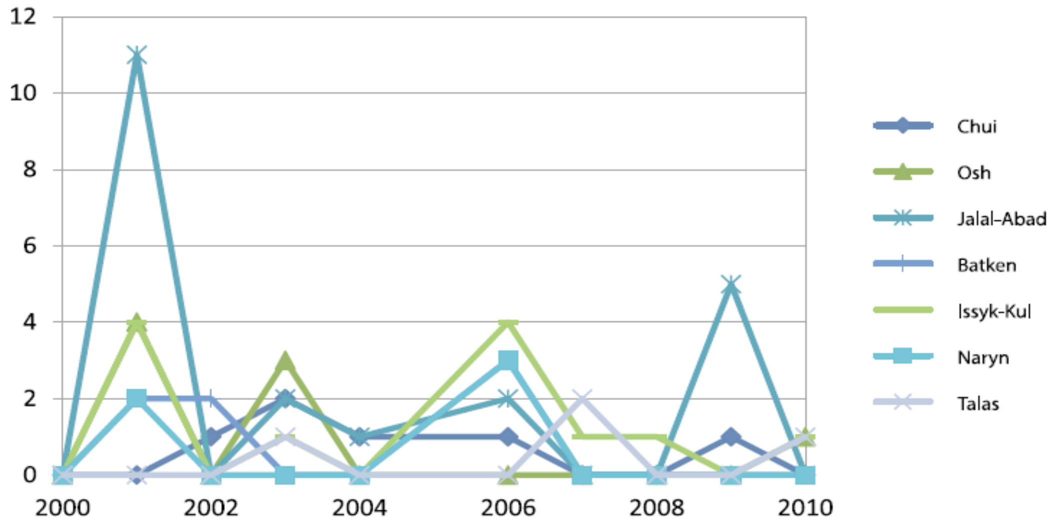


Figure 22: Variability in the number of rainstorms with breakdown by regions (CH - Chui, O - Osh, JA - Jalal-Abad, B - Batken, IK - Issyk-Kul, N - Naryn and T – Talas regions) for the period 2000 – 2010 (Source UNDP)

Indicator	Chui	Osh	Jalal-Abad	Batken	Issyk-Kul	Naryn	Talas
ES number	6	8	21	7	12	5	4
Damage, thousand USD in 2005	нд	нд	нд	нд	нд	нд	нд
Increase in ES number per year	-0,0273	-0,1545	-0,2455	-0,1	-0,0364	-0,0455	0,0636

NA – data are not available or not enough for the assessment

Figure 23. Relative vulnerability of the regions of Kyrgyzstan to rainstorms (source UNDP).

83. The hydrography of the region includes two large watercourses–Kokomeren and Western Karakol Rivers. The Kokomeren and Western Karakol Rivers are described as not mudflow dangerous rivers in the “Catalogue of mudflow dangerous rivers of Kazakhstan, Central Asia, and Eastern Siberia”.

6.3 Climate Change Adaptation Costs

84. The recommended adaptions discussed above will likely incur more financial investment. Road design, construction, and maintenance in Kyrgyz Republic are governed by guidelines that do not explicitly account for changes in future temperature and precipitation. However, frost penetration depths are already considered in the preliminary design and the drainage system is designed to cover the anticipated stormwater discharges. Bridges are dimensioned sufficient for the anticipated water flow passage in the rivers. Material specifications should be adapted to include the usage of polymer-modified bitumen, which is more resident to head waves and increased frost-thaw cycles. Extreme weather (rain) events might trigger landslides and mudflows, and therefore slope stabilisation through vegetation is recommended. Increased temperatures increase the risk of avalanches and

implementation of living snow fences (forestation) is envisaged. The cost for forestation has not been considered in the climate change adaption cost, since tree planting is already considered as environmental mitigation measures for the loss of vegetation due to road widening. During detailed design the location of slope stabilisation measures should be defined and included into the scope of the civil works.

Table 9: Estimated Costs of Adaption Measures

Adaption option	Cost	Benefit	Comments
Extended drainage system with larger culvert sizes		Reduce the risk of road over-flooding and water ponding along the roads	The adaption of the drainage system has been estimated at 20% of the overall drainage costs, assuming a 20 % increase of precipitation.
Improved material specification for asphalt and the use of polymer modified bitumen	The costs for improved asphalt layers with polymer-modified bitumen have been estimated at 5.4 million USD	Reduce the risk of pavement damages and increase pavement life	

85. The estimated costs for improved asphalt layers based on the estimated quantity of polymer modified bitumen and has been calculated as follows:

Road section	Unit	Estimated Quantity	Unit Rate (USD)	Amount (USD)
Km 0–Km 43 (Balykchi to Km-post 43)	Ton	475	2,100	997,500
Km 62–Km 89 (Kochkor–Epkin)	Ton	310	2,100	651,000
Km 89–Km 159 (Epkin–Bashkugandy)	Ton	987	2,100	2,072,700
Km 195–Km 274 (Aral–Too-Ashuu)	Ton	801	2,100	1,682,100
Total				**5,403,300**

86. For cost estimation purpose the usage of 'Duroflex (WA-80)' additive has been assumed. The price of the additive is 1.68 USD[66] per kg. Additional 25% for delivery and ancillary costs are added, resulting in a unite price of 2.1 USD per kg, equivalent to 2,100 USD per ton.

87. The adaptation cost estimate for extended drainage system based on the civil works cost estimate for drainage works. Due to climate change an increase of 20 % peak stormwater discharge has been assumed. Therefore also 20 % of the total drainage costs were estimated as climate change adaption costs. This simplified cost estimation approach has been used, since a detailed calculation of the cost increase of each culvert and side drain would exceed the scope of this study.

Road section	Total Drainage Costs (USD)	Assumed 20% Adaptation Costs (USD)
Km 0–Km 43 (Balykchi to Km-post 43)	3,872,050	774,410
Km 62–Km 89 (Kochkor–Epkin)	1,638,121	327,624
Km 89–Km 159 (Epkin–Bashkugandy)	3,433,442	686,688
Km 195–Km 274 (Aral–Too-Ashuu)	6,056,755	1,211,351
Total		**3,000,074**

66 http://tiu.ru/p44629804-modifikatory-asfaltobetona-duroflex.html и http://www.stroyportal.ru/catalog/section-asfalt-368/modifikatory-asfaltobetona-duroflex-wa80-683092432/

88. Slope stabilisation measures along the project road might be required between km 10 and km 12, km 90 and 120, km 130 – km 135, and km 215 – 225.

89. Anticipated slope stabilisation comprises mainly provision of vegetation cover of approximately 50 km2, which needs to be detailed during later project phases. The estimated costs for slope stabilisation are as follows:

Description	**Unit**	**Estimated Quantity**	**Unit Rate (USD)**	**Amount (USD)**
Planting and Maintenance of hard wood trees	each	47,000	25	1,175,000
Grass seeding	Km2	50	400	20,000
Total				**1,195,000**

90. Slope stabilisation measures to such extend are not considered in the preliminary design and therefore the costs are not considered in the overall estimate of climate change adaption measure. Further studies are required to assess the detailed extent of slope stabilisation measures through vegetation cover.

91. Incorporating the recommended climate change adaption measures increased the civil works cost by approximately 8.4 mill. USD (without contingencies and taxes), representing 4.01 % of the total civil works cost. The expected benefits of the investment in terms of anticipated reduction in future maintenance or repair costs have not been estimated.

VII. Climate Change Mitigation at the Transport Sector

92. As stated in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (2014), reducing global transport greenhouse gas emissions will be challenging unless the emissions can be strongly decoupled from GDP growth. Furthermore, without aggressive and sustained mitigation policies, transport emissions can increase faster than emissions from the other energy end-use sectors, as the transport demand per capita is expected to rise sharply in developing and emerging economies. The means to mitigate emissions include: avoided journeys and modal shifts due to behavioral change, uptake of improved vehicle and engine performance technologies, low-carbon fuels, investments in related infrastructure, and changes in the built environment. Indirect GHG emissions also arise, for example, during the construction of infrastructure.[67]

93. The technical potential to substantially reduce the current GHG emissions exist for all modes of transportation by 2030 and beyond. Energy efficiency and vehicle performance improvements range from 30 – 50 % relative to 2010 depending on mode and vehicle type. Over the medium-term to long-term change, investments in new infrastructure can further reduce GHG intensity through modal shifts. However, financial, institutional, cultural, and legal barriers constrain low-carbon technology uptake. Important factors are the high investment costs and the slow turnover of stock and infrastructure, especially if co-benefits, such as improved health, safety, accessibility, time savings and environmental benefits are not taken into account. On the other hand, investment in mass transit and other low-carbon

[67] Sims R., R. Schaeffer, F. Creutzig, X. Cruz-Núñez, M. D'Agosto, D. Dimitriu, M. J. Figueroa Meza, L. Fulton, S. Kobayashi, O. Lah, A. McKinnon, P. Newman, M. Ouyang, J. J. Schauer, D. Sperling, and G. Tiwari, 2014: Transport. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

transport infrastructure can help avoid locking to carbon intensive modes. Freight logistical systems' carbon intensity can be reduced through fiscal, regulatory and advisory policies.[68]

94. The transport sector emits non- CO_2 pollutants including methane, volatile organic compounds (VOCs), nitrogen oxides (NOx), sulphur dioxide (SO2), carbon monoxide (CO), F-gases, black carbon and non-absorbing aerosols. Of these, VOCs, NOx and CO are most relevant for diesel and petroleum operated road traffic. Black carbon and non-absorbing aerosols, emitted mainly during diesel engine operation, can have significant direct and indirect radiative forcing effects and large regional impacts. Transport is also significant emitter of primary aerosols that can have strong local and regional cooling effect through the scattering of light and production of secondary aerosols through chemical reactions.[69]

95. A recent international study on air pollution levels and the transport pathways in the Central Asian region observed and modeled aerosols in the region. Measurements of particulate matter (PM) mass and composition were taken at two locations in Kyrgyzstan and modeling analysis was performed to assess the contributions of local, regional, and distant sources to the PM concentrations. The study included PM2:5, PM10, black carbon (BC), and organic carbon (OC). BC comprised on average only about 1–2% of PM2:5 mass in CA with European emissions contributing 50% to the mean BC concentrations. Of national emissions, residential and transport are the most important sectors, each contributing 30% to BC, followed by 20% from industry, and with power the least important. According to simulations, future BC concentrations had a larger relative increase than PM2:5 concentrations. This suggests that health impacts and climate warming associated with these pollutants may increase over the next decades.[70]

VIII. Greenhouse Gas Emissions from the Project

96. The total GHG emissions of the Kyrgyz Republic were approximately 12,000 Gg CO_2 equivalent in year 2005, as compared to approximately 30,000 Gg CO_2 equivalent in 1990, according to the Kyrgyz Republic Second National Communication to the UN Framework. The total GHG emissions from transportation sector were estimated as 2,487.45 Gg CO_2 equivalent in year 2005. The calculations were based on the actual amount of motor vehicles, estimate of annual run, and fuel consumption volume per each category, taking into account significant volume of not reported imported fuel.[71]

---

[68] ibid.
[69] ibid.
[70] Kulkarni, S., Sobhani, N., Miller-Schulze, J., Shafer, M. M., Schauer, J. J., Solomon, P. A., . . . Denier van der Gon, ,H.A.C. 2015. Source sector and region contributions to BC and PM2.5 in central asia. Atmospheric Chemistry and Physics, 15(4), 1683-1705.
[71] Second National Communication to the UN Framework Convention on Climate Change, Republic of Kyrgyzstan, 2009.

Table 10: Kyrgyz Republic GHG Emissions 1990–2012[73]

	GHG emissions, Gg CO_2eq	Emissions from the transport sector, Gg CO_2eq	Percentage of transport sector emissions from the total of national emissions, %
1990[74]	30,258.9	5,053.03	17.1
2005[75]	12,017.1	2,487.45	22.0
2010[76]	13,008.54	-	-
2012[77]	13,794.74	-	-

97. The reduction in GHG emission levels reflects the abrupt decline of GDP, industrial production and transport in year 1995 compared to the 1990. The decline included the fall of transport levels down to 88 percent in 1995 from the 1990. The transportation levels have grown considerably since. However, as stated in the Second National Communication, the actual consumption of fuel and thus actual emissions from the transport sector can be much higher than estimated.[78]

8.1 Greenhouse Gas Emissions with and without the Project

98. The current level of GHG emissions caused by traffic on the existing roads, and the projected emissions after project finalization, are calculated based on the traffic counts and evaluations done for the CAREC Corridors Project. The HDM-4 software is used to model the emissions. HDM-4 model is globally used as a planning, programming and preparation tool for the highway improvement and maintenance activities.

99. The HDM-4 calculates pollutants produced as a function of: road characteristics, traffic volume/congestion, vehicle technology and fuel consumption. Of greenhouse gases, the model only includes CO_2. However, CO_2 emissions are on average 95-99% of the total greenhouse gas emissions from a passenger vehicle, after accounting for the global warming potential of all GHGs.

100. The volume and composition of current and future traffic was defined through traffic surveys that included manual classified counts and origin/destination surveys. The project road sections were divided into six homogeneous sub-sections in terms of traffic volume and composition between significant settlements and junctions. Each of these sections was covered by a manual classified traffic count (MCC). Manual traffic counts were classified according to the vehicle type and vehicle nationality, direction and time (hour).

101. Traffic counting results were converted into Annual average daily traffic (AADT) by using official correlation factors in Kyrgyzstan Road Authority. The following vehicle classification was used:

[73] The total emissions are not directly comparable due to different calculation methods, but give an indication about the emission trend.
[74] Emissions Summary for Kyrgyzstan. United Nations Climate Secretariat, no date.
[75] Ibid.
[76] EDGAR: Emission Database for Global Atmospheric Research. Calculation based on the energy balance statistics of International Energy Agency.
[77] Ibid.
[78] Second National Communication to the UN Framework Convention on Climate Change, Republic of Kyrgyzstan, 2009.

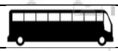
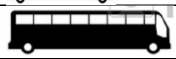
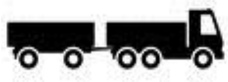
Category	Description	Illustration
1	Small Passenger Car	
2	Light bus (Van)	
3	Medium Bus	
4	Large Bus	
5	Light 2-axle truck (pick-up) up to 3,5t loading capacity	
6	Medium 2-axle truck, 3,5-12t loading capacity	
7	Heavy 3-axle truck, over 12t loading capacity	
8	Truck Trailer	
9	Truck Semi Trailer	

Figure 24: Vehicle classification.

102. The origin/destination (O/D) surveys done provide information about the journeys of traffic on the roads and are used to estimate the potential diversion of long-distance national and international traffic to the rehabilitated road. They also included other important details such as vehicle type, journey purpose, generation and attraction.

103. Traffic diversion was considered with reference to the new North-South Corridor implementation and its subsequent potential to attract additional traffic that currently would use other routes. The results from the O-D survey were used in determining the potential of traffic diversion, as well as additional local knowledge of the traffic circumstances.

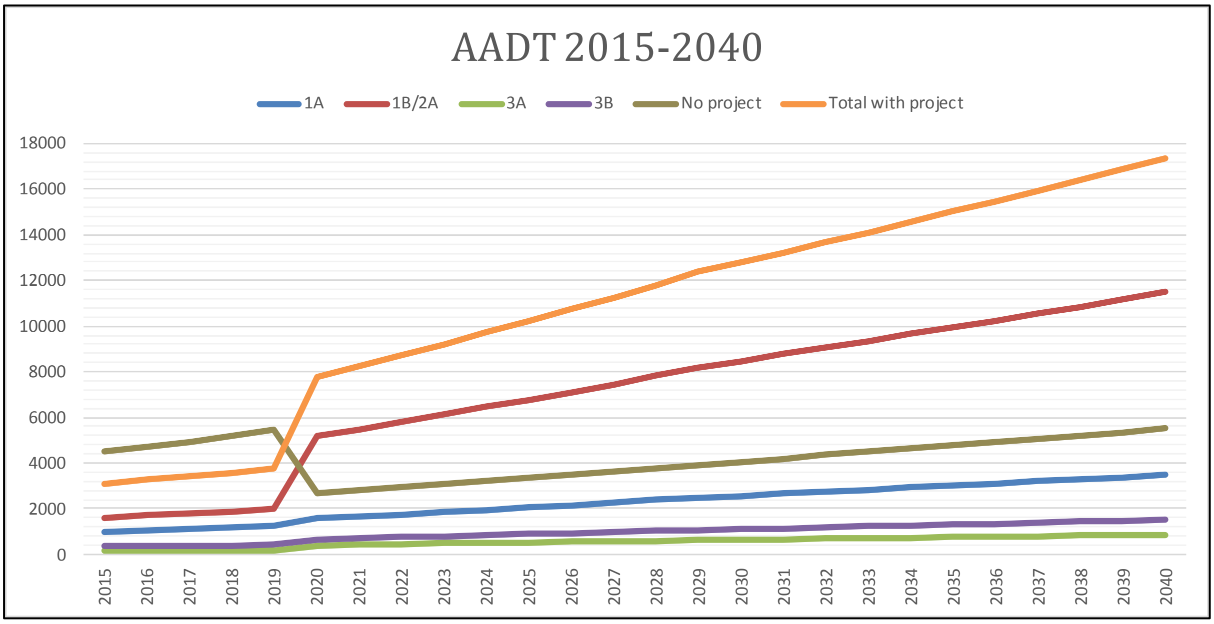


Figure 25: Annual average daily traffic (AADT) with and without the project.

104. As shown in Figure 25, the traffic volumes would grow significantly with the diversion of traffic to the improved road especially at the sections 1 and 2. This is reflected also in the growth of CO_2 emissions.

Table 11: Annual CO_2 Emissions With and Without the Project

	Annual CO_2 emissions (tonnes) without the project				Annual CO_2 emissions (tonnes) with the project			
	2016	**2020**	**2030**	**2040**	**2016**	**2020**	**2030**	**2040**
Section 1	10,473	11,849	16,935	24,644	N/A	30,831	48,137	63,418
Section 2	12,250	15,440	24,540	33,119	N/A	60,033	88,589	97,114
Section 3	1,849	2,812	4,257	5,773	N/A	3,749	6,113	8,127
Total Emissions	**24,572**	**30,101**	**45,732**	**63,536**	**0**	**94,613**	**142,840**	**168,660**

105. Although the growth in total CO_2 emissions is considerable, it should be noted that traffic and emissions will be reduced in other roads from which traffic is diverted into the improved project road. In addition, improvements in road condition contribute to a reduction in net CO_2 emissions.

106. The project road emissions are insignificant compared to total national emissions. According to the Kyrgyz Republic GHG emission scenario[79] with medium population and economic growth, the national GHG emissions would be approximately 15000 Gg CO_2 equivalent in year 2040. The project emissions would constitute about 1 % of the total emissions.

7.1.1. Greenhouse Gas Emissions from the Road Construction and Maintenance

107. The construction and maintenance phases of roads usually constitute about 5% of total life cycle emissions[80]. The construction phase emissions vary according to the type of road constructed and thus their resource intensity. Main emissions are related to earthworks and removal of vegetation, pavement, culverts, structures and road furniture. Below is a World Bank estimation[81] of GHG emissions for different road categories.

Table 12: Typical Breakdown of GHG Emissions by Generator for Various Road Categories **Emissions (t CO_2 eq./km)**	**Expressway**	**National Road**	**Provincial Road**	**Rural Road - Gravel**	**Rural Road - DBST[1]**
Earthworks	161.40	15.89	12.00	2.74	2.68
Pavement	1333.86	424.66	157.30	72.20	85.53
Culverts	238.48	51.45	16.69	11.85	11.57
Structures	1067.99	119.39	20.57	3.03	2.95
Road Furniture	432.40	182.42	0.00	0.00	0.00
Total	**3234.12**	**793.81**	**206.56**	**89.82**	**102.74**

[1]Double Bituminous Surface Treatment.

[79] The Kyrgyz Republic. Intended Nationally Determined Contribution, the UN Framework Convention on Climate Change, 2015.
[80] ADB Evaluation Study: Reducing Carbon Emissions from Transport Projects. July 2010.
[81] The World Bank. Greenhouse Gas Emissions Mitigation in Road Construction and Rehabilitation: A Toolkit for Developing Countries. November 2010.

108. For national roads, GHG emissions from the fabrication and extraction of construction materials represent about 90% of the global emissions. Material transportation is another important emission source. [82]

IX. Adaptation Measures Related to the Climate Change Concerns in Project Planning, Design and Implementation

9.1 Project-related Risk Assessment

109. As it has been stated in previous chapter the impacts of the project related to climate change issues has been analysed to be low or medium risks. The analyzes has been done by road sections and it is presented in the following table.

	Road Section 1	Road Section 2	Road Section 3
Landslides, precipitation	Low risk	Low risk	Medium risk
Landslides, earthquakes	Low risk	Low risk	Medium risk
Avalanches	Very low risk	Very low risk	Medium risk
Floods	Low risk	Low risk	Medium risk
Strong winds	Very low risk	Very low risk	Very low risk
Extreme temperature	Medium risk	Medium risk	Low risk
Drought	Medium risk	Medium risk	Low risk

110. Project design is based on the assessment of the conditions in the project site. There are several proposals related to the project planning, design and implementation which are stated either in environmental impact assessment or in this report.

9.2 Project Planning and Design Phase, Preventative Measures

111. The climate *Project planning phase* should include consideration of materials and construction work also from the point of view of GHG emissions. The choice of especially pavement types can influence the emissions, as listed below.[83] The impact of extreme temperatures on the pavement and their increasing occurrence should also be noted.
Pavement.

(i) Structures based on cement concrete have higher emissions, structures based on bituminous concrete have lower emissions, and composite structures have intermediate emissions. There is a factor from 1.6 to 3 between the higher emissions factors (thick cement concrete layers) and the lower (bituminous structures);
(ii) Structurally optimized pavement structures have lower emissions than the non- optimized pavement structures; and
(iii) Cold mixtures as well as recycling technologies and materials have lower emissions (a factor of three when compared to hot mixture bituminous structures).

[82] Adapted from The World Bank. Greenhouse Gas Emissions Mitigation in Road Construction and Rehabilitation: A Toolkit for Developing Countries. November 2010.
[83] The World Bank. Greenhouse Gas Emissions Mitigation in Road Construction and Rehabilitation: A Toolkit for Developing Countries. Executive Summary. November 2010.

112. The maintenance phase emissions of the road also vary according to the type of pavement, which should be taken into account in the design:[84]

(i) Staged construction seems to lead to significantly higher total emissions and the perpetual pavement strategy seems to lead to slightly lower emissions than standard pavement structure after 40 years, and
(ii) However, the damage factor after 40 years is significantly lower (i.e., better structural condition of the asset) in the case of perpetual pavement.

113. Road structures and road furniture also cause indirect emissions, the amount of which depends on the materials used. In general, steel has a high emission factor that, however, varies according to the steel production (recycling, origin of electricity etc.). When it comes to structures like bridges, the structure type has greater impact for a given material; the more complicated the structure type, the higher the relative emissions. Materials used for barriers should also be evaluated. The use of wooden barriers instead of steel or concrete ones is preferable from GHG emissions point of view, where possible. [85]

114. Project planning should also include the consideration of logistics, so as to avoid any unnecessary transportation. Local materials should be utilized when possible to minimize transportation needs. The Construction Material Investigation of the project includes identification and assessment of material sources in the vicinity of the road, as well as data on existing borrow areas and quarries.

9.3 Construction Phase, Preventative Measures

115. *Project construction phase* emission mitigation options are mainly related to earthworks, the transport of materials, and the use of construction equipment. Efficient road vehicles should be used for transportation to minimize direct vehicle emissions. The planning of logistics need also consider minimum obstruction to the existing traffic, so as to avoid unnecessary delays and thus emissions. Main issues related to earthworks are listed below.[86]

Earthworks

(i) Excavation in hard soil generates two to three times more GHG than in ordinary soil
(ii) The use of drilling rigs rather than light drillers is twice as productive, but produces 35% more GHG per cubic meter of rock excavated.
(iii) Productivity of labor intensive methods is 250 times lower, while involving three times more labor. If labor emissions are considered to be neutral, this is a significant reduction in emissions. However, health and safety aspects need to be considered.

116. The unnecessary removal of vegetation and cutting down of trees should be avoided, so as to avoid emissions. The impact should be mitigated by replanting of trees, which also contributes to carbon sequestration. Renewal of vegetation and slope stabilization is needed also to avoid erosion. The restoration of vegetation on the stripped slopes includes; selection of the fast-growing local types of flora; immediate revegetation of all slopes and banks, if not covered with gabions, and placement of fiber material to allow for seeds to sprout with account to local climate.

[84] Ibid.
[85] The World Bank. Greenhouse Gas Emissions Mitigation in Road Construction and Rehabilitation: A Toolkit for Developing Countries. 2011.
[86] Ibid.

117. It should be ensured that the contractor maintains and services construction equipment to keep it in proper technical condition to control emissions. Such equipment should be subject to regular inspections. Contractor shall also avoid equipment running idle.

118. Recycling of materials generally improves resource efficiency and reduces emissions. This can be quite significant with regard to materials like steel, but also other materials like wood should be re-used or recycled whenever possible. The contractor should also make and follow a waste management plan and avoid any open burning of waste.

119. The impacts of pavement roughness on vehicle GHG emissions can be quite significant, as improvements in pavement roughness can decrease fuel consumption. Proper construction techniques are therefore important to ensure low roughness.

9.4 Project Operation Phase, Preventative Measures

120. *Project operation phase* activities on emission mitigation mainly focus on the maintenance of the road so as to ensure safe and unobstructed traffic. As mentioned before, the road roughness impacts the emissions, so good maintenance of road contributes to minimizing emissions. Maintenance works should be done by using energy efficient vehicles and equipment and by causing minimum interference to the traffic. The works should be scheduled to off-peak times and hours.

121. In the long run, it should also be considered, if public transportation could be promoted. The modal shift from private cars to public transportation would contribute to emission mitigation, especially if energy efficient vehicle fleet was taken into use.