PRE-FEASIBILITY STUDY FOR NEW RAIL LINK FROM HAVELIAN STATION TO KHUNJERAB（PAK-CHINA BORDER)

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JUNE 2020

This is to certify that the

BE Civil Engineering Project entitled

PRE-FEASIBILITY STUDY FOR NEW RAIL LINK FROM HAVELIAN STATION TO KHUNJERAB（PAK-CHINA BORDER)

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ACKNOWLEGMENT

Allah Almighty has been very kind to help us in understanding, comprehending and working on this project.

Understanding and execution of the research project was carried out under the supervision of Dr. Inam Ullah Khan Assistant Professor of MILITARY COLLEGE OF ENGINEERING RISALPUR, without whose worthy guidance, support and interest this research might not have been accomplished. We must acknowledge our beloved parents, whom prayers have always been matter of encouragement throughout our life and especially during our academic career.

In the end, we must also acknowledge the assistance of Engineers battalions of FWO deployed along the KKH who assisted us in provision of technical support regarding this project.

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ABSTRACT

The reason of undertaking this project is to determine the feasibility of the railway track between Pakistan and China, since it's the missing railway line between two countries and is of vital importance for China Pakistan Economic Corridor (CPEC). Railway line is not only necessity of an hour for the growing bilateral trade between the two countries but will also warrant an uninterrupted and continuous logistic support mechanism round the year for a division size force deployed in the region of Northern Areas. In view of above, the research was carried out to answer following questions:

1) Possible routes between Havelian and Khunjrab for railway track.
2) Analysis of all tentative routes
3) Selection of best route with relevant details of geography and topographic details

Various possible routes were considered and worked upon. The natural topography and geological features were the main hurdles and obstacles in the project. Construction of tunnels was a pre-requisite for all the tracks. Moreover soil stabilization and various soil improvement methods were also required to be implemented for execution of the proposed project.

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CHAPTER 1: INTRODUCTION

1.1 GENERAL

Railway transportation being an important mode of transportation throughout the world plays a key role in passenger and freight transportation. The economic development is directly and strongly related to the availability of railway system as it is the most efficient, quickest and cheapest mode of transporting people and goods around the world. Pakistan railway is lagging far behind in the recent development of contemporary railways in the domestic traffic as well as in international standards of transportation. When it comes to mountainous terrains, It gets more worse especially when we talk specifically about our northern mountainous areas, where there is still no railway network and even the road network is in poor condition due to poor geography and natural conditions, thus unable to ensure continuous transportation of people and goods, thus a continuous and efficient mode of transportation is required which can be only available in the form of railway transportation.

After Pakistan got independence in 1947, the regions of Gilgit-Batistan, Azad Kashmir, and Indian occupied Kashmir became a bone of contention for both countries. Significance size Armed forces are deployed in this region. Due to the harsh climate, a limited time-window is available only in the summers when the logistics can be transported via land routes or by air. However, due to the continuous land sliding on Karakoram Highway (KKH), traffic often gets blocked unpredictably, whereas air operations get cancelled due to harsh weather. Moreover the development of China Pakistan Economic Corridor (CPEC) and Gawadar port will link Kashghar to Gawadar and create huge economic opportunities for both countries. Due to the Gawadar port, China will be able to have access to the Strait of Hormuz, Arabian Sea,

Persian Gulf and the Indian Ocean. Due to poor road density, Gilgit-Baltistan is the bottleneck of CPEC, thus transportation and logistics sector is required to expand not only in terms of road network for which the existing geology poses great restriction, thus the only available option is by altogether new construction of railway networks, which will fulfill the purpose of CPEC in true sense.

1.2 AIM OF THESIS

The aim of this thesis is to determine the feasibility of the railway track between Havelian (Pakistan) and Khunjrab (Pak-China border), since it's the missing railway line between two countries and is of vital importance for CPEC. Railway network is not only necessity of an hour for the growing bilateral trade between the two countries but will also warrant an uninterrupted and continuous logistic support mechanism round the year for a division size force deployed in Northern Areas of Pakistan. In view of above, the research was carried out to identify possible routes between Havelian and Khunjrab for railway track, analysis of possible tentative routes there by leading to selection of best route with relevant details of geography and topographic details.

1.3 ADVANTAGES OF THIS RESEARCH WORK

1. After independence of Pakistan, Gilgit-Baltistan, Azad Kashmir and Indian occupied Kashmir became disputed regions for both the countries. In history, both rivals have wagged wars on each other for multiple times and a Division size force is deployed in this region which requires continuous logistic support. Due to limited time window availability in summers, the logistics on highest posts in Kargil are dumped only in summers which are transported via land routes or by air.
2. Communication infrastructure in northern areas is inadequate as due to the continuous land sliding on Karakoram Highway traffic gets block randomly. On the other side due to poor weather in Northern Areas of Pakistan, flights to Gilgit Baltistan gets cancelled even for weeks, which create a huge problem for smooth dumping operation.

3. CPEC will create a new trade and economic opportunities for China and Pakistan. China is also looking forward to explore and exploit the mineral reserves in Baluchistan. The development of CPEC and Gawadar port will link Kashghar to Gawadar and create huge economic opportunities for both countries. Due to Gawadar port China will be able to have access to Straits of Hormuz, Arabian Sea, Persian Gulf and Indian Ocean.
4. Northern areas of Pakistan have huge tourism potential owing to it's landscape comprising of lush green valleys and snow covered mountains including K2, Nanga Parbat and Rakaposhi. Development of railway communication infrastructure will boost tourism in this region.
5. Construction of railway network will boost economic activities in this region as this will facilitate quick, cheaper and reliable transportation services in terms of goods and people.
6. With the up gradation of ML-1 (Karachi – Peshawar Railway Line (with link to Havelian)) and its link with our proposed railway track is a clear indication of futuristic planning and construction of Havelian to Khunjrab railway section, thus will provide continuous railway track from China to Arabian Sea.

1.4 THESIS MOTIVATION

The peculiar nature of climate and terrain in northern areas of Pakistan places additional constraints on existing communication infrastructure continuous logistic supply to our armed forces deployed in this disputed region is of utmost importance frequent blockage of Karakoram Highway due to landslides and interruption of air operation owing to weather constraints further aggravates this problem. Development of CPEC and Economic Zones has further increased the demand communication networks especially railway track. Moreover this region has huge potential of tourism which can contribute to country's economy and portray positive image of country across the globe. Thus development of such rail link has great potential to boost up economic development as well as to cater the security needs of the country in the present and future challenges of the region after the abrogation of article 370 (A) by India.

1.5 SCOPE OF WORK

This thesis will first identify possible routes for railway track between Havelian and Khunjrab based on the geography and topography. Analysis of tentative routes will then be carried out based on major engineering quantities, bridges and culverts, topography, socio economic aspects, transport volume forecast, hydrology, metrological and environmental aspects which will lead to selection of best route for this proposed railway project.

1.6 THESIS ORGANIZATION

1) The project is divided into various chapters and items discussed accordingly. Chapter 2 discusses the literature review and various parameters which would be kept in mind while carrying out the study.

2) Chapter 3 would be mainly based on our possible routes including a detailed analysis on each of that. It also includes the problems that might be encountered along with their possible remedial measures

3) Chapter 4 is related social and economic aspects of the project and how would it affect the two counties.

4) Chapter 5 would be discussing the present volume of the trade between Pakistan and China and a future forecast of the volume of trade

5) Chapter 6 Discusses the impact of the project on the environmental aspects and various parameters including noise waste products and many more.

6) Chapter 7 would be describing results and the discussions whereas chapter 8 is based on the conclusions and recommendations.

CHAPTER 2 : LITRATURE REVIEW

More than any other technical design or social institution, the railway stands for modernity. No competing form of transport, no subsequent technological innovation, no other industry has wrought or facilitated change on the scale that has been brought about by the invention and adoption of the railway.. Try to think of a world before the railway and the meaning of distance and the impediment it imposed when the time it took to travel from, for example, Peshawar to Karachi and the means employed to do so—had changed little for two millennia. Think of the limits placed on economic activity and human life chances by the impossibility of moving food, goods, and people in large numbers or at any speed in excess of ten miles per hour; of the enduringly local nature of all knowledge, whether cultural, social, or political, and the consequences of such compartmentalization. Railway tracks were purpose-built: nothing else could run on them—and trains could run on nothing else. And because they could only be routed and constructed at certain gradients, on limited curves, and unimpeded by interference from obstacles like forests, boulders, crops, and cows, railways demanded—and were everywhere accorded—powers and authority over men and nature alike: rights of way, of property, of possession, and of destruction that were (and remain) wholly unprecedented in peacetime. Communities that accommodated themselves to the railway typically prospered. Towns and villages that made a show of opposition either lost the struggle; or else, if they succeeded in preventing or postponing a line, a bridge, or a station in their midst, got left behind: expenditure, travelers, goods, and markets all bypassed them and went elsewhere.

Railway is the most efficient, the quickest and cheapest method of transporting people and goods in the world. All the industrialised nations have well developed railway networks spread to all the corners of their countries. When the British got hold over all of the Indian sub-continent, among the first things to accomplish was to establish a network of railway connecting all economic and strategic locations to help them manage the Indian sub-continent efficiently. While travelling to Quetta, one can only marvel at the tunnels dug through mountains in those times when no modern machinery existed. The colonial power gave Karachi, a big sprawling city of its time, a circular railway as a cheap and efficient way of public transport. The same pattern on a grander scale was repeated in what is now India.

The importance of railways as the principal mode of transportation for freight and passengers cab be described as follows:

1) Railways make it possible to conduct multifarious activities like business, sight seeing, pilgrimage along with transportation of goods.
2) It is suitable for long distance travel.
3) Plays an important role in national integration.
4) Railways bind the economic life of the country
5) It accelerates the development of the industry and agriculture.
6) Today the railways have become more important than all other means of transport put together.

However several parameters directly or indirectly affect the construction or design of a railway track. Initial construction costs have a direct effect on the design (earthwork costs, superstructure costs), but other costs, including user costs and out-of-system costs, have an indirect impact on the design of the alignment, and therefore should be considered in the design process. It is very important that all the critical costs of the project are taken into account when designing the alignment in order to obtain the optimal alignment. The costs normally considered are:

1) Right-of-way-dependent costs
2) Length-dependent costs
3) Traffic-dependent costs
4) Volume-dependent costs
5) Bridge- and tunnel-dependent costs

Right-of-Way-Dependent Costs

The costs associated with a road or railway route, depending on the passageway, include land acquisition and other costs for crossing the track from one area. Because of this, the railway track passageway has a special significance. According to the accuracy requirements, the study area is divided into cells with specific dimensions. It is assumed that each cell in the study area represents an area with the same cost of production. Crossing the railways from different cells carries different costs, and the final costs for the location depend on the total costs of the path components in the cells. With this cost system, cells that are located in areas where the railroad does not have to cross them (such as historic sites, or marsh locations or other special locations) can be defined as cells with a very high unit cost. This routing process will cause the total cost of the transit route in this area to be increased, and the probability of choosing it will be reduced.

Length-Dependent Costs.

The use of ballast in tracks is very common, as ballasted tracks have very good performance. Although the maintenance cost for this type of track is high, its construction cost is lower than for ballastless tracks. There have been no major changes in the principles of ballasted superstructures since railway tracks first emerged, but certain developments have occurred within the railway transport industry in order to promote greater safety and speed,the use of concrete ties and heavier rail sections, elastic fastenings, machining repair operations, and the development of advanced equipment for measuring various parameters of track components, maintenance management, and so on.

Traffic-Dependent Costs.

In road design, typically only the costs of route construction are reviewed, while the effect of alignment selection in railways involves other costs, including operating costs. Costs to be considered are:

a. The cost of purchasing, maintaining, and replacing rolling stock
    - Locomotive purchases

- Locomotive maintenance
- Wagon purchases
- Wagon maintenance

b. Track maintenance and reconstruction cost

c.. Cost in terms of the value of cargo and passenger time

Volume-Dependent Costs.

To calculate the volume of earthwork (excavation and embankment operations) on horizontal alignment at specified intervals, the area of transverse sections (stations) is determined, and the volume of soil operations between the two stations is then calculated. Accuracy in estimating the volume of earthwork is dependent on the distance between stations. When the distance is smaller, a more accurate estimate of earthwork will be achieved .

Bridge- and Tunnel-Dependent Costs.

Bridges and tunnels are used as a substitute for bulky embankments and excavations as well as a solution for crossing inaccessible areas such as rivers. Given the complexity of the cost function of the bridge and tunnel and its dependence on various parameters such as topography and land diversification, calculating the cost of construction and efficiency, and determining the optimal location of the bridge and tunnel becomes a complex problem. Because of the high cost of a bridge or tunnel, its proper alignment during the design stage can prevent substantial waste. In order to determine the position of the alignment required for the construction of a technical structure, the following are considered:

- If the excavation height exceeds the permissible level according to the material, then a tunnel needs to be constructed.
- If the height of the embankment exceeds the virtual limit, it is necessary to construct a bridge along the alignment.
- The bridge should be constructed if an alignment passes through an environmentally sensitive, marshy or river-bound area with operational problems on the embankment.

CHAPTER 3: METHODOLOGY

Pakistan is located in the northwest of the South Asia Subcontinent between north latitude 23°30' and 36°45' as well as between east longitude 61°and 75°31'. It is more than 1,600 km long from south to north, adjoining the Arabian Sea in the south with a coastline of 840 km long and neighboring Karakorum Mountains and Himalaya Mountains in the north. It is also adjacent to India, China, Afghanistan and Iran.

The starting point of Pakistan-China Railway Line Project is Havelian station 100 km north of Islamabad, the capital of Pakistan. The project will pass through Abbottabad, Dasu, Chilas, Gilgit, Hunza, Sost and finally end at Khunjrab (Mintaka), the border of Pak- China.

3.1 Study of Routes

3.1.1 Brief Description of Routes

Based on the landform, topographical features, hydrographic conditions and geological conditions and distribution of towns along the line of project location, four major routes have been worked out: East Route, Center Route, West Route and Gilgit Shortcut.

3.1.2 Center Route

The start point of the railway line has connection of tracks from the existing railway station at Havelian with an elevation of 859m. The line runs forward for 26km along Dor River and arrives at Kakul north to Abbottabad with an elevation of 1180m. Then the railway line runs forward to Siran River with the bed level of 970m which must be crossed over. Afterwards, the railway line must pass through a 1,900m high mountain and go down the slope to suit the elevation of Indus River valley. After meeting Indus River at Thakot the line runs northwards along Indus River. To suit Indus River valley, the railway line will arrive at the lowest point of the whole line at an elevation of 646.52m and reach Dasu . Because Pakistan is constructing a dam in (the

dam has an elevation of 975m) in Dasu and the altitude of the railway line must be higher than the dam elevation. Therefore, the elevation of the railway line in Dasu must be raised to above 975m. In a word, since the landform in this section greatly undulates and it is controlled by the dam elevation, 20% pusher grade will be applied for the railway to adapt to the undulation of landform.

After departing from Dasu Station, the railway line continues to run northwards along Indus River. It crosses over Indus River at Alam, the convergence of Indus River and Gilgit River and runs forward along Gilgit River in the northwest direction. When reaching Gilgit, the convergence of Gilgit River and Hunza River, it turns to the northeast direction and runs forward along Hunza River to Gure. There are three cascades of dam, with a water level of 975m (Dasu), 1180m (Basha) and 1280m (Raikot) from downstream to upstream respectively. After passing through Dasu, the altitude of railway line is higher than 975m..

As for the section from Gure to Mintaka, the railway line starts from Gure Station and continues running forward along Hunza River, and enters the convergence of three major mountain ranges of Hindu Kush, Karakuram and Himalaya. After the line reaches Sost, it crosses over Hunza River 18km from Sost in the north and then runs eastwards along Khunjerab River. The last section of about 30km of the railway line has an altitude of more than 3,500m and thus covered by ice and snow for five months per year. For the project, the line will run through down Mintaka on China-Pakistan Border with an altitude of 5500m and reach the destination of the project and Mintaka Station will be then established. The altitude of the railway line is 4,054.93m. This section is located in high latitude and cold mountain area. There are 18 high mountains above 7000m around it. It is high and precipitous with sophisticated engineering geology and fault development, rock fragmentation and frequent neotectonic activities. In addition, the area has so poor climate that temperature difference in the day and night is great, freezing and thaw alternately circulate each year and strong physical weathering often occurs, resulting in engineering geological disasters such as debris flow, landslide,

collapse, rockfall, icing disaster, snow drift, earthquakes and permanently frozen soil of special rock and soil at high altitude.

3.1.3 East Route

In this proposal, the railway line starts from existing Havelian station,goes east from Mansehra passing through Kagan,and meet with the center route at Chilas. For this proposal, the railway line is 63.215km shorter than that of center route proposal. However, for this proposal, landform and geological conditions along the line are sophisticated and 4500m high mountains must be crossed through. As a result, a 47.78km tunnel will be constructed. This area is located in high intensity seismic zone.

3.1.4 West Route

For this proposal, the railway line has tracks connected at the existing railway station in Havelian, crosses over Dor River and passes through 9 tunnels successively, then turns northwards and links up with the tracks in center route at Thakot. For this proposal, it will cross Indus river 4 times, there is little human habitation along the line with poor transport condition, it will not benefit local economy for very long distance.

3.1.5 Gilgit Shout Cut Route

This proposal will connected with all routes at Alam Bridge,go northward along the west bank of Indus river ,a 41.14km super long tunnel will be set to pass Gilgit mountain with the elevation reach to 1675m,after Gilgit station ,the line connect with central Route by 12.96km tunnel in Nomal.

This proposal is shorter than center route about 72.74km, it has 41.14km super long tunnel to be set as the same problem as East Route.

3.2 Topography and Geography

3.2.1 Topography along the Line

The railway line starts at the elevation of 860m and ends at the elevation of 4,055m, with a difference of 3,195m. In general the Line is high in north and low in south. Except for the starting section, which is relatively mild and open, the other sections are all high and medium mountainous areas of high topographic inequality. The area is of high topographic inequality and great elevation difference, therefore the topography is complex.

3.2.2 Engineering Geology

Areas the railway line will pass through are mainly various kinds of sedimentary rock, metamorphic rock, in different eras.

3.3 Hydrogeology

3.3.1 Surface Water

Surface water mainly includes snowcap and river water. River water mainly comes from the Indus River, the Gilgit River, the Hunza River, and the Khunjerab River. Compensation of river water is mainly from rainfall, underground water and snowmelt. The flow is small in winter while the summer it is freshet with large flow. The compensation is of mixed type and is mostly not corrosive.

3.3.2 Ground Water

Ground water mainly comprises phreatic groundwater in carbonate rock. Additionally, as the Line will pass through high altitude tundra, there is also freezing layer water.

3.3.3 Basic Earthquake Intensity

The area along the Line is intensive seismic area. The earthquake magnitude is at M6~M7 and the intensity is 7.5~9.5 degrees. The seismic parameters for each section are shown in the Table 2-1.

Table 3.1: List of Sectional Seismic Parameters for the Route of Proposed Railway

Locations	Earthquake intensity	Horizontal peak ground acceleration (PGA)
Havelian –Chilas	IX	≥0.30g
Chilas-Alam Bridge	VIII	0.20~0.30g
Alam Bridge – Khunjrab	IX	≥0.30g

3.3.4 Meteorological Data

The Project is located in the subtropical climate area of the South Asia Subcontinent. Because the Project spans a large area from south to north and the altitude difference is great, the climatic vertical zoning is distinct. The area from the starting point of the Project Havilian to Raikot is of subtropical climate, where the highest temperature in summer reaches 46 degree. The area from Raikot to the end point is of plateau mountain climate, thin air, strong solar radiation and low temperature where the lowest temperature in winter would reach minus 30. In Gilgit, the lowest and highest temperatures in summer would reach 9.4 and 45 while the temperature in winter would respectively reach minus 9.4℃ and 15℃. The climate in mountainous area is unstable. Mintaka Port in the last 30km of the Project is covered by ice for at least half a year.

The topography in the area leads to extreme rainfall. The annual average precipitation in each area is greatly varied, generally more rainfall at the south and less rainfall at the north. In 8% of the area, the annual precipitation is less than 15mm. In 22% the area, the annual precipitation is less than 250mm. In 47% the area, the annual precipitation is less than 500mm. In 86% the area, the annual precipitation is less than 1,000mm.

3.3.5 General Unfavorable Geology

The area the railway line will go through is of complex geological condition, active tectonic movement, developed geofracture and relatively fractured rock. Additionally, because of the harsh weather, great temperature difference between day and night and alternation and circulation of freezing and thawing, physical weathering is also intensive. Furthermore, the area is of fractured topography, cliff, continuous

snow peak, deep valley and rapid water flow, therefore the area along the Line is of widely distributed unfavorable engineering geological phenomena.

3.3.6 Collapse and Rock Heap

Because of the developed fault fracture zone and joint fissure, the mutual cutting between joint fissure of rock, the serious weathering and facture, hazards as slide, breaking and falling and rolling stone would easily occur along the joint intersection face or relieved fracture face of rock in steep areas. Moreover, because of the river incision and strong lateral erosion effects in mountainous area, the river terrace is corroded whereby cliff is formed and sloughing bank frequently occurs. The area the Line will go through is of many glacial deposits and the glacial cross slope formed resulting from ancient glaciation is steep. Part of them is of loose structure

3.3.7 Landslide

Because the bedrock is of varied production form, the rock is fractured. Secondly, the river incision and lateral erosion are strong, as a result free face will easily occur at the slope base. Therefore, bedding landslide will easily occur.

3.3.8 Snow Avalanche

The area is of high mountain, deep and narrow valley, steep bank (with height difference between valley and mountain mostly above 1,000m) and many snow peaks. Snow avalanche would easily occur each year during the time after autumn and before winter and the time after spring and before summer. The collapsing accumulated snow rapidly drops along the groove of mountain. Meanwhile, the dropping snow contains macadam, rock block and bed rock waste from sloping face. Large-scale snow avalanche would lead the blockage of river course and railway whereby is of great danger to the Line.

3.3.9 Glacier

Because there are many mountains around and the area above 5,000m is covered by snow all the year around, the glacier is very developed. For the glacier valley formed due to erosion, the section is of parabolic or “U” shape, mild and open valley bottom and steep side slopes on both banks. In the areas of modern glacier and edge of

snow accumulation, glacier mudflow is frequently caused, which would destroy and bury the railway.

3.4 Main design principle of subgrade

3.4.1 Width of Road Embankment

The shoulder width of road embankment shall be not less than 0.8m, while that of road cutting shall be not less than 0.6m.

3.4.2 Width of Subgrade

The width of subgrade shall be determined through calculation and based on the design running speed, the rail type, the space between lines, curve widening, widening of sedimentation on both sides of subgrade, shoulder width, maintenance etc.

3.4.3 Shape of Subgrade

The design shape of subgrade is triangle crown and 4% slope will be set from centerline of subgrade to both sides. In case of curve widening, the subgrade shall still be kept in triangle shape.

3.4.4 Subgrade Bed

For the subgrade of the steep slope section with half filling and half excavation, the soil of 1.0m below the subgrade surface shall be removed and backfilled with suitable material. 4% outward drainage slope shall be set at the crown surface of excavation section.

3.4.5 Side Slope of Subgrade

3.4.5.1 Embankment

For the section of ordinary filling, if the subgrade base is in good condition, the height of side slope of embankment and the slope shall be determined according to the filling type. Generally, the height of side slope of embankment shall not exceed 20m; if exceed, technical and economic comparison shall be made with bridge. If possible, slope shall be controlled by setting support structure in section controlled by building or influenced by topography, the side slope of immersible embankment shall be determined according to the type of filling and shall be decreased by one grade.

3.4.6 Subgrade Consolidation and Protection Works

Because hazards as slumping, slide, breaking and falling and flying stone frequently occur in the excavation section along the Line, generally measures as retaining wall, facing wall and slope protection will be taken to implement surface protection of side lope. For conditioned side slope, measures as anchoring and shotcreting would also be taken.

3.4.7 Subgrade Slope Protection

3.4.7.1 Cutting

Side slope of cutting of ordinary soil shall be protected by planting grass or by planting grass in mortar rubble frame. Where necessary, low wall shall be set for the side slope of cutting to strengthen and stabilize the bottom of side slope.

For the rock stratum of cutting side slope that easily weathers, protective measures as planting grass in frame of mortar rubble or slope protection of mortar rubble, fencing wall, spraying concrete and anchoring and shotcreting shall be taken according to the weathering degree of side slope.

For the cutting side slope of hard rock stratum that is not easily weathered, the protection measures shall be patching using masonry rubble, shotcreting mesh or spraying concrete.

3.4.7.2 Embankment

For the side slope of embankment of ordinary soil, the protection measures shall be planting grass, planting grass in slope protection of cut-off frame and laying geotechnics grid in layers for side slope, geonet grassing on slope, etc.

For the high side slope of rock-fill embankment, the surface of side slope will be of bricked masonry rubble.

If the subgrade base is paddy field or pond, measures as bailing and drainage, excavating mud or random rubble filling will be adopted as per condition.

3.4.8 Design Principle of Subgrade Drainage

Subgrade drainage shall be connected with the water drainage equipment of bridge, culvert and station and shall be in the complete drainage system together with natural drainage ditch, channel and river. Gutter shall be set at cutting top and drainage ditch shall be set on both sides of subgrade.

3.4.9 Design principle of cut-fill adjustment for subgrade

For the cut-fill adjustment, as far as possible excavated materials shall be used for filling and vertical adjustment shall be strengthened to reduce the construction earth and stone and save land. The tunnel spoil shall be properly used to the discipline of station and yard.

3.4.10 Design Principle of Environmental Protection in Subgrade Works

The construction of subgrade will lead to the damage at different degrees of the ecological condition and water and soil conversation along the Line; therefore, the following measures shall be taken:

- As far as possible, high filling and deep excavation shall be avoided and supporting measures shall be taken in the section of subgrade at steep slope to avoid peeling.
- As far as possible, excavated materials shall be used for filling during the cut-fill adjustment. Unavoidable waste bank or borrow pit shall be utilized in a centralized manner. To strengthen the slope base, masonry rubble shall be used to intercept spoil and used for retaining wall and dry-laid rubble shall be used. Moreover, the slope face of waste bank and borrow pit shall be protected by spreading grass seed and planting shrub. Where necessary, water interception and drainage facilities shall also be made.
- For the side slope of subgrade, as far as possible greening protection shall be implemented by planting grass or planting grass and shrub in the frame.
- The setting of drainage system shall be strengthened, e.g., chute, seepage chute of side slope, torrent canal, blind ditch, which shall

form a complete drainage system together with natural channel, culvert, station and yard and the existing drainage system, so as to avoid the influence of water flow on environment.

3.5 General Protection Works

3.5.1 Anchor pile

For the high side slope of cutting, normally centralized stress will be produced at the slope base because the height of the slope. Additionally, the geological condition is poor, so slide and damage will easily occur to side slope. Ordinary supporting works is incapable of ensuring the stability of side slope of cutting. Instead, anchor pile is used to pre-reinforce the slope, which is advantageous to the stability of the entire side slope. Because pre-reinforcement can be implemented before the excavation of side slope during the construction of pile, the excavation of earth, which is to be carried out after the pile is completed and reaches a certain strength, will not lead to the loosing and deformation of side slope earth during the excavation. As a result, the attenuation of earth strength caused by the release of earth stress, which again results from the loosing of side slope, can be effectively controlled.

Figure 3.1: Anchor pile

3.5.2 Retaining wall

Retaining wall is an engineering measure frequently used in the supporting works of side slope. When the side slope is not high or the geological condition of side slope is good, retaining wall of C15 rubble concrete will be used as the supporting works of toe in the design.

Figure 3.2: Retaining Wall

3.5.3 Slope Protection Works

For side slopes of different geological conditions, different protection shall be applied. When the earth of side slope is of high-water content and the geological condition is poor, supporting seepage chute shall be adopted in the design. The application of supporting seepage chute will timely remove the water in earth and dry the earth; therefore, the strength of soil mass shall not drop because of water, which prevents the sliding and slumping of the superficial layer of side slope. This measure is very effective to the reinforcement of earth side slope or the side slope in the falling and sliding section.

3.5.4 Arch Frame Grass Protection

For earth side slope with stable condition, arch frame grass protection shall be implemented in the design so as to beautify the environment and to prevent water

from overly scouring the surface, which leads to the sliding and slumping of the surface layer.

Figure 3.3: Arch Frame Grass Protection

3.5.5 Slope Protection through Grass Planting

To beautify the environment, the side slope will be protected by grassing.

3.5.6 Mortar Rubble Slope Protection

For the side slope of poor soil quality, mortar rubble slope protection shall be adopted to implement fully closed protection so as to prevent the invasion of water that leads to harm to side slope.

Figure 3.4: Mortar Rubble Slope Protection

3.5.7 Face Protective Wall

Face protective wall will be mainly used to the rock side slope of good geological condition but of loose and fractured rock.

Figure 3.5: Face Protective Wall

Generally, the side slope protection works above shall be not used alone but together with other reinforcement works of side slope.

3.5.8 Special protection works

Special subgrade point shall be reinforced with sheet pile wall and retaining wall on rest beams of pile foundation.

Figure 3.6: Sheet Pile Wall

For the working point of high side slope of cutting, prestressed anchor and frame girder shall be adopted for reinforcement.

Figure 3.7: Reinforcement Works of Prestressed Anchor and Frame Girder

In the section of dangerous rock and falling stone, comprehensive treatment including flexible prevention mesh for shielding, interception and reinforcement shall be implemented for the subgrade.

Figure 3.8: Flexible Prevention Mesh

3.6 Bridge And Culvert Works

3.6.1 Principle of Setting Bridge and Culvert

With the provision of satisfying natural flood discharge, taking less farmland, imposing less damage to the existing farmland irrigation system, the original relief and the overpass, the bridge & culvert works along the Line shall be properly arranged according to the topography, relief and geological conditions along the Line. For the line at high elevation and bases on excavation that will go through the suburb near town, the flat and open area or the section of unfavorable geology, generally elevated long bridge will be adopted. If the length of subgrade between rears of adjacent abutments is less than 150m and bridge can be a substitution of road, bridge shall be set continuously by lengthening the aperture of bridge. If the length of subgrade between adjacent bridge and culvert or adjacent culverts is less than 30m, the aperture of bridge shall be lengthened or the culvert position shall be relocated. In the design of bridge, aseismic calculation verify shall be implemented for bridge and aseismic measures shall be taken for the ranked seismic fortification intensity of the Project location.

3.6.2 Type of Superstructure

Generally, bridge span shall be equal span and preferentially 32m or 24m simply supported beam span shall be used, which shall mainly be 32m simply supported beam. Generally, the height of bridge abutment shall be controlled within 6

to 8m and high abutment and large cone shall be avoided. When the Line crosses highway or local road, generally frame bridge shall be used in case of no large span and is controlled by clearance. When the Line crosses deep valley, busy trunk road or railway where large span bridge is required, an economic and reasonable structural from shall be used depending on the actuality.

3.6.3 Type of Substructure

According to the requirements of economy, beauty and coordination with the surrounding, generally the substructure of bridge shall be rectangle pier, when the pier is higher than 30m, rectangle hollow pier shall be used and the entire bridge shall be of uniform pier type. The bridge abutment shall be of T shape. When the excavation depth of foundation of pier and abutment of bridge is less than 7m, open excavated foundation shall be used. If, to meet the requirements of hydrological and geological conditions, the foundation will be of deep embedment, foundation of bored pile shall be used. Generally, the diameter of bored pile selected shall be 1 to 1.5 m. The diameter of belled pile selected shall be 1.25 to 1.50 m. When the pile is longer than 15 m or there is ground water, bored pile shall be used. Generally, the selected thickness of bearing platform shall be 2.00~2.50 m and the platform shall meet the requirements of pressure distribution angle.

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3.7 Building Works

3.7.1 Principle of House Allocation

The house for technical operation of production and auxiliary office work for production shall be set according to the usage requirements and operation demand provided by each discipline and combining relevant regulation and stipulation. Except for large-span production building, stored building shall be designed and arranged in a centralized manner so as to save land use. Relevant codes as fire-protection stipulation and general standard for civil design shall be followed in the design of general plan.

3.7.2 Construction standard

Floor height: The floor height of house for productive technology and operation shall be determined as per process requirements. The floor heights for auxiliary office house for production and for residential house shall respectively be 3.3m and 3.0m.

3.7.2.1 Fitment: With the house fitment standard fitting into the local building and relevant investment saved, except for sectional office building and station building, for which major fitment shall be implemented, other houses shall be of ordinary painting.

3.7.2.2 External wall face: According to the style of external wall of station building, granite veneering and metal veneering shall be adopted and glass curtain wall shall be considered in the proper area. For other houses, part of the area of hallway shall be of wall tile and the rest area shall be of ordinary plastering wall or partial plastering.

3.7.2.3 Internal wall face: The hall in station building and the waiting section shall be of granite or aluminum sandwich plate veneering, and latex paint wall face shall be adopted for the office area at station. Except for the specified internal wall face, the rest parts of communication station, signal building etc. shall be of ordinary plastering or painting wall face.

3.7.2.4 Ground: The hall in station building and the waiting section shall be of granite ground and the office area at the station shall be of ordinary floor tile. The communication station and signal building shall be of terrazzo ground. The rest houses for various kinds of technical operations shall be of concrete or cement ground. The toilet, lavatory, shower room and kitchen shall be of floor tile ground.

3.7.2.5 Ceiling: The ceiling of station building shall be aluminum sandwich plate or gypsum plank ceiling meeting the space requirements. The other houses, except for that are of light-gage steel joist ceiling, shall be of plastered ceiling below R.C. plate.

3.7.2.6 Door & window: Special door & window shall be set for production house according to technical requirements and the rest houses shall be of wooden door and plastic-steel window.

3.7.2.7 Office building and residential building with night shift shall be of screen door and window and prevention measures shall be taken.

3.7.2.8 Roofing: The roofing of various kinds of depots, shed buildings and houses of ceilings shall be of non-overhead insulation roofing, and all other houses shall be of overhead insulation roofing. Waterproofing measures shall be taken for roofing adopting waterproofing material of high polymer composite coiled material.

3.7.3 Structural Type

3.7.3.1 Main production building, passenger station building, signal building, communication station, traction substation, boiler house etc. shall be of frame and cast in-situ beam and plate. Other buildings shall be of brick-concrete structure and cast in-situ beam and plate.

3.7.3.2 Ordinary houses for office work and technical operation and houses for living and public welfare shall be of brick-concrete structure and cast in-situ beam and plate.

3.7.3.3 Steel structure may be adopted based on the architectural modeling and structural requirements.

3.7.3.4 Ordinary house shall be of non-reinforced spread foundation and R.C. strip foundation. Pile foundation, independent foundation or other types of foundations may be adopted based on the requirements of upper structure and geological condition.

3.7.3.5 Construction material: Based on such principle, as much as possible the local material shall be used.

3.8 Track

3.8.1 Rail and fittings

3.8.1.1 The main track shall be designed as 50kg/m standard length and 25m new rail. For the tunnel longer than or equal to 1,000m, the design shall be of wear-resistant and corrosion resistant rail at the same level. The turnout of main track shall be of the same rail type as that of main track.

3.8.1.2 Rail joint shall be of abutting joint. For curve inner track, shop-fabricated shortened track shall be adopted to adjust the position of rail joint.

3.8.1.3 The bolt torque of rail joint shall be not less than 600N·m.

3.8.2 Rail sleeper, fastening and laying number in each kilometer

3.8.2.1 Sleeper preferably of concrete would be used.

3.8.2.2 Rail sleeper of main track shall be Type II concrete sleeper. In ordinary section, 1,680 sleepers shall be laid in each kilometer. For the tunnel longer than 1,000m, 1,760 sleepers shall be laid in each kilometer.

3.8.2.3 In the section of ballasted bridge and shoulder retaining wall to lay rail guard track, the design of prestressed concrete bridge sleeper shall be adopted.

3.8.2.4 Rail fastening

3.8.2.5 The fastening for concrete sleeper shall be elastic fastening.

3.8.3 Ballast bed and pavement thickness

3.8.3.1 Grade I ballast bed shall be adopted by the line, the top surface of ballast bed shall be level with the top surface in the middle of sleeper.

3.8.3.2 Pavement thickness of ballast will be non-permeable and of of double ballast bed design. The bedding course shall be 30cm in

thickness and the top ballast shall be 25cm in thickness. The rock subgrade or permeable soil subgrade shall be designed as single-layer ballast bed 30cm in thickness.

3.8.4 Design of Route Sign and Signal Sign

3.8.4.1 Route sign and signal sign shall be set in the place not less than 2m from the outer side of rail end. The sign not exceeding the top surface of rail shall bet set in the place not less than 1.35m from the outer side of rail end.

3.8.4.2 All signs shall be R.C. and reflecting materials.

Table 3.2: Quantities of Main works for Track

S/N	Name of item	Unit	Quantity	Remarks
1	Length of main track	km	662	
2	Track laying of main track (Concrete sleeper)	km	656.47	Steel rail: 50Kg/m, concrete rail sleeper: 1,680/Km
3	Ballast	M^3	1853600	

3.8.5 Scope and Unit Division

3.8.5.1 Unit one: Havelian Junction Station

3.8.5.2 Unit two: Havelian~Mintaka

3.8.5.3 Unit three: Mintaka Customs Station

3.8.6 Estimate principle

3.8.6.1 The estimate is prepared on the basis of construction under the normal construction environment, It excludes the possible incremental expenses due to change of construction period and so on resulting from the external environmental change.

3.8.6.2 The estimate excludes the possible incremental expenses due to change in labor cost or material and equipment cost in the international market, as well as change in the social economic indicator of Pakistan such as inflation, change in exchange rate etc. It also excludes the tariff and all taxes and fees to be levied by Pakistan Government and the departments concerned.

3.8.6.3 The estimate covers the railway construction cost only, excludes the fees for purchase of land, demolition of and compensation for ground and underground buildings and structures, as well as the costs of such works as road diversion, highway bridge and pedestrian overpass..

3.8.6.4 The estimate is calculated at the exchange rate: USD 1 =60.8 Rupee.

3.8.7 Total Amount Estimated

3.8.7.1 The total amount estimated for 662km main track from Havelian to Mintaka is USD$10,236,789,290. In which, The total amount estimated for Havelian Junction Station is USD$214,659,092. And the total amount estimated for the section from Havelian to Mintaka is USD$9848,268,886.

3.8.7.2 The total amount estimated for Mintaka Customs Station is USD$173,861,311.

3.8.9 Basis for estimation

3.8.9.1 Preparatory **works**

3.8.9.2 Cost of temporary works

3.8.9.3 It includes 200km temporary road for transportation of building materials, plant for storage of building materials, yard for tying rail link and girder fabrication and storage yard for track works, ballast yard for railway construction and operation maintenance, water facilities for construction of tunnel and bridge works.

3.8.9.4 Transport cost of equipment and materials

3.8.9.5 According the present situation of materials market in Pakistan, the main materials to be used in this project will be purchased from China and transported by different ways based on different natures. Cement, steel, rail fastening for track, track fitting, bridge bearing, wire, cable and equipment will be purchased from China and transported by truck to construction site through Khunjrab; rail will be purchased from China, and transported by sea to Pakistan and then to Havelian Junction Station by railway within Pakistan.

3.8.10 Subgrade Strengthening and Protection

3.8.10.1 Mortar rubble: It will be used for slope protection of subgrade and cutting and used in the drainage system facilities including gutter and side ditch. The materials will be the local rubble and machine-made sand processed from rubble. Cement mortar will be used to brick. The cost covers that for the excavation of foundation pit, scaffold building and removal, bricking of rubble with cement mortar, setting of inverted filter of permeable soil and expansion joint.

3.8.10.2 Rubble concrete: It will be used in the retaining wall of subgrade and cutting slope. The local rubble and machine-made sand processed from rubble will be used as concrete aggregate. The cost covers that for the excavation and backfill of foundation pit, fabrication, installation and removal of retaining wall's form, building and removal of scaffold; mixing, pouring, tamping and curing of concrete, setting of inverted filter of permeable soil and expansion joint

3.8.10.3 Reinforced concrete: It will be used in the sheet pile wall and joist of pile foundation at special subgrade. The broken stone and machine-made sand processed from the local rubble will be used as concrete aggregate. The cost covers that for the excavation of foundation pit; fabrication, installation and removal of formwork, building and removal of scaffold; fabrication and installation of reinforcement cage, mixing, pouring, tamping and curing of

concrete, setting of inverted filter of permeable soil and expansion joint.

3.9 Bridge works

3.9.1 Super Major Bridge

3.9.1.2 There will be 82 bridges longer than 500m, their total length is 68,710 linear metre, including one double-track bridge with a length of 770 linear metre, 12 three-track bridges with a length of 9720 linear metre, and 2 four-track bridges with a length of 1760 linear metre.

3.9.1.2 The broken stone and machine-made sand processed from the local rubble will be used as concrete aggregate. Simply supported prestressed concrete beam will be fabricated and stored in the new temporary grinder fabrication factory in Havelian and erected while laying tracks and the prestressed concrete continuous beam will be subject to in-situ casting. Pedestrian slab and balustrade of bridge will be installed after beam erection.

3.9.1.3 The cost covers that for boring, digging and backfill of open-cut spread foundation, bored pile and pored pile; fabrication and installation of reinforcement cage, mixing, pouring and tamping of concrete for pile foundation, fabrication, installation and removal of concrete form of pier and abutment; mixing, pouring, tamping and curing of concrete; prefabrication and erection of prestressed concrete beam, pouring, tamping and curing of concrete for prestressed concrete continuous beam and fabrication and installation of reinforcement cage, installation of bridge bearing, fabrication and installation of pedestrian slab, balustrade, inspection ladder, railing, cradle and refuge platform of bridge.

3.9.2 Major Bridge

3.9.2.1 There will be 93 bridges with length from 100m (included) to 500m, their total length is 28980 linear metre, including 2 double-track bridges with a length of 460 linear metre, 12 three-track bridges

with a length of 3520 linear metre, and 3 four-track bridges with a length of 1150 linear metre.

3.9.2.2 The broken stone and machine-made sand processed from the local rubble will be used as concrete aggregate. Simply supported prestressed concrete beam will be fabricated and stored in the new temporary grinder fabrication factory in Havelian, and erected while laying tracks, prestressed concrete continuous beam will be subject to in-situ casting. Pedestrian slab and balustrade of bridge will be installed after beam erection.

3.9.2.3 The cost covers that for boring, digging and backfill of open-cut spread foundation, bored pile and pored pile, fabrication and installation of reinforcement cage; mixing, pouring and tamping of concrete for pile foundation, fabrication, installation and removal of concrete form of pier and abutment, mixing, pouring, tamping and curing of concrete; prefabrication and erection of prestressed concrete beam; pouring, tamping and curing of concrete for prestressed concrete continuous beam and fabrication and installation of reinforcement cage, installation of bridge bearing, fabrication and installation of pedestrian slab, balustrade, inspection ladder, railing, cradle and refuge platform of bridge.

3.9.3 Medium Bridge

3.9.3.1 There are 4 bridges with length from 50m (included) to 100m, their total length is 250 linear metre. All are reinforced concrete frame bridges

3.9.3.2 The broken stone and machine-made sand processed from the local rubble will be used as concrete aggregate. In-situ casting will be used. Pedestrian slab and balustrade of bridge will be installed after bridge construction.

3.9.3.3 The cost covers that for the excavation and backfill of foundation; fabrication and installation of bridge steel bar; mixing, pouring, tamping and curing of concrete, fabrication, installation and

removal of bridge's concrete form, and fabrication and installation of pedestrian slab and balustrade of bridge.

3.10 Tunnel **Works**

3.10.1 The whole line comprises 223 tunnels with a length of 368,815 linear metre.17 tunnels are longer than 6km, with total length of 134,360 linear metre. Complex lining will be used in terms of tunnel lining, with preliminary support provided.

3.10.2 Concrete will be used as lining material, and mortar anchor, mat reinforcement, section steel frame, shotcrete etc will be used in preliminary support.

3.10.3 The cost covers that for the excavation of tunnel and service gallery; transportation of wasted ballast, concrete lining, preliminary support, waterproofing and drainage treatment, portal protection and installation of power cable, control cable and fun cable and equipment purchase etc.

3.11 Track **Works**

3.11.1 Track Laying

3.11.1.1 774.636km track will be laid in the whole line, including 118.166km track in stations. The temporary grinder fabrication factory and track laying base will be built in Havelian Junction Station Rail will be purchased and transported to the track laying base. Sleeper will be manufactured in the temporary grinder fabrication factory in Havelian, rail and sleeper will be mechanically laid from Havelian to Mintaka after being tied into track skeleton at the track laying base. Meanwhile, bridge girder will be erected.

3.11.1.2 The cost covers that for such track materials as 50kg rail, concrete sleeper, rail fastening and fitting, joint bar, as well as assembly, transportation and laying of track skeleton.

3.11.2 Ballast Laying

3.11.2.1 Ballast manufactured according to design requirements at the ballast storage yard will be transported to the laying site. Layered paving of ballast shall be carried out according to requirements, and sub-ballast can be transported to subgrade surface by truck.

3.11.2.2 The cost covers that for manufacture, transportation, paving, tamping, shaping, and sinking smoothing of ballast.

3.11.3 Track-Related Works

3.11.3.1 It includes the supply and installation of marks for line, signal and grade crossing, as well as supply of spare parts of track.

3.11.3.2 The cost covers that for crossing earthwork, crossing board, crossing protection facilities, bumper post and stop buffer, installation of line and signal marks, standby rail, turnout, rail fastening and fitting, sleeper etc.

3.12 Housing Works

3.12.1 It includes the houses of productive nature for railway operation such as passenger transport house, freight house, technical operation house, communication house, signal house, power house, water supply and drainage house, locomotive house, maintenance house as well as dwelling and dormitory of staff and the supporting roads and walls in the study scope, 180,000m^2 in total.

3.12.2 The cost covers that for foundation reinforcement of house, water supply and drainage, lighting, heating, ventilation, and indoor equipment foundation.

3.13 Water Supply and Drainage Works of Station

3.13.1 It includes water supply and drainage works of water supply station and tank station (point) in the study scope. It shall meet the water supply and drainage requirement of each station (point) for production, living and fire protection.

3.13.2 A set of water supply and drainage equipment and pipe network shall be set up at every station (point) according to the station arrangement and water source.

3.13.3 The cost covers that for construction of water source and water supply building, laying of water supply pipeline and ancillary works, drainage building, laying of drainage pipeline and ancillary works, purchase and installation of water purification, sterilization and effluent treatment.

3.14 Communication Works

3.14.1 It includes long-distance communication, division communication, area communication, station-yard communication, wireless communication systems needed by railway operation in the study scope.

3.14.2 The cost covers that for laying of communication (optical fibre) cable, purchase and installation of transmission equipment, access network equipment, dispatching communication equipment, telephone switching equipment, conference telephone (television) equipment, wireless communication equipment and communication power equipment.

CHAPTER 4: SOCIO-ECONOMIC ANALYSIS OF THE PROJECT

4.1 Physical Geography of Pakistan

Pakistan territory covers an area of 79.6×10^4 km^2. Located on the northwest of South Asian Subcontinent, Pakistan lies close to Arabian Sea on the south and borders India on the east, China on the north, Afghanistan and Iran on the west. Its coastline reaches as long as 980km.Three fifths of the whole territory are mountainous areas and hilly land. The southern coastal areas are arid deserts, while the northern parts are continuous plateau pastures and fertile soil. The Himalayas, Karakorum Mountains and Hindu Kush, three of the world-famous mountains, converge at the northwest of Pakistan and form a peculiar landscape. Indus River, which originates in China, runs southward from north for 2,300km and finally flows into Arabian Sea. South Pakistan features tropical climate and the rest part sub-tropical climate.

4.2 Population and Administrative Division

4.2.1 Pakistan is a multi-ethnic country with a total population of 210,000,000, among which Punjab group accounts for 63%, Sindhi people 18%, Pathans 11% and Baloch people 4% etc. More than 95% of the population believes in Islam (the state religion) with the minority believing in Christianity, Hinduism, Sikhism and so on. The national language is Urdu and official language is English. The major ethnic languages are Punjabi, Sindhi, Pashto, Balochi language and so on.

4.2.2 Pakistan is divided into 4 provinces, 10 Federally-Administered Tribal Areas (FATA), with Islamabad being Federal Capital Territory (FCT). Each province is subdivided into special districts, counties, countries and villages.

.4.2.3 The population density of Northern Areas of Pakistan and Balochistan is the lowest. Particularly, the population density of Northern Areas is only 11 per square kilometer. China-Pakistan Railway is located in KPK Province and Northern Areas of Pakistan, which fall into economically underdeveloped areas.

Table 4.1: Area and Population Density etc. of Provinces and Districts of Pakistan.

Item Scope	Area (km^2)	Population (10,000 persons)	Population density (persons/ km^2)	Provincial capital and major cities	Notes
Pakistan	796096	14900	187	Islamabad	
Balochistan	347190	722	21	Quetta	
KPK	74521	1948	261	Peshawar	Project location
Punjab	205344	8085	394	Lahore	
Sind	140914	3343	237	Karachi	
FATA	27220	349	128		
FCT	906	89	982	Islamabad	
Northern Areas	72520	80	11	Gilgit	Project location
Kashmir	11639	283	243	Muzaffarabad	

Note: the population data was collected in 2005

4.3 General Situation of Social Economic Development

4.3.1 Overview: Pakistan is an underdeveloped country under capitalist market economy system. Pakistan's GDP aggregates 314.6 billion US dollars with GDP per capita being 1482 US dollars. Agriculture plays a key role in the national economy. Major crops of Pakistan are divided into food crops including wheat, rice, millet, sorghum, corn, barley and economic crops including cotton, sugar cane, tobacco etc, among the above crops, the most important ones are cotton, wheat, rice and sugar cane. Pakistan's industrial foundation is weak, and the major industries are textiles, sugar industry, grain & food processing industry, leather processing industry, cement production, iron & steel, fishery and so on. Export is mainly based on agricultural products and the manufactured and generally, there is some trade deficit every year. Among South Asian countries, Pakistan's service industry is relatively developed and information technology application level is relatively high, even in northern mountainous areas (north section

districts of Karakoram Highway), international long-distance telephone and international internet service are relatively convenient.

4.3.2 Resources: Pakistan is relatively rich in mineral and waterpower resources. The major mineral reserves are 4411m^3 of natural gas, 139 million barrels of oil, 4.3×10^8t of iron, 4.12×10^8t of copper, 7400×10^4t of bauxite, large quantity of chrome ores, marble and precious stones. Forest coverage rate is 4.8%.

4.3.3 Agriculture: Pakistan is a developing country with agriculture being the backbone of economy. The government adopts relatively liberal economic development policy. In Pakistan, labor force engaged in agricultural production accounts for 51% of that of the whole country. The major agricultural products are wheat, rice, cotton, corn, sugar cane and so on. Agricultural output value accounts for more than a quarter of GDP and about 45% of exports earnings. Harvest of the four crops, i.e. cotton, rice, wheat and sugar cane, has a direct impact on growth rate of the national economy. There are huge irrigation systems on Indus Plain, which is reputed as "granary", and the northern valleys. Those provide good irrigation works for the production of food and economic crops such as rice, wheat, cotton and sugar cane and so on. The food is basically self-sufficient; Rice and cotton can even be exported. As located in subtropical zone, Pakistan is rich in fruit resources and therefore, it is traditionally reputed as oriental "fruit basket". Plain and wash are big producers of bananas, oranges, mangos, guava and various melons while mountainous areas and plateau are big producers of peach, grapes, persimmon and so on. Planting industry has had a great development in recent years with irrigation area being constantly expanded. Meanwhile, improved varieties of crops such as wheat, cotton and so on are being popularized. While production of agricultural tractors is on the rise, the government also organizes the import of small tractors. Besides, the government also provides guidance in terms of policies and increases agriculture credits, introduces foreign fine-breed livestock for hybridization, increases animal husbandry equipment and veterinary stations as well as popularizes

artificial insemination in the breeding of cattle and sheep etc. In recent years, output of animal husbandry products has been raised significantly.

4.3.4 Industry: Pakistan's industrial foundation is relatively weak. Industrial output value accounts for about 25% of the GDP of Pakistan, with light & textile industry taking the leading role. It is encouraged by the government to establish small processing enterprises in the rural areas to absorb surplus rural labor force. The largest industry sector of Pakistan is cotton textile industry and the rest are wool textile, sugar, paper, tobacco, leather, machine manufacturing, fertilizer, cement and power industry. Energy source is a weak link in the chain of national economy and the electric quantity can not meet the demands of economic development.

4.3.5 Service industry: The output value of service industry accounts for about 50% of GDP with retail & wholesale being the biggest sector. In recent years, finance and insurance industries show strong momentum of growth. Tourism develops relatively slowly.

4.3.6 Foreign trade: In recent years, efforts have been made by the government to accelerate industrialization, promote the development of export-oriented industries, attach top priority to the development of import substitution industries, expand exports and narrow down trade deficit. At present, Pakistan keeps trade relations with more than 70 countries and regions. The major imports are oil & oil products, machinery & transportation equipment, iron & steel products, fertilizer, electrical products and so on. The major exports are rice, cotton, textiles, leather products, carpets and so on.

4.3.7 Foreign trade policy: Pakistan is the member state of WTO and formulates its own trade policy within the framework of WTO. Apart from the necessary restraints as per specific requirements, generally speaking, Pakistan's foreign trade policy is relatively open on the whole and doesn't attach excessive restrictions on imports. An overwhelming majority of commodities can be imported freely and tariff is the major leverage to adjust import. The management of import is mainly carried out by means of laws and regulations and the Federal Ministry of Commerce, which is in charge of import affairs,

issues and revises laws and regulations on import management according to the situations. Pakistan attaches low tariffs or even zero tariff on commodities encouraged to be imported, otherwise a high tariff would be attached. Based on the general situations of developing countries, Pakistan's overall tariff level is not high and it has been reduced in the recent two years. In the year of 2000-2001, the highest tariff in Pakistan is 35%; in the year of 2001-2002, import tariffs of more than 4,000 kinds of commodities were brought down, with the highest being 30%.In the year of 2002-2003, the tariff rate of more than 2,500 kinds of commodities were brought down once again, with the highest tariff being 25%.At present, apart from the high-tariff protection policy on cars, motorcycles and some transportation vehicles, the highest import tariff for other commodities is 25%.Now, the import tariff of Pakistan fall into 4 grades, that is 25%, 20%, 10% and 5%.Zero-tariff policy is now implemented on some commodities, such as some mechanical equipment of foreign-invested projects. China and Pakistan signed *Preferential Trade Arrangement between the Islamic Republic of Pakistan and the People's Republic of China* on Nov. 3, 2003.

Table 4.2: Bilateral Trade Between Pakistan and China in the Past Years

Unit: 10,000 US dollars

Year	Total amount	Import	Export
1996	96375	62148	34277
1997	106700	68800	37900
1998	91300	52400	38900
1999	97100	58100	39000
2000	116200	67000	49200
2001	139700	81500	58200
2002	18000	124200	55800

2003	243000	185500	57500
2004	306100	247000	59000
2005	426100	342000	83300
2006	525000	424000	10100

4.4 Traffic Structure and Development

4.4.1 Overview of traffic development: Highway plays the leading role in the domestic passenger and freight transportation of Pakistan. In recent years, the improvement of highway network and the increase of air transport network are far faster than that of railways. Highway and air passenger and freight transport volumes increase at a fast speed.

4.4.2 Railway: The full length of Pakistan's railway is 7,791km and the Peshawar—Lahore—Karachi Railway which runs through the South to the North is the main trunk.

4.4.3 Highway: The full length of Pakistan's highway is 9722km and the number of motor vehicles of various kinds reaches about 4.8 million. The full length of Karakoram Highway, which was completed and put into use in 1978, is more than 806km and it plays a key role in the development of northern mountainous areas and the strengthening of ties between China and Pakistan.

4.4.4 Shipping: There are 15 merchant ships with the total tonnage reaching 261,836tonne; Pakistan has two international ports, i.e. Karachi and Qasim Ports, and both of them are in the region of Karachi. Located on southern Arabian Sea coast, Karachi Port is the biggest one in Pakistan and seacraft, whose tonnage reaches 10,000, can be moored in the Port. 90% of Pakistan's ocean-shipping related trade is done in Karachi Port.Located in a place 40km southeast of Karachi City, Qasim Port is a new port and mainly serves Pakistan's iron & steel factories. It is also used for the export of pig iron, coke, rice and cotton.

4.4.5 Air transport: There are 46 civil aircrafts in Pakistan International Airlines, which fly to 38 international airports and 32 domestic airports. Full length of the flight course is 345,900 km. There are four international airports in Pakistan, and they are respectively in Islamabad, Karachi, Lahore and Peshawar.

4.4.6 The table shows that, except railway freight volume accounted for 31.91% of the whole highway & railway freight volume in the year of 2004-2005, highway passenger & freight transport volume accounted for more than 90% in the rest years. Therefore, highway transport system plays a leading role in Pakistan's overland transport system in both passenger and freight transport.

4.5 Status and Development of Pakistan Railway Network

Since the first railway connecting Karachi with Kotri was completed in 1861, during the subsequent period of more than a century, Pakistan's railway has experienced a long-time development and made great achievements. A 7,791km railway network containing 7,346km broad-gauge railway and 445km meter-gauge railway and covering the major cities of Pakistan, such as Islamabad, Lahore, Peshawar, Karachi and so on, has been completed on the basis of the first single-track railway of 169km and the current domestic railway network of Pakistan is shown in the following figure.

However, as most of the current railways were built in late 19^{th} century and early 20^{th} century, technology and equipment level of the Pakistan railways is relatively low, both operation and management means are very old, lagging far behind the recent development of highway, aviation and shipping. In the domestic traffic market of Pakistan, the proportion of railway is far behind that of other transportation means. It is especially worse in northern mountainous areas, where there is still no railway due to the poor geography and natural conditions. Statistics show that in 2006, 81.43 million person-times of passengers were delivered by railway, and the turnover of passenger traffic reached 25.62 billion passenger-km; railway freight volume reached 602×10^4t and fright turnover was 59.1×10^4tkm.

Table 4.3: General Situation of Pakistan's Highway Network (Unit: km)

Time	High-class highway		Low-class highway		Total	
	Length	Growth	Length	Growth	Length	Growth

	(km)	speed (%)	(km)	speed (%)	(km)	speed (%)
1990-91	86839	-	83984	-	170823	-
1991-92	95374	9.8	87335	4	182709	7
1992-93	99083	3.9	90238	3.3	189321	3.6
1993-94	104001	5	92816	2.9	196817	4
1994-95	111307	7	96338	3.8	207645	5.5
1995-96	118428	6.4	99917	3.7	218345	5.2
1996-97	126117	6.5	103478	3.6	229595	5.2
1997-98	133462	5.8	107423	3.8	240885	4.9
1998-99	137352	2.9	110132	2.5	247484	2.7
1999-2000	138200	0.6	110140	0	248340	0.3
Jan-00	144652	4.7	105320	-4.4	249972	0.7
Feb-01	148877	2.9	102784	-2.4	251661	0.7
Mar-02	153225	2.9	98943	-3.7	252168	0.2
Apr-03	158543	3.4	97527	-1.4	256070	1.5
May-04	162879	2.7	96879	-0.7	259758	1.4

Note: data are provided by Pakistan's Ministry of Communications

The national trunk highway network plays leading role in Pakistan's highway transport system and is the most important infrastructure in the normal operation of Pakistan's national economy. The full length of Pakistan's national trunk highway network is 9,031km, consisting of state-level highway, motorway and strategic road. Located in North West Province and Northern Areas of Pakistan, Karakoram Highway is north-south oriented and just the N35 highway in the national trunk highway network. It is the most important traffic line of north mountainous areas and southwest of North West Province.

Table 4.4: Highways in Pakistan

No	Route	(Km)
N-5	Karachi-Thatta-Hyderabad-Moro-Multan-Sahiwal-Lahore-Jhelum-Rawalpindid-Peshawar-Torkham	1819
N-10	Lari-Gwadar-Gabd (Makran Coastal Highway)	653
N-25	Mansehra-Naran-Jhalkhad	240

N-35	Hasandbdal-Abbottabad-Thakot-Gilgit-Khunjerab (Karakoram Highway, KKH)	806
N-40	Lakpass-Nokundi-Taftan	610
N-45	Nowshera-Dir-Chitral	309
N-50	Kuchlac-Zhob-Di Khan	531
N-55	Kotri-Shikarpur-DG Khan-DI Khan-Kohat-Peshawar (Indus Highway)	1264
N-65	Sukkur-Sibi-Sariab	385
N-70	Qila Saifullah-Loralai-DG Khan-Multan	447
N-75	Qila Saifullah-Loralai-DG Khan-Multan	447
N-80	Tumol-Fatehjang-Khushalgarh-Kohat	146
M-1	Peshawar-Islamabad	155
M-2	Islamabad-Satra Mile-Lower Topa (Murree)-Kohala	90
M-3	Pindi Bhattian-Faisalabad	53
M-9	Karachi-Hyderabad	136
S-1	Jaglot (KKH)-Shangrila-Skardu	167
S-2	Kohala-Muzaffarabad	40
	Total:	9031
Legends: N: National Highway M: Motorway S: Strategic Road		

4.6 Social Economy and Traffic Structure of Districts along the Railway Line

Starting from Havelian, the railway will run along Indus River, Gilgit River, Hunza River and Khunjerab. Before reaching Khunjerab, it will also run through Abbottabad, Gilgi and Sost and reach as long as 673.948km.The railway will run through north Pakistan, including the two districts of Gilgit and Diamer of Northern Areas and the four districts of Abbotabad, Mansehra, Batagram and Kohistan on Northwest Pakistan borders. For so long a time, due to the influence of the natural conditions, traffic environment and situations of Kashmir, the economic and social development of this area lags far behind that of other areas of Pakistan.

4.6.1 Overview: the overall economic level of areas along the railway line lags behind the average economic level of Pakistan and these areas fall on the list of economically-underdeveloped areas of Pakistan. Their area is 147,000km^2,

accounting for about 18.5% of Pakistan's total land area. The area is located in the subtropical climate zone of South Asia Subcontinent. Because the Project area crosses south to north, there are great changes in altitude and vertical climatic zoning is obvious. Draught and seasonal rainstorm are common, usually bringing negative impact to agricultural production and farmers' income. Besides, the area is located on the edge of suture zone between Indian plate and Asiatic plate. Its geological structure is extremely complicated and the neotectonic movement is frequent, therefore it belongs to high-risk earthquake zone. In the area, the population density is relatively low and economy is relatively underdeveloped. Agriculture and the traditional handicraft industry are the major pillar industries as well as the most important revenue sources of the local residents. In the area, the industrial foundation is weak and the development level of the third industry is relatively low.

4.6.2 Agriculture: Agriculture is the major pillar industry of areas along the railway line. North Pakistan is located in the dissected mountain of the Himalayas and south slope of Karakorum Mountains. Due to the big changes in altitude, vegetation there is featured by vertical distribution and inhomogeneity of development. Vegetation distribution is mainly affected by climate and topography. Unfavorable natural conditions cause that most lands are barren with low output and scarce vegetation. The arable land distribution is extremely uneven. In some areas, water resources for irrigation and livestock feeding are quite limited (Rivers and lakes are few). All above plus low land output cause quite low agricultural production value. The major agricultural products are wheat, maize, barley, millet, fodder and tomatoes and the major fruits are apple, grape, apricot, pear, plum, cherry, walnut, almond and pomegranate. Due to the limitations of traffic conditions, most agricultural products are consumed by the local market with few being transported to other places or exported.

4.6.3 Industry: Industrial foundation of areas along the railway line is weak. Due to the inconvenient traffic, it is difficult to transport raw materials needed in industrial production and the final products by land at a large scale. Besides, the lack of water resources, power and communication equipment also causes that large-scale industrial production can not be carried out in areas along the

railway line. At present, there are only some small-scale cement production industries and processing industries of low added-value.

4.6.4 Tourism resources: Areas along the railway line are rich in tourism resources, which run through two of the world's hugest mountains namely Himalayas and Karakorum Mountains, with Indus River, Gilgit River, Hunza River being along it. The construction is of extreme difficulty and the landscape is of amazing beauty. This is one of the most formidable mountainous landscapes in the world as well as the coveted place of geologists, alpinists and travelers. In areas covered by the Project, your eyes will be caught by Himalayas, Karakorum Mountains, the Pamirs, Hindu Kush and some famous glaciers. From plains to arid mountainous regions, from canyons whose rocks take on a variety of queer shapes to villages surrounded by snow-capped mountains, from plateau lakes, rivers to deserts, Karakoram Highway runs through districts of various landscapes with magnificent natural landscape being everywhere. Hunza, the only place in the world where 5 mountains of more than 5,000m can be in sight at the same time, is reputed as "paradise in dreams of westerns". However, due to the limitations of traffic conditions and economic development level of areas along the railway line, tourism recourses of these areas are just developed to a limited degree.

4.7 Traffic structure of areas along the railway line

Highway network of North Pakistan, which the Project runs through, is relatively underdeveloped than compared with places of Pakistan. At present, there is only one Karakoram Highway as land transportation means, connecting Kashi, Xinjiang, China and Thakot, Pakistan. Its full length is 1,200km, with 806km in Pakistan.

15,000 builders spent 20 years on the construction of Karakoram Highway, which was officially opened in 1978 and was opened to tourists in 1986.As the highway runs through Karakorum Mountains, so it is named Karakoram Highway and abbreviated to KKH. In China, it is sometimes referred to as Sino-Pakistani Friendship Highway or Pamirs Highway.

Karakoram Highway runs through Pamirs, which is reputed as "the roof of the world" and the two mountains of Karakoram Mountains and Himalayas that connect China and Pakistan. As the highest-altitude cross-border highway in the world, it starts from the mountain pass of Khunjerab that is on the border of China and Pakistan and whose altitude is 4,700m, then it

windingly runs southward from north along Khunjerab River, Hunza River, Gilgit River and Indus River, finally reaches Thakot, whose altitude is 460m, and connects to the highway to Islamabad, which is built by Pakistan.

KKH runs through two of the world's hugest mountains of Himalayas and Karakorum Mountains, with Indus River, Gilgit River, Hunza River being along it. The construction is of extreme difficulty and the landscape is of amazing beauty. However, due to the adverse impact of the natural conditions, landslip and road-blocking caused by debris flow and avalanche are frequent, rendering the traffic of Karakorum Highway into extremely terrible conditions. The combination of geological and climatic actions makes here a unstable zone. Peaks and cliff fall to pieces and finally to the rivers, which run through age-old extinct volcanos and remains of ancient coasts. In rainy seasons, large-scale landslide always keeps the highway from smooth traffic and bridges are always destroyed by floods caused by changeable glaciers. After the highway was completed, repair and improvement have never been stopped. Therefore, a special road maintenance and emergency response organization (Military Engineer) was formed in Pakistan Army. Due to the terrible weather, this highway is just open from May to November every year since it was fully opened in 1989.

4.8 Traffic Volume Survey

In order to get an accurate understanding of traffic and traveling situation of Pakistan's Northern Areas, especially that of KKH, we commissioned MAES (a local consulting company of Pakistan) to take around-the-clock uninterrupted observation record of two-way traffic volume of important traffic nodes on KKH for a general understanding of the present passenger and freight transport situations.

Table 4.5 NEW RAIL LINK FROM HAVALIAN TO PAK - CHINA BORDER SUMMARY OF CURRENT TRAFFIC FLOW

Date : 04 July 2007 to 05 July 2007 TIME: Day shift- 07:00 – 19:00_Night shift 19:00 – 07:00

SR. NO.	Check point	Coming		shifts	No. of Sheets	Motor Cycle	Car/ Taxi	Jeep/ Suzuki/ Passenger	Pajero	Hiace Wagon	Medium Bus/ Flying Coach	Bus	Loader Pickups	Tractors/ Trucks/ Trailers	Total
		From	To												
1	Hasanabdal	Hasanabdal	Abbotabad	Day	80	278	2073	1140	229	661	445	185	185	580	5776
				Night	42	160	866	387	86	272	287	72	86	578	2794
		Abbotabad	Hasanabdal	Day	80	261	2053	1163	194	665	476	184	185	625	5806
				Night	40	145	835	342	97	290	273	55	72	558	2667
2	Mansehra	Abbotabad	Mansehra	Day	69	560	1446	396	364	689	287	50	166	525	4483
				Night	44	40	845	256	296	276	275	54	385	748	3175
		Mansehra	Abbotabad	Day	67	704	1331	373	432	635	300	56	202	684	4717
				Night	41	73	810	230	270	327	264	54	370	603	3001
3	Besham	Besham	Gilgit	Day	18	61	355	341	49	82	119	4	103	171	1285
				Night	5	5	81	80	24	8	37	34	26	56	351
		Gilgit	Besham	Day	18	46	393	349	42	74	116	9	89	170	1288
				Night	5	3	76	77	24	25	23	30	36	67	361
4	Gilgit	Chilas	Gilgit	Day	19	59	119	160	35	128	35	30	38	93	697
				Night	5	17	28	37	8	26	17	10	8	62	213
		Gilgit	Chilas	Day	19	95	152	190	37	139	59	30	38	98	838
				Night	6	22	24	58	15	29	19	11	10	68	256
5	Danyor	Gilgit	Danyor	Day	8	35	47	29	19	17		12	15	73	247
				Night	3	8	21	5	7	7		3	3	35	89
		Danyor	Gilgit	Day	11	68	55	26	18	28		11	14	71	291
				Night	4	9	28	9	5	4		5	5	31	96
					584	2649	11638	5648	2251	4382	3032	899	2036	5896	38431

Data source: MAES

CHAPTER 5: CHINA-PAKISTAN RAILWAY TRANSPORT VOLUME FORECAST

5.1 Freight Volume Forecast

5.1.1 Local Tpt Volume

The local transport volume refers to transport volume which would be handled at different stations along the railway line, that is, the volume delivered by and received at every station. Forecast means of this transport volume will be based on survey data of the current transport situations, i.e. the current KKH transport volume survey data. Freight exchange at areas along the railway line will be analyzed and the local transport volume will be forecast according to the national economy and social development statistics and planning materials of areas influenced by the Project, agricultural & industrial production conditions and development & exploitation of mineral resources in the catchment area of the Project as well as analysis of induced economic impact, etc. after the completion of the Project. The major forecast means are production & marketing balance method, consumption indicators per capita, elastic coefficient method, regression analysis and so on.

5.1.2 Forecast and Analysis of Transport Volume of Major Stations along the Railway Line

Industrial economy is underdeveloped in areas along the railway line and exploitable resources are relatively fewer. Agriculture is the major basic pillar industry as well as the major income channel of the local residents. Wheat, maize and barley are the major agricultural products. Besides, fruits such as apple, grape, apricot, pear, plum, cherry, walnut, almond, pomegranate etc. and livestock products are the major agricultural products of the area. Due to the complicated natural conditions of areas along the railway line, arable land distributes in an extremely uneven way. Especially in Kohistan and Diamer, due to the terrible natural conditions, cold winter, dry & hot summer, arid land and sparse population, at present, arable land suitable for agricultural production is quite little. But in areas such as Batagram, Mansehra, Abbotabad and Gilgit,

agricultural production conditions are relatively better. Land there is fertile and suitable for agricultural production.

As per the above analysis, and meanwhile, in order to save capital investment for the Project in the initial stage and make full use of the short-distance transport function of transportation means such as highway, the principle of "opening first & perfection second, and centered transaction of freight transport" shall be considered in the design. The forecast of the local transport volume is shown in the following table.

There will be 7 stations on the railway dealing with freight transport. In the near future, the freight to be delivered is 53×10^4t and freight to be received is 77×10^4t. In the far future, the freight to be delivered is 73×10^4t and freight to be received is 108×10^4t.

Table 5.1: Forecast of Local Transport Volume (Unit: 10^4t)

Station	In the near future			In the far future		
	Delivered	Received	Total	Delivered	Received	Total
Havelian	20	30	50	25	40	65
Kakul	6	9	15	10	13	23
Mansehra	4	6	10	6	9	15
Baffa	5	5	10	7	8	15
Batgram	4	6	10	6	9	15
Gilgit	12	18	30	15	25	40
Passu	2	3	5	4	5	9
Total	53	77	130	73	108	181

5.2 Analysis Of Status Quo and Forecast of Passing Transport Volume

After the completion of the line, passing transport volume will be the major freight operation to be carried out by the railway. The completion of the railway will build an around-the-clock land transportation corridor of huge transport capacity in real sense between China and Pakistan. The project will further prompt trade between China and Pakistan by saving transportation time, reducing transportation costs and guaranteeing transportation safety. Besides, as the reformation of Pakistan's railway network and the completion of the relevant roads under planning, as well as the current available Pakistan-Iran Railway and Pakistan-India Railway, there will be a railway network connecting Central Asia, East Asia, West Asia and South Asia. Then Pakistan will become a veritable golden path and its strategic position will be greatly enhanced. Therefore, passing transport volume will become the major component of transport volume of the Project.

China is Pakistan's second biggest trade partner, and the bilateral economic and trade cooperation has covered fields such as mutual investment, project contract, technological cooperation and so on. In addition to projects such as Gwadar Port, many hydropower stations will and are under the cooperative construction of China and Pakistan. China Sunhu Chem Products Co., Ltd. will build two 30×10^4kw thermo-electric plants in Tar Coal Mine. Besides, Pakistan will import three 3,000t/d cement clinker production lines and a 6,000t/d cement clinker production line from China. To sum up, the prospects between China and Pakistan cooperation in various fields are quite bright.

In recent years, trade between China and Pakistan keeps growing. In the years from 1996 to 2004, the annual growth rate of bilateral trade volume reached 15.5% and the trade volume reached 3.06 billion US dollars in 2004, among which value of Pakistan's imports from China reached 2.47 billion US dollars and value of exports to China came to 0.59 billion US dollars. The major imports are mechanical and electronic products, textile products, transport equipment, chemicals and daily necessities; the major exports are textile raw materials & products, mineral products, leather & products, chemical raw materials and products as well as livestock and so on.

There are bright prospects for trade cooperation between China and Pakistan. Pakistan is rich in resources and China holds advantages in fields such as equipment

manufacturing industry, household electrical appliances manufacture, infrastructural construction, mineral resources development and high-tech industry. The two parties are highly complementary. Along with the economic development of the two countries, the bilateral cooperation will be further promoted. Especially after the setup of free trade area, trade relations between China and Pakistan will be further strengthened.

At present, due to the limitations of transportation costs and traffic conditions, imported & exported freight between China and Pakistan are mainly transported by sea. As the China-Pakistan road is of low grade and easily influenced by geography, geology and climate, the transport volume is quite small. According to statistics of the customs, in the year of 2006, the freight exported by Pakistan to China (including non-trade freight) via Khunjerab Port was only about 10×10^4t. The imports from China are much fewer, limiting to handicrafts and a small quantity of fruits.

The construction of the Project will greatly shorten land transportation distance between China and Pakistan, cut transportation costs, improve transportation conditions and bring the condition of around-the-clock operation to the way. It is of great attraction to freight transportation and exchange between China and Pakistan. Forecast of passing transport volume of the Railway is made according to statistics of trade between China and Pakistan & other relevant countries, with a view to factors such as economic development and resource demands of each country.

Table 5.2: Passing Transport Volume Forecast.

Section	2020		2030	
	Up	Down	Up	Down
Havelian~Khunjerab	25	113	40	183

5.3 Social and Economic Aspacts

5.3.1 Summary of Effect District

The proposal of new railway link between Pakistan and China is not only highly beneficial for trade between the two counties but also other social and cultural relation and defense strategic point of view. The line passes in four districts of KPK and two districts of Northern Areas, covering 283 and 433 kilometer distance respectively. The northern area is most visited tourist destination in Pakistan and consists of beautiful valleys and green high mountains.

Among the KPK districts, the Abbottabad district is extremely beautiful, charming and pleasant climate with population of 881000 and the area is 1967 square kilometers.. The literacy rate is 57%. The Mansehra district consist of beautiful valleys and climate is cold in winter and less warm in summer. The population is 1153000 and the area is 4579 square kilometer. The literacy rate is 36% while variety of the flora and fauna is available. The Batagram district is mostly mountainous and with thick forests. The population is 307000 and is mostly Swati Tribe in the area of 1507 square kilometer. The literacy ratio is nearly 29% with less education trend especially in females. The Kohistan district consists of huge mountains and with numerous deep and narrow valleys in which Kohistani tribe with population of 472500 souls. The climate is extremely cold in winter and warm in summer. The people are socially, economically backward and having only 12% literacy rate. The area is rich of flora and fauna species.

In the Northern Area, Diamer district is composed of high and rugged mountains with cold winter and warm and dry summer. The population is 204000 with literacy rate is only 14%. The people are socially aloof and social system can be categorized from well cooperative to extremely harsh. The tribes are Sheen and Yashkoon. The majority of the population is in lack of basic facilities. The Gilgit district is bleak and rugged, hemmed in all sides by the mightiest Karakuram and Himalayan mountains ranges. The northern mountains are permanently covered with snow. The climate is extremely cold in winter and warm in summer. The important tribes are Yashkoon, Sheen, Wakhi and Kashmiri. The Hunza people are having Ismailies religion and their dress and culture is

European style. Due to a lot of development works by the government and non-government organizations, the people are economically active, and literacy ratio is also high i.e. 67%. The population of the district is 247000.

The Northern Area has rich mix of natural and cultural heritage makes the region particularly important tourist destination. The area secure as a principal water catchment for Indus River, upon which a majority of Pakistan' irrigation and hydroelectric depends.

5.4 Sensitive Areas on the Route

There are four district of KPK and two districts of Northern Areas fall at the route of newly proposed railway link if aligned along the KKH. Among the four district of KPK, the Kohistan district somewhat socially different. Similarly in Northern Areas Diamer district has same position. The people of both these districts are socially aloof. This is reflected in the nature and the social norms of the area. The social systems can be categorized from being very collaborative to extreme harsh. This tribal system follows its own codes of conduct and justice. The tribes are very tightly organized and bonded through close kinships. Tribal leadership is still intact and codes are rigidly implemented. The social structure of some tribes however has been modified in some areas mainly due to their proximity to settled areas. However, this will be some what difficult but not impossible to settle the issues with these people. Mutual understanding, participatory approach, especially with the notable person of the village or involvement of religious leader may resolve all the social issues.

The remaining areas, three districts, of KPK i.e. Abbotabad, Mansehra and Batagram and Gilgit district of Northern Area are highly cooperative, socially well explained people. No problem can be arising in these areas except land compensation. The land compensation rates of Gilgit district are announced yearly by the Deputy Commissioner. These values are implemented to all public and private sector. The land value of settled districts of KPK can mutually agree with the local people comparing with the revenue record of KPK revenue Department.

5.5 Comparison with Road Project

The railway journey is much safe and cheaper as compared to road journey. The mega road projects are already under construction like up-gradation of KKH, Mansehra-Chillas via Babusar road and Haripur-Thakot along Indus river road. It seems that there is no proposal under consideration of road project other than above projects. So in future only the scope of railway line project will be the beneficial in all respect if technically feasible. It will affirm high positive effects on the development on the area and need of the govt. level that a new transportation project will be built. The opportunities to build the road highway have already been availed up to some extent and now are to maintain the existence road properly. The railway line performance is much high in case of transportation, stabilization, and reliability and less negative impact for environment. The investment for railway system would conversion directly to the investment for locals. It will create more chance for labor, buying local goods, and local architecture materials etc. The railway traveling is the stable stream of passenger and transportation.

The upper hand of the above remarks, it would deliver more convenience between the two friend countries on government level and federal government of Pakistan and local inhabitants.

5.6 Analysis of Social Impact

5.6.1 Client Group Analysis

Traffic is a significant activator for economic development and poverty elimination. In areas influenced by the Project, poverty in places with developed traffic is less. For instance, as Southern Areas of Pakistan is in plain areas, its traffic network is far more developed than that of Northern mountainous regions, therefore, its economic development level is far higher than that of Northern areas. On this basis, it can be believed that construction of China-Pakistan Railway will further promote economic development of areas influenced by the Project, and its positive impacts include:

1) Traveling and transportation will be easy, safe and cheap comparatively.
2) All weather reliability.
3) It will reduce transportation cost.
4) It will increase access to local market for local produce and products.

5) Access to new employment centers.
6) Employment of local workers to project itself.
7) Better access to health care and other social services.
8) Strengthening of local economies.
9) Comparatively less air pollution, noise, environmental damage from accidents.
10) It will help in the other development works, especially in mega projects.

Based on analysis of groups to be benefited, the major potential client groups of China-Pakistan Railway include:

- Residents of areas influenced by the Project. They will travel by train and can get services and other advantages provided by the railway. Cost of railway transportation is lower than that of road transportation.
- Consignors delivering goods out of and in the area influenced by the Project. Transportation cost will be lower than that of the present auto transportation.
- Businessmen will seek to create new markets or get the substances they need in areas influenced by the Project.
- Potential investors. They will evaluate investment opportunities in areas influenced by the Project.
- Tourists. They will visit scenic spots in areas influenced by the Project.
- Passengers who have to change trains in areas influence by the Project.
- Consigners who have to change trains in goods transportation.
- Businessmen and potential investors that have to change trains in areas influenced by the Project.

5.6.2 Poverty and Social Vulnerable Group Analysis

13 (30%) out of 43 villages or towns influenced by the Project are on the list of poor regions by Pakistani Government. Most regions are in Northern Areas. Households whose annual income is less than 100 dollars along the railway reach about 60% and

households with annual income less than 50 dollars accounts for 39.5%. Data analysis shows that most residents in the area fall within poverty line by the government.

Analysis on findings of the social impact investigation by consulting experts shows in areas along the railway, women accounts for about 50% of the whole population and education there is also quite under-developed. 54% of adult male labor force is illiterate while women have far less access to education, and women illiterate reaches as high as 74%.

The major poverty causes of areas influenced by the Project are as follows:

- Natural disasters. Area influenced by the Project is in northern Pakistan, which is located in sub-tropical climate zone of South Asia Sub-Continent. Because the Project area crosses south to north, there are great changes in altitudes and vertical climatic zoning is obvious. Draught and seasonal rainstorms are common, usually bringing negative impact to agricultural production and farmers' income. Besides, the area is located on the edge of suture zone between Indian plate and asiatic plate. Its geological structure is extremely complicated and the neotectonic movement is frequent, therefore it belongs to high-risk earthquake zone.
- Barren land. Area influenced by the Project is the dissected mountain of the Himalayas and south slope of Karakorum Mountains. Due to the big changes in altitude, vegetation there is featured in vertical distribution and inhomogeneity of development. Vegetation distribution is mainly affected by climate and landform. Unfavorable natural conditions cause most lands are barren with low output and scarce vegetation.
- Weak infrastructure. Traffic is underdeveloped in areas influenced by the Project. Presently there is only a China-Pakiston Highway. Due to the influence of natural conditions, it is easy to get into disruption. The area lacks power, drinking water and communication equipment, meanwhile it is far from big cities in which social welfare service can be provided.

- Lack of water. In some districts, water resources for irrigation and livestock feeding are quite limited (Rivers and lakes are few).Plus low land output, agricultural production value is quite low.
- Income channels are limited. In the countryside, traffic is underdeveloped and the most basic agricultural production or primitive processing are generally what the countrymen depend on for living. People who depend on agriculture for living are easily influenced by natural disasters. They usually face big risks and also easily influenced by climate and market fluctuation.
- Deposits are limited. Due to the fact that most households are poor in the areas influenced by the Project, they lack deposits or they don't have relatives or friends with deposits who can offer help when they suffer from natural disasters, misfortune or diseases.
- Economy is underdeveloped. Apart from cultivating land and working in other places, the remote countryside lacks employment opportunities. Markets in these areas are small and industry is underdeveloped, meanwhile access to bigger markets is limited by traffic.
- Lack of technology and practical experience. Being far from market, it is difficult for households in the countryside to make use of best technology and practical experience to boost their output.
- Lack of medicine. Some households have disabled or frail and sick members. This means they have to pay extra money on medicine for people who are not able to work. However, these households are already quite poor.

CHAPTER 6: ENVIRONMENTAL ASPACTS

6.1 Features and Distribution of Major Pollution Sources and Pollutants

6.1.1 Noise

The main noise pollution sources during the construction period are various construction equipment and transport vehicles, which will cause certain influence to the surrounding environment during construction and material transport. The construction machinery in the construction site includes loader, excavator, bulldozer, concrete mixer, heavy crane, which are the main noise pollution sources. According to great amount of past monitoring data, Table 1 shows the noise source intensity of the common construction machinery.

Table 6.1: Noise Source Intensity of Common Construction Machinery and Transport Vehicle

Name of construction machinery and transport vehicle	Noise level Leq (dB)				
	10m	30m	60m	120m	220m
Bulldozer	76～82	66～72	60～66	54～60	＜40
Excavator	76～84	66～74	60～68	54～62	＜40
Scraper	76～82	66～72	60～66	54～60	＜40
Loader	81～84	71～74	65～68	59～62	＜40
Rock drill	82～85	72～75	66～69	60～63	＜40
Diesel pile driver	90～109	80～99	74～93	68～87	44～63
Drop hammer pile driver	94～105	84～95	78～89	72～83	48～59
Land leveler	78～86	68～76	62～72	56～64	＜40
Roller	75～90	65～80	59～74	53～67	＜45
Concrete mixer	70～86	60～76	54～70	48～62	＜40
Riveting machine	82～95	72～85	66～79	60～73	＜49
Vibrator	70～82	60～72	54～66	48～60	＜40

Name of construction machinery and transport vehicle	Noise level Leq (dB)				
	10m	30m	60m	120m	220m
Hoist	84～86	74～76	68～70	62～64	＜40
Heavy crane	85～95	75～85	69～79	63～73	＜49
Truck	72～82	62～72	56～66	50～60	＜40
Tractor	75～90	65～80	59～62	53～68	＜45

The main noise pollution sources during the operation period are traveling of trains, shunting work, whistling, service of locomotive and so on, which distribute in stations, depots and substations. The following table shows the noise source intensity of passenger train and freight train.

Table 6.2: Noise source intensity of freight train and passenger train (Unit dB)

Item	Speed (km/h)	Noise source intensity of passenger car	Noise source intensity of freight car	Measurement condition & position
Traveling of Train	30		75.0	Continuously welded rail track, 25m away from the center of the track in use and 3.5m above track level
	40		76.7	
	50	72	78.2	
	60	73.5	79.5	
	70	75.0	80.8	
	80	76.5	81.9	
	90	78.0		
	100	79.5		
	110	81.0		
	120	82.0		

6.1.2 Vibration

Table 6.3: Vibration Source Intensity of Railway Trains

Item	Speed (km/h)	Vibration source intensity of passenger train	Vibration source intensity of freight train	Measurement condition & position
Traveling Train	50	76.5	78.5	On the ground 30m away from the center of the track in use, Grade I railway, continuously welded rail track, 60kg/m rail, concrete sleeper, ballasted track, embankment line, good track level, alluvion in terms of geology, axle load of freight train is 21t, and axle load of passenger train is 23t.
	60	76.5	79.0	
	70	76.5	79.5	
	80	77.0	80.0	
	90	77.0		
	100	77.0		
	110	77.0		
	120	77.5		

6.1.3 Waste Water

The waste water to be produced in construction period is mainly domestic sewage by construction team and a little oily sewage by construction machinery, equipment and so on.

During operation period, the production wastewater is mainly the oily sewage from production depots and points along the line, such as locomotive depot, rolling stock depot and so on. The main pollutants are petroleum oil, COD and SS. Domestic sewage mainly comes from the living quarter and administrative area of large stations such as Havilian, Abbottbed, Gilgit and other stations along the line. The main pollutants include COD, SS, BOD_5 and so on.

6.1.4 Exhaust Gas

The atmospheric pollution sources of this railway include the mobile pollution source from the diesel locomotive traveling on the line and the exhaust gas to be discharged by boilers of each production station, depot and point. The main atmospheric pollutants to be discharged include soot, SO_2, NO_2, CO and so on, among which the exhaust gas to be discharged by diesel locomotives will cause unfavorable impact on the atmospheric environment in some areas along the line.

6.1.5 Solid Waste

Solid waste is produced from production activities of railway transportation and various living facilities which serve transportation production. The solid waste mainly includes domestic garbage from administrative area and living quarters of stations, garbage from the waiting hall, and garbage to be dumped by the passenger trains. The garbage stated above will pollute the environment of the areas along the line in the case of failure of proper treatment.

6.1.6 Air

Table 4 shows the oil consumption of diesel locomotives on the whole line and discharge of atmospheric pollutants.

Table 6.4: Discharge of Atmospheric Pollutants from Diesel Locomotives (Unit: t/a)

Pollution source	Service life	Oil consumption	Soot	SO_2	CO	NO_X
Diesel Locomotive	Near Term	50446	767.3	161.4	358.3	957.6
	Future Term	75669	1151.0	242.1	387.5	1436.4

6.1.7 Solid wastes

The solid waste along this line mainly includes garbage from passenger trains and domestic garbage to be produced by employees and passengers in waiting at stations.

Garbage from the passenger trains on the line is estimated as 718t/a in the near future, and 856t/a in the far future.

Table 6.5: Discharge of Solid Wastes along the Whole Line

Sort	Discharge amount (t/a)
Domestic garbage from employees	448.6
Garbage from passenger trains	383
Total	831.6

6.2 Ecological Environment

The impact of railway construction project on ecological environment mainly reveal as the loss of the original land function and damage to the vegetation due to change in the land use type resulting from the permanent occupation of land by the main part of project. The main part of the project will occupy 1504.13 ha. land. In addition, waste earth, ballast, excavation of ground surface and filling resulting from construction of the main part during the construction period will form bare side slope, which will result in severe even extremely severe soil and water loss in the case of failure of preventive measures.

6.3 Impact of Soil and Water Loss Caused by Earthwork of Project

This line is 662km long, involved with 65 stations and 223 new tunnels with a length of 368.8km. The muck volume of the tunnels along the whole line is about $1970\times10^4m^3$. The total earth and stone volume of the subgrade works is $3217.5\times10^4m^3$, including $1451.5\times10^4m^3$ fill and $1766\times10^4m^3$ cutting. The total earth and stone volume of station and yard works is $1926\times10^4m^3$, including $987\times10^4m^3$fill and $939\times10^4m^3$ cutting.

Because of the factors such as steep topography of the area along the line, fractured rock, well developed gulley erosion of Karakorum Mountains along both banks of Indus River, low vegetation coverage, poor ability of earth to keep soil and water as well as high one-time rainstorm intensity of the area along the line, the implementation of the project is apt to cause soil and water loss; therefore, this area is a significant section

which requires prevention of soil and water loss. The muck volume of this project is great and the topography of the area along the line is steep, therefore, the condition for mucking is very difficult. In next stage, it is significant to strengthen the site selection of spoil ground.

6.4 Impact of Land Expropriation and Removing on Environment

Land of 3290.6 ha. will be expropriated for the project. The types of land expropriated are mainly wasteland and woodland. The implementation of the project will greatly impact the agricultural production. The expropriation and removing for this project will also impact the ecological environment of the nearby towns, whose infrastructure such as residential and traffic facilities, and the public communication will be influenced.

6.5 Impact on Wild Animals

After the accomplishment of the project, the railway will divide the originally integrated habitat of wild animals into two parts, which will not only influence their breed bug and migration, but also influence their normal feeding behavior; therefore, necessary measures must be taken to relieve the negative impact of the railway on wild animals.

6.6 Impact of Tunnel Leakage on Environment

The line has 223 tunnels with a total length of 368.8km, including 15 tunnels with a length more than 6km, and 2 tunnels with a length more than 10km. Most of the tunnels is located below glacier. According to the past experience and lesson, tunnel construction may result in leakage of surface water leakage and ground water, which may have further impact on the water source for living, production and farmland irrigation of the nearby areas, and even change the ecological environment of ground surface on the top of the tunnels. Therefore, overall environmental monitoring shall be carried out for long and large tunnels on the line in construction. Great importance shall be attached to subsidence and deformation of structures on tops of tunnels and change of water source, the related information of which shall be sent to the construction and design organization so that

they can timely take preventive measures and minimize the impact of tunnel construction on the surrounding environment.

6.7 Protective Measures for Wild Animals

Attention shall be paid to environmental protection and provision of passages for wild animals. The preliminary suggestions on establishment of animal passage are as follows: tunnel is preferred in nature reserve and mountains for large mammals acclimatizing to mountain environment will not be disturbed if the train travels through tunnels, therefore, high bridge is preferred in the vast valley and river shoal of plateau in which wild animals live (the clearance of bridge shall be more than 5m and width shall be not less than 20m so that wild animals can cross the railway smoothly) and can be constructed at the major migration passages of wild animals for breeding. However, the simplest method available for long section of railway is to reduce subgrade height, decrease subgrade gradient (less than 35 degrees), recover the vegetation on the slope of subgrade, reduce the contrast between the railway and the surrounding environment, and adopt grade crossing passage with mild slope, so that wild animals can easily cross the railway. Moreover, "overbridge" can be constructed for wild animals according to the real situation. Such "overbridge" allows trains to pass through the culvert below. The top of the bridge shall be planted with sod, and the outer edge of side slope shall be lined with stones so as to simulate the natural hills.

Figure 6.6: Local Wild Animals

Meanwhile, according to the requirement of the local residents, the railway construction department shall provide the passage for domestic animals that can also be used as the auxiliary passage of wild animals. For medium-sized and small animals such as bharal, the clearance of the passage below bridge shall be more than 3m; for large animals such as wild yak, the clearance of the passage below bridge shall be more than 4m. The approach span of bridge crossing rivers shall be properly lengthened so that animals can pass river shoal. The passage above tunnel is designed for animals in alpine mountains. Guard fence shall be installed to prevent animals entering tunnel.

In order that the railway will not disturb inhabiting and breeding of rare wild animals, efforts shall be made to bypass national parks and nature reserves in design, and noise shall be reduced during construction so that it will not disturb wild animals. Opinions of herdsmen in the areas along the line shall be incorporated into the program of the amount and location of wild animal passages, which shall be demonstrated by the wild animal protection experts invited. Management shall be strengthened to prohibit poaching, especially poaching in nature reserves. The pasturing area of domestic animals shall be away from alpine pasture, which shall be the habitat of ibex and Markhor. Regulation shall be established to forbid felling.

6.8 Protective Measures for Ecological Environment

In the program study, the railway location shall bypass the environmental sensitive spots such as national parks, nature reserves, famous scenic spots and so on, and corresponding protective measures shall be taken for Pakistan Khunjerab National Park and Chinese Taxkorgan Natural Reserve that the railway location cannot bypass so as to reduce impact of project on the wild animals and plants in the reserves.

- Efforts shall be made to minimize occupation of farmland and woodland. If is available technically and economically, efforts also shall be made to take the cutting as fill and balance cutting and fill so as to reduce borrow amount and spoil amount as well as borrow area and spoil area.

- In the program study, the railway location and station location shall be selected on the basis of the master plan of towns and cities along the line and great importance shall be attached to the protection of urban ecological environment
- In the design of bridge and culvert, flood discharge requirement of rivers crossed by the railway shall be taken into consideration and p great importance shall be attached to the protection of irrigation facilities of farmland along the line.
- Muck of tunnel shall be used to the filling of subgrade and station and yard in order to reduce the muck amount and spoil area. Suitable dump ground shall be selected for unavailable muck on the basis of fully considering the geological condition and flood control requirement as well as minimizing occupation of farmland and woodland. Meanwhile, the height of slope at tunnel portal shall be subject to strict control in order to reduce disturbance to the natural landform and mitigate soil erosion.
- Both engineering measures and planting measures shall be taken for borrow area and spoil area, if permitted, the borrow area and spoil area shall be reused as farmland and afforested according to the principle of "cultivating, greening, and afforesting if permitted. Large spoil area shall be subject to specific design and the surrounding environment and engineering geological condition shall be taken into comprehensive consideration for site selection, retaining wall shall be established at toe of slope and the spoil area and muck area shall be leveled and greened (reused as farmland).
- The side slope of subgrade subject to double protection from engineering measures and planting measures. Slope protection by means of engineering method is preferred according to the local climatic condition and slope protection by planting at oasis shall be considered, both of which will form a comprehensive protection system.
- Greening design: Afforestation with poplar and masson pine etc shall be conducted in oases of river valleys that the line crosses according to the soil condition, climatic condition, mixed growth condition and so on.

6.8 Noise and Vibration Control Measures

- Noise producing equipment will be furnished with muffler and vibration damper, and necessary sound insulation and absorption treatment will be performed for the rooms storing noise producing equipment.

- Masonry beam is preferred to reduce the structural noise of bridge. Box beam is the first choice, and box beam and frame beam will be used for bridges of the Project.
- Comprehensive control measures such as installation of sound insulated window and construction of noise barrier will be taken for the sensitive spots influenced by railway noise such as schools, residential areas according to the result of noise impact prediction, situation beyond standard, building structure and so on.

  (1) Scheme of noise reduction with sound barrier: Sound barrier will be constructed in large residential area along the line to reduce noise according to the preliminary noise prediction result of the sensitive spots influenced by railway noise. Sound barrier can be of reflection type and sound absorption type. The façade of sound barrier shall be beautiful and harmonious with the surrounding environment. Please refer to the picture below for the effect drawing of sound barriers in section with typical subgrade and bridge.

  (2) Scheme of sound insulated window: Sound insulated window will be installed in small residential area to reduce noise according to the structure and quality of building, topographical condition, engineering type and so on.

  (3) Removing is preferred for scattered individual houses along the line according to the house quality and degree of noise impact.

6.9 Conclusions of Environmental Impact Analysis

The construction of this project has small impact on Khunjerab National Park along the line and no impact on Ggulmit National Park, Garnar Scenic Spot and so on. Soil and water conservation measures, grass and tree planting in the area occupied by the Project can be taken to mitigate soil and water loss and damage of vegetation so as to control soil and water loss. The main part of the project will be subject to comprehensive measures such as those for noise reduction, decrease in vibration intensity, control over noise source transmission route and protection for the noise sensitive spots to reduce the influence degree and scope of train running noise and vibration. All of which will meet the national environmental requirement of Pakistan on the basis of strengthening drainage of production wastewater and domestic sewage, control over electromagnetic interference and solid waste treatment and control.

In general, the impact of this project on environment can be mitigated and eliminated through environmental protection measures; therefore, this project is feasible in terms of environmental.

Chapter 7 RESULTS AND DISCUSSIONS

Item		Unit	Center Route	East Route	West Route	Gilgit Short Cut Route
Length of railway line		Km	662.000	598.785	661.726	59.393
Subgrade	Earthwork	10∧4m3	2928	2333	2838	1831
	Masonry	10∧4m3	313	249	303	196
Bridge	Super major bridge	No.s	86	78	92	62
	Large and medium bridge	No.s	93	66	99	71
Tunnel	L＜1000	No.s	144	67	149	86
	1000~3000m	No.s	40	39	44	21
	3000~6000m	No.s	22	21	24	27
	6000~10000m	No.s	15	12	13	12
	10000~20000m	No.s	2	2	2	4
	L≥20000m	No.s	0	1	0	1
Total length of bridge and tunnel		Km	466	443	472	467.305
Proportion of bridge and tunnel to railway line		%	70	74.03	71.41	79.29
Number of stations		No.s	65	56	63	52
Estimated Cost		Billion (USD)	10.237	13.284	10.289	12.767

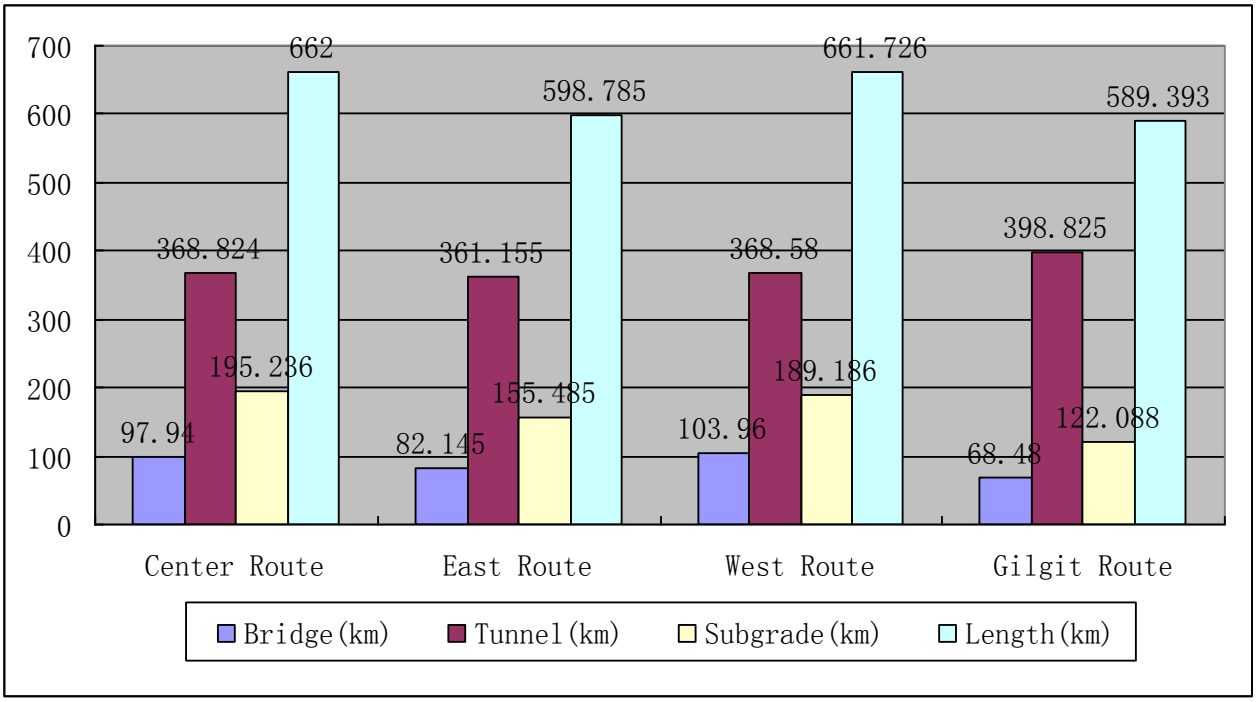

Table 7.1: Advantage and Disadvantage Analysis Between Different Routes

Routes	Advantage	Disadvantage
Center route	This route goes along the assembling area of residents with rich tour resource, the construction of the railway will lead the development of tour as well as local economic development, further to promote the economic and cultural development along the line. This railway starts from Havelian which only 100km away from the Pakistan capital Islamabad, the construction of this railway will promote the communication of economy and culture between China and Pakistan, to realize Pakistani economical circle base on the center in Islamabad and traffic rapid assembling and dispersing from north to south. Engineering difficulties is comparatively small with saving cost	It has longest length within four study routes
East route	This route is 63.215km shorter than the center route proposal with more straight and smooth alignment.	A 47.78km super long tunnel has to be set with a lot problems regarding construction, safety

		and operation, therefore, it will cause huge amount of cost to design and build.
West route	Land Acquisition is less costly.	There is little human habitation along the line with poor transport condition for about 100km, it will not benefit local economy. This route will cross Indus river 4 times with highest bridge 82m high and 1250m long construction will be more difficult.
Gilgit short cut route	This route is 72.74km shorter than the center route proposal with more straight and smooth alignment.	A 43.14km super long tunnel has to be set with a lot problems regarding construction, safety and operation, therefore, it will cause huge amount of cost to design and build.

Chapter 8 CONCLUSION AND RECOMMENDATIONS

8.1 Conclusions of Route Selection

Results of comparison between the proposals are as follows:

- East Route and Gilgit Short Cut Route is not recommended under current technical condition due to super long tunnel
- For center route proposal, engineering quantities are large and 20% pusher grade is applied, hence it requires large investment. But since the line runs through many towns, it can well serve economic development along the line. Comparatively, for west route proposal, it requires small engineering quantities and 10% grade can be extended to Gure Station with a length of 453km. But a section of more than 100km of the railway line will run through areas with little human habitation, preventing it from well boosting the local economic development. In addition, as for west route proposal, the line will cross over Indus River four times, and the highest bridge is 82m high and 1250m long, thus high piers must be constructed in Indus River, which makes construction much difficult.

Therefore, Centre Route Proposal is recommended based on this study.

It is reiterated Development of a railway track connecting Pakistan with the regional superpower is a need of hour. The proposed project would not only play a vital role in socio-cultural development of the country especially the northern part of it but also play a vital role in bilateral trade and economic growth. Though the upgradation of ML-1 track has been incorporated in CPEC project ,the importance and need of such vital rail link cannot be ruled out and this project is an endevour to critically analyse this project .Though there are some stumbling blocks in the development of such project mainly its topography and geological issues however these issues can be resolved . The most important aspact which the authors want to highlight is its stretigic implications with regards to defence forces of Pakistan. Presence of a division size force along with a complete wing of Frontier corps in Gilgit-Balitistan warrents uninterrupted logistic supply to be maintained round the year which is often blocked mainly to poor topographic issues along with closure of Babusar Top during winter season.Presence of

such a link would definitely ensure that uninterrupted logistic chain to be maintained With some modifications and better engineering practices this project can be of greater use not for the country but also for the regional as well as international trade along with serving the defense requirements of the country.

8.2 Recommendations

1) Construction of railway track is an hour of need thereby it must be started as early as possible.
2) Foreign investment should be encouraged for this project.
3) Various stakeholders including Environmental as well as Tourism Department must be incorporated in this project.
4) The project must be linked with ML-1 project for its efficient utilization.
5) The project must be designed keeping in view internationally applicable rail gauge.
6) Peculiarities of climate and terrain of the Northern Areas must be duly weighed in the design process.
7) Various international agencies including ADB , WB must be approached for the project with compatible interest rates for the financial assistance.
8) The project would be of a great assistance for revival of steel as well as construction industry in Pakistan.