Environmental Impact Assessment

Project Number: 51257-001
April 2019

GEO: North–South Corridor (Kvesheti–Kobi) Road Project

Part 3 (Section C)

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C. Alternatives

C.1 General

310. One of the objectives of an EIA is to investigate alternatives to the Project. In relation to a proposed activity “alternatives” mean different ways of meeting the general purposes and requirements of the proposed activity. The following section provides an assessment of alternative corridors, alignments, transport modes and technologies, as well as the ‘no action’ alternative.

311. Specifically, this section of the EIA Considers:
   a) The ‘No Action’ Alternative
   b) Upgrading of the Existing Road ‘Alternative Zero’
   c) Alternative Corridors and Alignments assessed during Pre-Feasibility and Feasibility Study
   d) Alternative Pavement Types
   e) Alternative Construction Camp and Laydown Areas
   f) Alternative Tunneling Techniques

C.2 The No Action Alternative

312. The “No Action” Alternative in this instance is defined as a decision not to undertake the proposed construction of the Project Road meaning road users would continue using the existing road without any additional upgrades (above and beyond typical maintenance works).

313. The existing road is 35 km long. Between Kvesheti and Kobi it runs through Gudauri ski resort and Jvari Pass (2,400 masl). However, the existing road suffers from a number of technical and safety issues as follows:

- **Alignment:** the parameters are out of the National standard requirements (minimum radiiuses, gradient, super-elevation, junctions, accesses, no population by-passes) and because of it, safety of road users and the local community is jeopardized.

- **Cross-section:** the minimum width of the carriageway/lane or shoulders is not enough at some stretches.

- **Pavement:** bad/very bad condition of the structural section of the pavement and/or the pavement itself.

- **Drainage:** lack of longitudinal/transversal drainage at some stretches. Rain water and debris running onto the road surface which can result in accidents.

- **Cut slopes, retaining walls and protection structures:** Currently in bad condition and do not fully prevent mudflows, rockfalls and/or landslides.

- **Avalanches:** Inadequate avalanche protection tunnels and galleries, meaning some parts of the highway are still exposed to avalanche risk and existing protection does not allow bi-direction movement of HGV traffic as shown in Figure 62.

- **Lack of visibility and/or lighting.**

- **Lack of signalling and/or safety barriers,** for traffic flow and pedestrians.

The “No Action” Alternative would see the continued deterioration of the existing road pavement and its drainage structures and a continuation of the high ratio of accidents noted in Section B.6.

314. In addition to the technical and safety aspects the following significant issues are associated with the existing road:
• The road is often closed due to snow fall during the winter months. From the strategic point of view, this road section has become a key traffic hub in the Caucasus region, the traffic discontinuity is a major impediment to meet the increasing transport demand on the North-South Corridor and harnessing the economical and tourism potential of the region.

• There can be significant congestion on the road especially during the tourist season which leads to degradation of air quality in and around Gudauri which is one of Georgia’s prime tourist destinations during the winter.

• Difficulties maneuvering HGVs, especially in the areas highlighted in Figure 62 below, which leads to a high level of delays and demand affected. The table below further illustrates this issue.

Table 22: Percentage of Annual Demand Affected Due to Prohibition of Traffic

<table>
<thead>
<tr>
<th>Kvesheti-Kobi</th>
<th>Bus</th>
<th>Heavy vehicles</th>
<th>Light vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-2016 annual average delay (hr)</td>
<td>2,351</td>
<td>2,384</td>
<td>1,096</td>
</tr>
<tr>
<td>% of the annual demand affected</td>
<td>34.6%</td>
<td>35.1%</td>
<td>16.1%</td>
</tr>
</tbody>
</table>

Figure 62. Existing Road Conditions

315. Table 23 provides a summary of the operational and construction impacts of the ‘no action’ alternative against the proposed Project.
Table 23: Comparison of No Action alternative and Alternative with a project

<table>
<thead>
<tr>
<th></th>
<th>Positive factors</th>
<th>Adverse factors</th>
<th>Positive factors</th>
<th>Adverse factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural environment:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ambient air</td>
<td><strong>Operation:</strong> An expected improvement of the road’s performance properties and traffic conditions will lead to a reduction in individual vehicle emissions against the no action alternative. Traffic will be smoother, no stop and go related emissions, no waiting with switched engine required, shorter distance – i.e. less fuel consumption (less emissions).</td>
<td><strong>Construction:</strong> Temporary air pollution by exhaust gases from construction machinery and vehicle emissions during transportation of construction materials. <strong>Operation:</strong> Traffic related emissions during operation of the road. However, as indicated later in this report, these emissions are not anticipated to be significant in Khada Valley.</td>
<td><strong>Construction and Operation:</strong> There will be positive impacts for communities in the Khada valley along the proposed new alignment which will not be affected by vehicle emissions during construction and operation, although as noted they are not anticipated to be significant.</td>
<td><strong>Operation:</strong> As traffic volumes grow air quality will be further degraded in the Project corridor, especially in the Gudauri area. Increased air emissions will be generated during acceleration and deceleration of vehicles and slow-moving traffic due to the complexity of the existing alignment and the poor throughput of tunnels will lead queuing related emissions as cars engines idle.</td>
</tr>
<tr>
<td><strong>Acoustic impact</strong></td>
<td><strong>Operation:</strong> Noise levels in the Gudauri area, a significant tourist area, will be reduced. In addition, the proposed bypass around Kvesheti will reduce noise levels to an extent in the village if adequate mitigation measures are installed as discussed later in this report.</td>
<td><strong>Construction:</strong> Short term localized noise impacts related to construction works will impact upon local residents. However, many of these impacts can be mitigated by the measures outlined in this EIA, e.g. through correct siting of camps and time and activity restraints. <strong>Operation:</strong> Operational noise levels may increase in the valley area, but the number of receptors is low, and the mitigation measures proposed as part of this EIA will ensure that all identified receptors are below national and IFC guideline limits for noise.</td>
<td><strong>Construction:</strong> There will be positive impacts for communities in the Khada valley along the proposed new alignment which will not be affected by construction noise.</td>
<td><strong>Operation:</strong> Noise levels in the tourist area of Gudauri will continue to increase which will have a potentially negative impact on tourism. Noise levels in Kvesheti will also continue to increase in the center of the village, thus having potentially negative impacts on residents.</td>
</tr>
<tr>
<td><strong>Natural environment:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>soils, land resources, surface and ground water, vegetation/flora and fauna</td>
<td><strong>Operation:</strong> Moving road farther from protected area boundaries.</td>
<td><strong>Construction:</strong> New development in a greenfield area. Risk of impact on land and water resources during construction. Removal of vegetation within the road easement area. Impact/disturbance of fauna. However, most of these impacts can be mitigated via the recommendations made in this EIA and proactive</td>
<td><strong>Construction and Operation:</strong> The no action alternative has significant benefits in the Khada valley in terms of biodiversity where forests will remain untouched and there will be no disturbance to fauna.</td>
<td><strong>Operation:</strong> Roadkill on the existing road will continue, and this may lead to vehicle accidents as cars swerve to avoid animals on the road. The environment adjacent to the existing road will continue to be degraded by high noise levels and garbage which is scattered along the road.</td>
</tr>
</tbody>
</table>
### Socio-economic environment

<table>
<thead>
<tr>
<th>Positive factors</th>
<th>Adverse factors</th>
<th>No Action Alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction</strong>: Creation of jobs in an economically depressed area. <strong>Operation</strong>: Reduced number of road accidents. Reduced travel time. Improvement of access to the villages that used to be cut off in winter. Development of roadside services and entrepreneurship. Creation of new jobs related to road maintenance services. Improvement of the region’s social and economic performance. Improved cargo traffic and traffic safety in particular in winter season. Potential improved tourism potential in Khada valley for winter sports, use of the new bridge, mountain biking and hiking. Potential to make living in villages viable all year round.</td>
<td><strong>Construction</strong>: Short term noise, air quality and vibration related impacts during construction. Temporary deterioration of transport conditions during the construction phase. <strong>Operation</strong>: Landscape-visual impact, although this is subjective.</td>
<td><strong>Construction</strong>: No construction related impacts such as noise and vibration. <strong>Operation</strong>: No landscape-visual changes. No loss of property or livelihood for residents.</td>
</tr>
<tr>
<td><strong>Operation</strong>: Persisting problems with traffic and accessibility in winter. The expenses to repairing the existing road.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
C.3 Upgrading of the Existing Road (Alternative Zero)

316. The upgrading of the existing road, referred to in this report as ‘alternative zero’ has been assessed from a technical, financial and socio-environmental perspective. The following section describes why this alternative has not been selected.

Technical Aspects

317. As noted in Section C.2, there are a range of technical and safety issues relating to the existing road. Technically, it is possible to upgrade the existing road, but it will not resolve the key issues described below.

318. It is possible to upgrade the pavement, add safety barriers, slightly upgrade the alignment at some curves (small enhancements at some points) and provide a few galleries. These actions would not have a significant impact to the landscape/local communities along the existing alignment. But functionality and safety of the road would remain at the same levels. It is possible to accommodate drainage, safety barriers, pavement within the existing road; but not a relevant change avoiding high gradient, U-turns or going through Gudauri.

319. In order to significantly upgrade the safety and functionality of the existing road the current alignment would need to be significantly changed, enhancing the gradient, minimum radius, cross section (enough space), visibility, etc.

320. This would result in a completely different scenario to what is currently seen. Deep cut-slopes, junctions, tunnels, and bridges would all be required which would have a significant impact on the landscape and the local communities.

321. Further, to ensure no road closures because of adverse weather conditions in the winter (snow) something similar to a continuous gallery would be required for a long stretch (several kilometres, with a combination of tunnel and gallery). The end result would be very similar to a long tunnel after completion of the construction, but there would be significant construction impacts during this period, even more significant than constructing a tunnel on its own.

322. Given the fact that there is no alternative route to Kobi from Kvesheti (and no detour route) the construction period, of several years, would have huge impacts on road users and the local community as portions of the road are closed to allow for construction works. This could have significant impacts on the local economy for a number of years, including the Gudauri tourist area.

323. In this scenario the impact on the landscape and environment is also significant as well as the required investment. Even with these works completed, the functionality would still be lower than the proposed Project (as the alignment must still go up and down from the Jvari pass).

324. Alternative Zero was also assessed from a geological perspective. The alignment of the existing road is located in areas of medium and significant geological risk as shown in Figure 63.
Figure 63: Geological Risks in the Project Area

Note: this picture belongs to the Pre-feasibility stage; after that, the Khada valley alternative was enhanced by modifying the alignment (in advance of Begoni, Tskere) and providing some extra tunnels & protection structures to avoid geological risks at the outside road.

Financial Aspects

325. Alternative Zero was also analysed at pre-feasibility stage from a cost benefit perspective. In all the cases, the proposed Project (which formed the preferred alternative) provides an Economic Internal Rate of Return (EIRR) > Social Discount Rate (SDR), which means that social returns for the project justifies the use of resources being proposed (for the purposes of the CBA, following World Bank suggestions a SDR, of 8.0% was used in the economic analysis as Georgia as a potential cohesion country). Therefore, alternative zero was not considered prudent.

326. Previous studies clearly demonstrated the viability of the current investment, as well as defining the general lines of action, all in accordance with the technical professionals of the Georgia Department of Roads, and the involved international financial institutions (World Bank, Asian Development Bank and European Bank for Reconstruction and Development).

Environmental Aspects

327. Around 8 km of Alternative Zero is in the limits of the SPA/IBA area (see Section E.2 for more details of these areas, and Figure 64 for a map of the affected area). This area of the existing road suffers from a significant waste management issue as road users empty literally tonnes of garbage every year along the portion of the road in the SPA/IBA area. Continued use of the existing road would see this situation endure and degradation of the SPA/IBA environment continue. Crucially, the proposed Project avoids this area by tunnelling under the SPA/IBA for much of its extent in its northern portion and the resulting footprint within the SPA/IBA is much smaller than for the Alternative Zero.

328. The existing road is also located along a bird migration corridor, that goes along the Tetri Aragvi river close to portions of the fragmented Kazbegi National Park. The proposed Project follows the Tetri Aragvi river for a much shorter portion thereby reducing potential impacts to this area and the newly extended Kazbegi National Park.
Alternative Zero would also involve many of the environmental impacts identified with the ‘do nothing’ scenario above, e.g. noise levels and air emissions would increase in the built-up areas of Kvesheti and Gudauri.

Given all of the above constraints Alternative Zero was ruled out for further consideration.

C.4 Alternative Road Corridors and Alignments

Introduction

This section of the EIA sets out the process that resulted in the selection of the alignment for the proposed road that is now being prepared for implementation.

At the outset of the project study, based on initial map assessments, it was generally understood that there would be two possible broadly defined locations for the proposed project road: (i) close to the existing road alignment through the Gudauri valley; and (ii) along a new alignment to the east, through the Khada valley. Presented below is the sequence of studies and decisions that ultimately led to the project road being located in the Khada valley.

The studies commenced with a pre-feasibility study (PFS) that assessed nine (9) alignments in three (3) specific corridors within both valleys. The PFS continued to refine the alternatives finally selecting four (4) potentially possible alignments in three (3) corridors. These alignments were further assessed during the PFS via a comprehensive multicriteria analysis approach that took into account three groups of criteria, briefly (i) functionality from...
terrain and geological, traffic, local population access, and operational perspectives; (ii) economic and financial considerations for both construction and long term operations and maintenance considerations; and (iii) environmental and social aspects from biodiversity, surface water, protected areas, and other related perspectives.

334. The results of the analysis of alternative alignments are presented below, with the results for the environmental and social aspects criteria group set out in a detailed table. The outcome of the process was a rational and evidence-based decision that the proposed road alignment should be in the Khada valley, between Kvesheti and Kobi, and that it should include an 8 km long tunnel through the mountain range between Tskere and Kobi.

Pre-feasibility Stage

Inception / Interim Phase

335. During the pre-feasibility study (PFS) of the Project the process of selecting the road alignment was initiated. Given the complex topography, presence of the aforementioned protected areas and geological conditions in the Project area the number of feasible alternative corridors and alternative alignments within those corridors was limited.

336. Nine alternatives were considered during the initial stages of PFS preparation (Inception and Interim phases of the PFS). Depending on the design speed, these options were bundled into three alternative corridors with two design speeds:

<table>
<thead>
<tr>
<th>Table 24: Design speed by alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corridor</td>
</tr>
<tr>
<td>I</td>
</tr>
<tr>
<td>II</td>
</tr>
<tr>
<td>III</td>
</tr>
</tbody>
</table>

Pre-feasibility phase included the production of several reports discussing potential alternatives, including the Inception Report, Interim Report, Draft Pre-feasibility Report and Final Pre-feasibility Report. Through this phase the alternatives were continually refined.
Figure 65: Alternatives for design speed 60 km/h
Figure 66: Alternatives for design speed 80 km/h
337. The following tables describe each of the alternatives illustrated above within its respective corridor.

**Corridor I**

<table>
<thead>
<tr>
<th>Alternative Alignment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Corridor 1 follows the river valley at its left side for a 60 km/h speed. The first stretch of the alternative consists of an upgrade of the existing road from Kvesheti to the zig-zag of Gudauri. From this point on, it is proposed a new alignment along the riverside, going ahead with 7% slope for 5 km and entering an 8.4-km length tunnel (level S portal 1930, N portal 2020). The main challenges are the landslides and the rock falls, and also the alluvial fans from the transversal valleys.</td>
</tr>
</tbody>
</table>

**Corridor II**

<table>
<thead>
<tr>
<th>Alternative Alignment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Corridor II goes up to the Gudauri area by lifting to the Kvesheti plateau from the existing road. Both alternatives, 2 and 3, have the same alignment to access to the top of the plateau. According to the existing slopes of the plateau, the best way is continuing upstream along the current road and then cross the river and turn back downstream and going up in the slope at the same time. The access way to the plateau sums up the opposite slopes: alignment from 1.6% to 6.8% up and plateau 3.5% down. Once there, the alignment continues along the Gudauri area. Alternative 2 presents a shorter outside road and enters a 11.3-km long tunnel, S portal at level 1,860 m and N portal at 1,920 m, rounding to the left the volcanic cone and the contact aureole. The main challenge is to avoid the volcanic cone and the contact aureole. Starting from the same first stretch, Alternative 3 runs outside for longer than 2, and because of that the tunnel for this proposal is shorter (10.0 km) and the portals higher (2,200 m), rounding the volcanic area to the right. Both alternatives, 2 and 3, are designed for 60 km/h</td>
</tr>
<tr>
<td>3</td>
<td>The main challenge is to avoid the volcanic cone and the contact aureole. Starting from the same first stretch, Alternative 3 runs outside for longer than 2, and because of that the tunnel for this proposal is shorter (10.0 km) and the portals higher (2,200 m), rounding the volcanic area to the right. Both alternatives, 2 and 3, are designed for 60 km/h</td>
</tr>
</tbody>
</table>

**Corridor III**

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Alternative bypasses Kvesheti by cutting the slopes and valleys behind the population (far from the river). On one hand this is a challenge from the geotechnical point of view, because of the landslides; but on the other hand, this allows the alignment to gain enough level to cross the river and enter the plateau. A 700-m long bridge with piers of height over 100 m would be required. Probably an arch bridge would fit for this situation. From the plateau on, the alignment remains at the same side of the Tskere valley, going up with a continuous slope of 7%. The high level of the alignment reduces the length of the tunnel, in this case to the shortest one (4.7 km). The portals are located at level 2,260 m (S) and 2,230 m (N).</td>
</tr>
<tr>
<td>5</td>
<td>Alternative is based on Alternative 4. Only differs for the Kvesheti bypass and the entrance to the south portal of the tunnel. The proposal crosses the river from the back of the population in a direct way by a 1-km long viaduct (high piers over 100 m). The slope of the elevation profile varies from 5% to 7%. The tunnel is 7.2-km long and the portal are located at levels 2,100 (South) and 1990 (North).</td>
</tr>
<tr>
<td>6</td>
<td>Alternative 6 continues upstream along the current road and after Kvesheti crosses the river and turns back downstream, lifting to the plateau (advantage of opposite slopes) and rounding it with an average slope of 6%. The alignment enters the Tskere valley crossing from one side to another to better adapt to the topography. Some bridges appear to be necessary, one of them around 0.5 km long and over 100 m of pier height; an arch seems to be a proper solution. The proposal finally enters an 8.2-km long tunnel, with a continuous slope. The South portal is located at level 1,870 m and the North at 1,980 m. Design speed 60km/h.</td>
</tr>
<tr>
<td>7</td>
<td>The alternative 7 avoids the population of Kvesheti by crossing in advance the river to the opposite side. The proposal is to gain enough elevation to jump to the plateau with a 550-m long bridge (height of piers around 80 m). The alignment connects to the Alternative 4 at the entrance of the Tskere valley. The proposed tunnel is 7.0-km long and the portals are located at level 2,100 (South) and 2,020 (North) respectively.</td>
</tr>
</tbody>
</table>
Alternative 8
The corridor lifts the alignment to the Kvesheti plateau and from there enters to the Tskere valley. Located at the other side of the Corridor with a completely different approach to the Kvesheti plateau. Before entering this village, the alignment crosses the river and starts going up steeply (7%) surrounding the corner mountain; because of that it does not require significant bridges. Once in Begoni plateau, the proposal continues upstream forward than Alternative 6, to finally entering a 6.7-km long tunnel at level 2,000 m (South portal) and ending at level 1,970 m (North portal).

Alternative 9
Alternative 9 bypasses Kvesheti close to the mountains, cutting the slopes and valleys behind the village. The alignment crosses the river upstream and turn back downstream at the other side, going up with an opposite slope to the plateau, which is an effective method to get the top. From the plateau on, the alignment enters the Tskere valley, changing from side to side in order to avoid the geotechnical problematic slopes. It would be required a 370-m long bridge (high piers over 120 m). An arch bridge is considered to suit for this proposal. The alignment continues for 5 km with a continuous slope of 7% to finally enter a 6.8-km long tunnel. The South portal is located at level 1,990 m and the North at 1,980 m.

Draft / Final PFS Phase
338. As the PFS progressed into the draft and final PFS phase these nine alternative alignments were narrowed down for further study into four alternatives each comprising one alignment.

339. The main assumptions to be considered for designing the alignments were:
- To avoid a three-lane long tunnel, which requires that the gradient be less than 2% in advance to the portal.
- To locate the long tunnel out of the influence of the volcanic cones and the related contact aureole zones (geological constraints).
- To set the long tunnel portals under the 2,000 m level (for better winter maintenance conditions).
- To avoid areas of debris deposits and landslides; and generally, to avoid deep cut slopes in the hillsides defined as geologically non-stable.
- To minimize the third lane length for the road generally (depending on the gradient and the lengths of the road sections).
- To bypass the existing populations for the 80 km/h design speed.
- To set a design speed of 80 km/h both for the long tunnel and other structures (whatever the design speed would need to be for the remaining sections of the road alignment).

340. Based on these assumptions, 4 alignment alternatives were developed across three corridors, differing in their way to access from Kvesheti (level 1,300 m) to the long tunnel portal (around 2,000 m). These alignments are described below, and illustrated in Figure 67 following.

341. **Alternative 1** runs through the Tetri Aragvi riverside, improving the alignment of the current road and adopting the Kvemo Mleta bridge and some other minor structures. From the starting point of the zig-zag curves to Gudauri, there would be a new alignment at middle height of the hillsides. This requires a continuous sequence of bridges going up to the south portal of an 8.4 km length tunnel, located under the Jvari Pass in the Gudauri area. After the north portal, the new alignment connects to the existing road for 2 km.

342. **Alternative 2** follows upstream of the existing road for 3 km; after passing Arakveti it crosses the Tetri Aragvi river and turns down in the opposite direction. The alignment goes up cutting the front hillside in order to get the Kvesheti plateau, where it then turns down again
(big S curve) towards the Gudauri area. The tunnel is 11.4 km long and connects to the existing road close to Kobi.

343. **Alternative 3** bypasses Kvesheti at the riverside and goes up to the Kvesheti plateau in a very similar way to Alternative 2 but adopting bigger parameters for the alignment geometry in order to provide an 80 km/h design speed. After that, it enters the Khada valley, changing from one side to another according to the geotechnical conditions as far as Tskere where it enters the south portal of an 8.0 km length tunnel.

344. **Alternative 4** bypasses Kvesheti and winds up to the Kvesheti plateau similarly as Alternative 3 but going up quickly with higher grades. Once along the Khada valley the road switches from one side to the other for the most advantageous geotechnical conditions up to Tskere where it enters the south portal of an 8.0 km length tunnel.

**Figure 67: Pre-feasibility Study Alignment Options**

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**Multi-criteria Analysis**

345. The alignments were further assessed based on a multi-criteria analysis approach (MCA). International standards (such as UK DMRB\(^\text{14}\)) have been followed for defining alignment selection criteria. The MCA assessed three broad criteria:

- **Functionality**, including: a) alignment features, b) estimated traffic at opening, c) travel time for vehicles, and c) population served.

- **Economic considerations** including: a) total investment cost, b) total maintenance cost including winter maintenance and potential closures, and c) economic benefits.

- **Environmental and social aspects** including: a) biodiversity, b) surface water, c) ground water, d) protected areas, e) soils, f) landscape, g) resettlement and social factors, and h) road safety – summarised in the Table 25 below.

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\(^{14}\) [http://www.standardsforhighways.co.uk/ha/standards/dmrb/index.htm](http://www.standardsforhighways.co.uk/ha/standards/dmrb/index.htm)
### Table 25: Pre-feasibility MCA Summary – Environmental and Social Aspects

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Phase</th>
<th>Alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expected to affect a protected area. High risk should be considered.</td>
</tr>
<tr>
<td>Protected Areas</td>
<td>Construction and Operation</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alternatives 2, 3 and 4 impact is expected.</td>
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<tr>
<td></td>
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<td>3</td>
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<tr>
<td></td>
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<td>bypass the mentioned protected area, so no direct</td>
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<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>risk should be considered.</td>
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<tr>
<td>Spoil Disposal</td>
<td>Construction</td>
<td>Amount of spoil is slightly higher than for alternative 3 and 4. Impact is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ranked as medium. Risk of other impacts (pollution with spilled fuel/oil,</td>
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<tr>
<td></td>
<td></td>
<td>waste water, littering) is similar as for other alternatives</td>
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<tr>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Longest tunnel, i.e. amount of spoil is highest compared to other</td>
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<tr>
<td></td>
<td></td>
<td>alternatives. Impact related to disposal of spoil is ranked as high. Risk</td>
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<tr>
<td></td>
<td></td>
<td>of other impacts (pollution with spilled fuel/oil, waste water, littering)</td>
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<tr>
<td></td>
<td></td>
<td>is similar as for other alternatives</td>
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<td></td>
<td>4</td>
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<tr>
<td></td>
<td></td>
<td>The tunnel is the shortest, i.e. amount of spoil is lower</td>
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<tr>
<td></td>
<td></td>
<td>compared to other alternatives. Impact is ranked as low.</td>
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<tr>
<td></td>
<td></td>
<td>Risk of other impacts (pollution with spilled fuel/oil, waste water,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>littering) is similar as for other alternatives</td>
</tr>
<tr>
<td>Landscape</td>
<td>Construction</td>
<td>Medium visual impact related to the new infrastructure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Similar as for other alternatives</td>
</tr>
<tr>
<td>Resettlement and Social Considerations</td>
<td>Construction</td>
<td>Medium visual impact related to the new infrastructure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Similar as for other alternatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium visual impact related to the new infrastructure.</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Impacts related to nuisance caused by dust, emissions and noise/vibration is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>low. The scale of resettlement needs to be specified at subsequent stage of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>assessment. Presumably low impact.</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>
# Environmental Impact Assessment for the Kvesheti-Kobi Road Section

<table>
<thead>
<tr>
<th>Operation</th>
<th>Medium impact, depending on location, is expected during operation of the road. Impact will be observed in Kvesheti and Kvemo Mleta areas.</th>
<th>Impact related to dust, emissions, noise, vibration is expected in the stretches located close to alignment. Impact on Kvesheti and other settlements crossed by alignment will be the case. Impact is ranked as Medium.</th>
<th>Medium to low impact related to dust, emissions, noise, vibration is expected in the stretches located close to alignment.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road safety</td>
<td>Operation</td>
<td>As a conclusion, the higher speed the more severity for the drivers. In this sense, design speed of 60 km/h (Alternatives 1 and 2) would be better than 80 km/h (Alternative 3 and 4). But on the other hand, Alternatives 1 and 2 do not avoid all the population areas (Alt.-1: Kvesheti and Kvemo Mleta; Alt.-2: Kvesheti), so it is assumed that pedestrian casualty for these alternatives would be potentially higher.</td>
<td></td>
</tr>
<tr>
<td>Biodiversity</td>
<td>Construction</td>
<td>Most of alignment runs through tunnel. Alignment might affect a protected area. Impact on flora and fauna is ranked as high</td>
<td>Most of alignment runs through tunnel. Moderate impact on biodiversity in the sections where forest is crossed.</td>
</tr>
<tr>
<td></td>
<td>Operation</td>
<td>Keeping in mind sensitivity of the area according to preliminary evaluation impact is ranked as high</td>
<td>To protect wildlife and cattle from road accidents safety barriers can be used to reduce the risk of impact. Mitigation measures to avoid noise impact will be introduced. According to preliminary evaluation impact is ranked as medium</td>
</tr>
<tr>
<td>Surface Water</td>
<td>Most part of the section will go via tunnel. Impact on surface water may be observed only in the starting section of the new alignment. According to preliminary estimate impact is ranked as low.</td>
<td>No impact on surface water expected.</td>
<td>Most part of the section will go via tunnel. Impact on surface water may be observed only in the starting section of the new alignment. According to preliminary estimate impact is ranked as low.</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Construction</td>
<td>Impact on ground water may occur during construction of tunnels in case the ground water aquifer is crossed. There are springs along alignment at various distances from the RoW. According to preliminary estimate none of them is located in the impact zone. However, for avoidance of impact, mitigation measures will be identified on case by case basis.</td>
<td>No impact on ground water is expected during operation of the road and tunnel.</td>
</tr>
</tbody>
</table>
Overall, the MCA concluded that the preferred alternative is Alternative 4: through the Khada valley which permits a design speed of 80 km/h.

Specific Geotechnical Issues that informed the alignment selection

As part of the PFS a detailed analysis of the geotechnical aspects of the four alignment alternatives was prepared that fed into the MCA. The conclusions of the analysis were that the only feasible long tunnel option is the one that has its southern portal in Tskere. The other options, such as Alternative 2, are considered beyond an acceptable geological risk level and could result in tunnel construction failure, an “unaffordable” risk not just in terms of financial aspects, but also safety.

Regardless of the risk ranking provided in the geological risk maps below (Figure 63 it is important to distinguish between unaffordable risks and any other ranked risks (from low to high). For the road section outside of the tunnel, avalanches are considered an “affordable” risk; the method to cope with this risk is providing protection structures (cut and cover tunnels, galleries).

However, for the road section outside the tunnel, landslides are an unaffordable risk; there is no option to stop them, whatever the level of investment or the proposed protection structures. There is only one way to solve this issue; move the alignment into a different location. There are specific relevant examples of landslides at the existing road from Kvemo Mleta upstream. For this reason, the road has been designed to bypass Kvesheti at the riverside and not at the back, close to the mountains; and the reason for the arch bridge changing from one side to the other at Khada valley, e.g. to get away from hillsides ahead of Zakatkari (at this side of the Khada valley).

350. Something similar occurs when considering the location of the main tunnel. In this sense, for the tunnel, materials coming from a volcanic eruption (and affected because of that) are revealed as a serious issue for the feasibility of the tunnel as shown in Figure 69 below.
351. Focusing specifically on the Alternative 2 corridor located near Gudauri (particularly following feedback from two NGOs), the following risks were identified:


- Stability of Cretaceous rocks (black shales) or squeezing characteristics of ampelite shales. This is related to poor properties of the materials coming from the volcanic eruption (and affected because of that). Considering the high overburden, this results in serious risks for the completion of the tunnel. High risks of construction safety and extreme risk of irreversible entrapment of the tunnel boring machine, which goes beyond significant expense or delay: the probability of a tunnel construction failure becomes relevant. This is the key point.

- Ground water inflows and rock falls in Jurassic limestones. Low risk.

- The tunnel intersects a regional fault related to a thrust fault between the Jurassic and the Cretaceous Succession, with potential risk related to ground water or weak materials. Medium risk of construction delay and additional cost, but since this is located over a small stretch, this is not a major issue.

352. In contrast to Alternative 2, the geological risks for the tunnel of Alternative 3 and 4 (located adjacent to Tskere) are lower. The Alternative 2 tunnel is 40% longer (meaning a much larger investment), requires heavier support (again, larger investment) and the risk of construction failure or additional costs is much greater.

353. In summary, based on the above analysis the Alternative 2 tunnel presents an unacceptable level of risk, and could not be recommended for the project.

354. Accordingly, the Khada valley option through Tskere presents the only technically and financially feasible option.

355. Therefore, the final conclusion of the geotechnical aspects of the PFS was that Alternative 3 and 4 (via Tskere tunnel) were the most safe, feasible and low risk options for the
Environmental Impact Assessment for the Kvesheti-Kobi Road Section

main tunnel, considering the geological complexity, the investment and the construction success.

356. From this point on, the feasibility study then focused on developing the alignment of the road in the Khada valley, to avoid natural hazards (landslides and avalanches), minimize environmental and social impacts and to ensure efficient operations and sustainability.

Feasibility Stage

357. At the Feasibility Study phase Alternative 4 was assessed further and three further alternatives were developed that broadly correspond with the Alternative 4 selected in the PFS. The following figure illustrates these three alternatives.

Figure 70: Feasibility Study Alignment Alternatives

358. Alternative 1 is 22.10 km long bypassing Kvesheti at the riverside and goes up to the plateau crossing the existing road, the Aragvi river and the crest of the plateau by means of 3 long bridges, between 264 and 555 m. After that, it enters the Khada valley, changing from one side to another according to the geotechnical conditions. The highest bridge (169 m) is located on the Khada river to cross to the left bank and 4 more bridges are necessary up to reach the plateau of Begoni. After that another bridge is located to cross the river again changing to the right bank up to Tskere where it is placed the portal of an 8.1 km length tunnel.

359. Alternative 2 is 21.97 km long and it bypasses Kvesheti in the same way and goes up to the plateau crossing the existing road, the Aragvi river and the crest of the plateau by means of 3 long bridges, but reducing the length of the bridge at the crest from 430 m to 136 m, this is due to the displacement of the route towards the plateau increasing the high of the slopes. After that, it enters the Khada valley through the highest bridge (173 m) located on the Khada river to cross to the left bank and 3 more bridges and a tunnel are necessary up to reach the plateau of Begoni. Finally, another bridge is located to cross the river again changing to the right bank up to Tskere where it is placed the portal of an 8.1 km length tunnel.

360. Alternative 3 is 22.61 km long and it begins in the by-pass to Kvesheti as the previous alternatives and goes up to the plateau crossing the Aragvi river by one bridge 492 m long. Beyond the bridge there is a portal tunnel in the slope of the plateau that reach the top in a smoothly way, with a gradient of 4.5 %. Then, it enters the Khada valley through the highest bridge (164 m) located on the Khada river to cross to the left bank and 3 more bridges and 2 more tunnels are necessary on the lateral gorges up to reach the plateau of Begoni. From this point another bridge crosses over the river changing to the right bank up to Tskere where it is placed the portal of an 8.87 km length tunnel.

Detailed Design Alternatives

361. At the detailed design stage, Alternative 3 was developed further.
Some changes to the alignment were made in order to; a) reflect new environmental legislation (Since 2014 environmental legislation has changed. Some of laws, regulations and policy documents in the area of biodiversity (listed in Annex II to the referred strategy document) have been updated, revised. As example – Environmental Assessment Code was adopted.), b) reduce risks and impacts, and c) improve the safety of the alignment. The main changes were made in Kobi-Tskere (Lot 2) section.

**Kvesheti-Arakveti section**

In the starting section of the road two options were considered:

- Bypassing residential area closer to the mountains (not shown on the drawings given above).
- Bypassing Kvesheti by diversion of the traffic to the strip between the settlement and the river.

The first option was discarded because of geological risks (sequence of landslides, debris deposits and non-stable hillsides). In addition to that, the need of heavy supports and retaining structures leading to significant visual impact backed the decision. Based on hydrological analysis carried out by the Design team alternative 2 was found to be feasible. The option allows to use the space between the residential area and the new road for spoil disposal. After planting of the area with vegetation 5ha of green new space will be created. This will provide better protection of the village from impact during high water events and, on the other hand, act as a green barrier reducing noise in the residential quarters. Note: implementation of flow modelling in this section is required to ensure that the change of hydrology after the change of the riverbed shape has no impact (does not cause scouring/erosion) on the area on the opposite side of the river.

**Access to the plateau on the other bank of the river**

Option including bridge and the road to access the plateau was ‘replaced’ with tunnel alternative (blue one) to ensure better safety in winter. The tunnel was considered preferable from the view of visual impact. Use of the tunnel will help to reduce: the need of deep cut slopes; the scale of the impact on vegetation; the length of the stretch where during operation of the road impact on soil quality may occur; as well as disturbance of wildlife (the blue one represents the final design).
Figure 72: Access to the Plateau

Note: alignment considered in Feasibility Stage (yellow line) vs Final Option (blue line)

Zakatkari section.

366. This realignment moves the road further from the protected areas and reduces the curves which may have safety impacts. (the blue one represents the final design).

Figure 73: Enhancing the Minimum Radius for Connection to Gudauri

Note: alignment considered in Feasibility Stage (yellow line) vs Final Option (blue line)
Begoni section

367. With consideration of the rugged terrain and risk of landslides and avalanches in the area cutting slope was considered as non-advisable. To minimize geotechnical risks, the option with a range of bridges was substituted with a sequence of tunnels.

Figure 74: Previous Version (left) and Proposed alignment (right) at “Begoni Curves”

368. The alignment has been shifted towards the border (minimum distance from the edge 5m) of the cliff to minimize disturbance of population.

Tskere section

369. Alternative bypassing Tskere farther from the west (yellow alternative) with tunnel starting north to the village is longer. Respectively higher is its visual impact and impact on Tskere residents caused by noise and emissions from the road. Besides, the ‘open’ road alignment is under higher risk of avalanches.
370. To minimize cut slopes and avoid the mention problems, the tunnel entrance was moved away from the village. The tunnel will start with a cut and cover section. The surface of the C&C tunnel will be replanted to merge with the background environment and minimize visual impact. The arrangement of the tunnel will reduce noise and emission related impacts on Tskere residents. Safety risks associated with avalanches will also be avoided.

**Figure 75: Tskere Area**

![Figure 75: Tskere Area](image)

Note: alignment considered in Feasibility Stage (yellow line) vs Final Option (blue line)

371. An alternative location of the junction closer to Mughure-Tskere was considered (see Figure 76). However, considering the landform, available space, technical requirements for the road, use of the junction, proximity to the residential areas and the expected scale of impact on environment, and despite the size of the junction, the current design was considered as preferable (see Figure 31 for the final design).

**Figure 76: Junction alternative**

![Figure 76: Junction alternative](image)
Kobi section

372. The last stretch of the tunnel has been reshaped to reduce interference with gas pipelines. The alignment has been adapted to the current road with a maximum gradient of 4.2% to keep on using the existing bridge.

Figure 77: Kobi Area

Note: alignment considered in Feasibility Stage (yellow line) vs Final Option (blue line). Image is an old version which does not show the existing new road alignment as per Figure 19.

C.5 Alternative Transport Modes

373. Rail is cost-effective as a means of transporting bulk goods (coal, fuel, aggregates etc.) over long distances, or containers from port to port. There is no indication that there is demand for transporting bulk commodities along the project road corridor in anything like the quantities needed to create a viable service. The costs of developing a rail link have not been estimated but would be extraordinarily high.

374. The feasibility study origin and destination surveys revealed that the origins of northbound traffic at Jinvali and proceeding to Russia were almost equally split between Armenia and Georgia. The destinations of southbound traffic at Larsi originating in Russia (including Belarus and Ukraine) were, similarly, almost equally split between Armenia and Georgia. Consequently, at least half of the existing freight traffic cannot be routed by rail. Accordingly, rail is not a viable alternative option to the proposed Project.

C.6 Alternative Pavement Types

375. Asphalt and concrete pavement types have been considered. Priority was given to asphalt. This type of pavement has been chosen for the following reasons:

- less noise during operation – compared to concrete (less nuisance to the residents and wildlife);
- less vibration compared to the concrete (significant factor to consider, keeping in mind presence of the buildings construction without mortar);
- better visibility of horizontal marking on asphalt surface (safety consideration)
- better efficiency in snow/ice melt conditions;
- recyclability of material.

376. However, the other types of payment will also be used for other portions of the road:

- The pavement of the emergency galleries will be concrete, since the traffic along the gallery will be circumstantial.
- Concrete will be used on the high slopes (>12%) due to the constructive limitations to asphalt on high slopes.
- For local diversions with very low traffic, that are nowadays paved with asphalt and gravel the same type pavement will be restored.

**C.7 Alternative Construction Camps and Laydown Areas.**

377. The locations of these facilities are not currently known. The Contractor will choose the sites which will need to follow the guidelines for siting and permitting as outlined in this EIA, including consultations with local residents. Employment of local labor force will reduce the need for a large construction camp size.

378. A range of auxiliary facilities during construction will include:

- Concrete batching plants and casting yard
- Pre-cast yard for piers and viaducts
- Laydown areas for tunneling and other equipment
- Materials storage areas
- Truck/vehicle parking areas
- Waste storage areas
- Construction Camps

379. The number, location, size and layout of these facilities will be specified by construction company. The EIA provides recommendations for site selection and mitigation of impacts. The Contractor will be responsible to prepare and submit Site installation layout plan, Construction camp layout plan and Construction Camp Management Plan for approval by RD, MoEPA and the Lenders. (See Section F for additional information).

**C.8 Alternative Tunneling Techniques**

380. Various tunneling option have been compared. The list includes:

- cut and cover,
- drill and blast,
- boring (using Tunnel Boring Machine (TBM)),
- NATM (sequential excavation – New Austrian Tunneling Method).

381. Advantages and shortcomings of methods are given below (). (Note: technical risks are not considered within this assessment).

<table>
<thead>
<tr>
<th>Method</th>
<th>Description of works</th>
<th>Disadvantage/shortcoming</th>
<th>Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut and Cover</td>
<td>Works include:</td>
<td>Dust along the C&amp;C alignment</td>
<td>Negligible vibration compared to other methods</td>
</tr>
<tr>
<td>(C&amp;C)</td>
<td>trench excavation,</td>
<td>Noise along the C&amp;C alignment</td>
<td>Efficient for shallow tunnels</td>
</tr>
<tr>
<td></td>
<td>tunnel construction</td>
<td>Visual impact during construction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>soil covering</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>excess material removal/disposal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method</td>
<td>Description of works</td>
<td>Disadvantage/shortcoming</td>
<td>Advantage</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| NATM - Drill and Blast (D&B) | Works include:  
• reinstatement of the site  
• Vegetation clearance required | • Dust in the portal area  
• Noise in the portal area  
• Visual impact in the portal area during construction  
• Safety risks related to use of explosives  
• Structural support measures required  
• Higher vibration level compared to TBM | Localized potential environmental impacts:  
• Dust, noise and visual impact mainly in the portal areas  
• Lower dust, noise and visual impact compared to C&C  
• Less vegetation clearance compared to C&C  
• Less disturbance of land compared to C&C  
• Less duration of vibration compared to TBM |
| TBM            | Works include:  
• Excavation.  
• Placement of the lining segments.  
• excess material removal/disposal  
• High duration of vibration  
• Requires space for assembling and dismantling – i.e. is related with higher impact on land  
• Unexpected conditions tend to have bigger impact on the process than in case of D&B  
Hard rock can cause wearing of cutter and slow down the tunneling process or even make TBM inefficient | | Localized potential environmental impacts as in case of D&B and NATM  
• Dust, noise and visual impact mainly in the portal areas  
• Lower dust, noise and visual impact compared to C&C  
• Less vegetation clearance compared to C&C  
• Less disturbance of land compared to C&C  
• Often used for excavation of long tunnels. |

382. There are some technical limitations related to the methods listed above:

- In relation to the curve radius for D&B there are normally no practical limitations, whereas for TBMs, narrow curves may cause problems.
- TBM is unable to bore a niche.
- Cut and cover is not reasonable for long tunnels, besides, restriction related to landform are also worth to mention.

383. It is important to highlight that the risk for accidents from handling explosives is eliminated by TBM tunneling. The risk of accidents related to stability of excavation face is also much lower with the TBM option since the machine works under the protection of a steel shield.

384. Both operators of a TBM or drilling rig are exposed to noise and vibrations. This can be reduced to an acceptable level by installing an insulated and vibration dampened operator’s cabin. The problem for the crew occurs when additional tasks have to be done outside the operator’s cabin, like rock support, rail erections, charging during boring etc. The noise from a
jumbo is still higher than from a TBM, but on the whole there is no significant difference between the methods (drill and blast vs TBM) regarding noise.

385. Air pollution from the blasting is a problem in D&B tunnels, because of gas emissions and reduced sight. The main pollution problem in TBM tunnels is dust, especially if the quarts content in the rock is high. The content of fines in the muck is higher than in the D&B muck.

386. Mucking in D&B tunnels is normally executed with diesel engine loaders. Loaders with electrical motors are an option. In TBM tunnels the mucking is carried out by the TBM itself and the TBM is always electrical driven.

387. With consideration of the length of the main tunnel (> 8 km), advancement rates of D&B and TBM, geotechnical characteristics of the rocks – use of a TBM for the main tunnel is considered as advisable.

388. In some sections, selection between mechanical and drill and blast excavation technique (in NATM tunnels) will be made on case by case basis. In case feasible mechanical excavation must be given priority in locations particularly sensitive to vibration.