ECONOMIC AND FINANCIAL ANALYSIS

A. Background

1. Khyber Pakhtunkhwa is a province in northwestern Pakistan. It covers almost six degrees of latitude and is mainly mountainous. The condition of the existing provincial highways is much below the desired standard both in terms of width and surface. Limited financial resources and the damaging effect of heavy axle loads have put the roads under tremendous strain. The network is deteriorating, resulting in a shorter pavement life and higher vehicle operating costs. Road maintenance and rehabilitation in the province is seriously lagging, and only 27% of the provincial highways maintained by the Pakhtunkhwa Highway Authority (PKHA) are in fair to good condition; the remaining 73% are in poor condition.

2. For almost all of its 53.9 kilometers, the road between Mardan and Swabi is in good condition, despite its use by some heavily overloaded goods vehicles: trucks carrying locally quarried stone and other construction materials, and trucks and tractor-trailers carrying agricultural and forestry products. But the current mix of fast- and slow-moving traffic, dominated by motorcycles and rickshaws, imposes constraints on speed and increases the risk of collisions. The two-lane, single-carriageway configuration is no longer considered appropriate. Moreover, the road connects to the new Swat Expressway between Nowsheera and the Swat Valley in northern Khyber Pakhtunkhwa (constructed by the provincial government) and is likely to play a feeder role for the China–Pakistan Economic Corridor (CPEC).[1]

3. The rationale for the proposed additional financing project focuses on the road's role as a link between the districts of Mardan and Swabi, which have a combined population of 4 million. The road supports a variety of agricultural, industrial, commercial and educational activities. Most notable from a traffic generation point of view are the Premier Sugar Mill and Distillery (PSM) in Mardan city; several smaller textile and edible-oil mills; five quarries; four public universities, Mishal Medical Complex, and numerous private colleges and academies; a police training school; Shewa Adda Camp for internally displaced persons; and markets for the rural population. Nearby Rashakai, on the M-1 motorway, was dubbed "Technology City" and is expected to develop as a high-tech industrial zone on the CPEC.

B. Traffic Forecasts

4. Traffic counts were made at four locations along the Mardan–Swabi road by a consultant engaged by the PKHA to produce a design and feasibility study for the additional financing project. Table 1 shows the weighted average traffic volume, disaggregated by vehicle type. The dominance of 2- and 3-wheelers stands out, as does the very low share of trucks (4%, of which almost all are rigid trucks (a truck where the axles are fixed to the frame, which is separate from a tractor/trailer combo, where each piece has its own axles). There are many more animal-drawn vehicles than semi-trailer trucks. A 10% adjustment was made to allow for the seasonality of agricultural traffic, especially traffic associated with sugar cane crushing season. Nevertheless, the adjusted count cannot be claimed as an accurate estimate of annual average daily traffic. It is the best estimate available, and this was considered in sensitivity testing.

5. The same consultant projected traffic to 2028, as required under its contract with the PKHA, and for design purposes it projected equivalent single axle loads for a further 10 years. It

[1] ADB recognizes this member as the People's Republic of China.

used growth rates of 8.45% per annum for motorcycles, rickshaws, and cars and taxis; and 2.83% for all other vehicles, with a weighted average of 7.20% per annum. Historically and intuitively this seems implausible. The present analysis uses the same vehicle-type-specific growth rates as for a similar dualization project in National Highways Authority (NHA). Applying these to the vehicle mix on the Mardan–Swabi road produces a weighted average of 3.43% per annum.

6. This may be conservative. The records of the Government of Khyber Pakhtunkhwa show vehicle registrations growing at an average annual rate of 9.8% during 2001–2015, the highest rate (12.8%) being for motorcycles. Registrations may not be a reliable guide to usage on provincial roads, but the possibility of more rapid traffic growth is accommodated in sensitivity testing. For comparison, an earlier study of proposed interventions on a selection of Khyber Pakhtunkhwa provincial roads projected average growth of 5.5% per annum.

Table 1: Traffic Count, 2018 (Average Daily Traffic)

	Animal drawn vehicles	Motor cycles	Rick-shaws	Cars & taxis	Pick-ups, vans and jeeps	Mini-buses	Buses	Tractors + trailers	Trucks				Total motorized
									2-axle	3-axle	4-axle	5-axle	
Traffic count*	79	4,796	3,404	4,249	1,463	310	52	340	372	186	20	7	15,199
Adjustment	8							34	37	19	2	1	93
Adjusted count	87	4,796	3,404	4,249	1,463	310	52	374	409	205	22	8	15,292

*Distance-weighted average of 4 counts made at Shahdand Baba, Shahbaz Gari, Yar Hussain and Gohati.
Source: Pakhtunkhwa Highways Authority consultant surveys with subsequent weighting and adjustment.

7. As well as an increase in traffic owing to general demographic and economic growth, an upgraded road is likely to generate traffic. It could also cause some traffic to divert from the M-1 and/or N-5 by offering a toll-free route to Haripur, Abbottabad, and thence to Gilgit Baltistan and the People's Republic of China via the Karakoram Highway. The traffic forecasts with and without the project are shown in Table 2.

Table 2: Forecast Average Daily Traffic, 2018–2040 – with and without Project

	With Project			Without Project		
Section	**2018**	**2030**	**2040**	**2018**	**2030**	**2040**
Normal traffic	15,292	23,198	33,485	15,292	23,198	33,485
Generated traffic (10%)	0	2,320	3,349	0	0	0
Diverted traffic (5%)	0	1.160	1,674	0	0	0
Total	15,292	26,678	38,508	15,292	23,198	33,485

Source: Asian Development Bank estimates.

C. Economic Costs

8. The additional financing project's economic cost was calculated by applying a conversion factor of 0.85 to the estimated financial cost of PRs9,550 million,[2] after subtracting price contingencies and financing charges from this total. The conversion factor is the standard one estimated and used by the NHA in its own economic analyses, including the Highway

[2] Financial cost data are taken from the cost estimate prepared by the detailed design consultant with update dated April 2018.

Development and Management Model 4 (HDM-4)-based formulation of a periodic maintenance program for inclusion in the annual maintenance plans. For the Madran–Swabi road, applying this factor produced an economic cost of PRs7,484 million, to be expended over 3 years in the proportions 12%, 60%, and 28%. The investment is assumed to have a residual value of 25% at the end of the appraisal period.

9. The activities under the additional financing are limited to dualization, with no upgrades to or improvements of the existing carriageway. It is therefore assumed that its effect on maintenance costs will be (i) the additional routine and periodic maintenance costs borne by the PKHA for the new carriageway; and (ii) a somewhat reduced deterioration on the existing carriageway thanks to the reduced traffic load, and consequently longer intervals between overlays. From analysis undertaken in 2017 by the NHA, the average per-kilometer costs of PKR22.7 million—functional overlay triggered when the road roughness index (IRI) reaches 5—and PKR1.27 million for routine maintenance in every other year were estimated and applied to provincial roads and national highways alike.

D. Economic Benefits

10. Road users will benefit from shorter travel times and, to a lesser extent, less maintenance costs and tire wear. The impact on road user costs will be greatest when traveling on the new carriageway but will also apply on the existing carriageway because of the assumed slower deterioration. A clear distinction was made in the analysis between time-dependent costs, which will be reduced for all road users, and distance-related costs, which will be reduced only for users of the newly constructed carriageway.

11. It is likely that the dualization will lead to fewer accidents too, because of reduced conflict between through-traffic and local traffic and between fast- and slow-moving vehicles. But no empirical data exist on which to base an estimate of this effect; and it is possible that, because of increased speeds, accidents may be less frequent but more severe, in which case the total cost of accidents may even increase. Therefore, no attempt was made to include benefits of this kind in the analysis.

12. **Time-dependent cost savings.** The NHA also makes periodic estimates of the value of passengers' time, based on gross domestic product per labor force participant and weighted in order to differentiate between passengers and unpaid drivers of the various passenger vehicle types. The latest data show working time values of PRs300/hour (cars), PRs150/hour (motorcycles), and PRs75/hour (rickshaws and buses). It was assumed that non-working time accounts for 70% of all travel time for all vehicle types and is valued at 25% of working time. Average vehicle occupancies were assumed at 2 (motorcycles), 3 (rickshaws and cars), 15 (minibuses), 25 (medium buses), and 40 (heavy buses).

13. No empirical data exist to support these assumptions, and it was found that agencies and consultants in Pakistan use a wide variety of figures. Moreover, the distinction between working and non-working time is problematic in an economy where a high proportion of people work informally or as peasant farmers. Accordingly, no attempt was made to fine-tune the valuation of time, e.g., by applying a shadow price selectively to labor.

14. Existing traffic speeds were observed but not formally measured. A judgement was made about speeds in the without-project and with-project cases, and these are presented in Table 3. They are applicable equally to the existing and new carriageways. It is further assumed that during construction of the new carriageway, average speeds on the existing carriageway will be reduced

by 20% because of construction-related traffic, including heavy equipment, and the likelihood that traffic will be interrupted from time to time to allow safe access to the construction sites. Since this occurs at the very start of the appraisal period, it has a large negative impact on the additional financing project's economic performance.

15. As traffic grows, it is to be expected that average speeds will decline over time. However, it is likely that changes to traffic composition and management will have an opposite effect; these changes include (i) replacement of old, underpowered vehicles with newer vehicles as incomes rise; (ii) in particular, progressive replacement of obsolescent trucks; and (iii) enforcement of vehicle weight limits, whose absence now is a major cause of obstruction, congestion, break-downs, and accidents on all of Pakistan's highways. Moreover, these effects will be felt in both the without-project case and the with-project case, having little effect on net benefits. Therefore no attempt was made to predict changing speeds over time.

Table 3: Assumed Average Speeds (km/h)

Scenario	Motorcycle, Trishaw	Car, Taxi, Jeep	Pickup, Van, Light Truck	Bus	Medium/ Heavy Truck	Articulated Truck
Without project	35	60	50	40	40	40
With project	45	85	70	60	55	55

km/h = kilometer per hour.
Source: Asian Development Bank estimates.

16. **Distance-dependent cost savings.** Data on unit costs (market prices of vehicles, tires, fuel, lubricants, labor) and taxes to be deducted in an economic analysis were provided by the NHA. These data are entered into the World Bank model RED and made available to analysts on request. The latest data were provided in May 2018 and have been used in the present analysis. It is assumed that the existing carriageway has an average IRI of 3.5, and the new carriageway will start with an IRI of 2.5. A formula was devised to mimic a road's progressive deterioration and restoration by periodic maintenance.[3]

17. The project will have some effect on greenhouse gas emissions. It was assumed that (i) only trucks' emissions would be significantly affected, because their lower power-to-weight ratios disproportionately penalize intermittent braking and acceleration; (ii) carbon dioxide (CO_2) emissions are by far the most significant greenhouse gas emissions in road transport—2.70 kilogram of CO_2 per liter of diesel fuel;[4] (iii) the social cost of CO_2 emissions is equivalent to \$30 per ton,[5] growing at 5% per year; (iv) the combined effect of increased average speeds (optimum fuel consumption being achieved at around 60 kilometers per hour) and much reduced braking and acceleration due to congestion would be to reduce emissions by 10%; and (v) by the same token, emissions would increase by 10% during construction. Trucks using the Mardan–Swabi road now emit an estimated 20,000 tons of CO_2 per annum. The reduction produced by the above assumptions would add an estimated PRs115 million (\$0.92 million) to the additional financings project's net present value (NPV). Allowing for uncertainty surrounding the assumptions, and some lesser impact on other vehicle classes' emissions, one may assume an

[3] IRI in year N+1 = IRI in year N $\times$ 1.05 (with project) or 1.06 (without project) + 0.03. Functional overlay restores the surface to an IRI of 3.5.

[4] ADB. 2016. *Guidelines for Estimating Greenhouse Gas Emissions*. Manila.

[5] Derived from a "carbon tax profile" in ADB. 2013. *Climate Action South Asia (CASA Information Update No.2)*, Manila. This may be compared with the current market price of European emission allowances: €21.45/tonne with a recent spike to almost €25/tonne.

addition to the project's NPV in the range of PRs100 million–PRs200 million ($0.80 million–$1.60 million).

E. Results of Economic Analysis

18. The economic analysis was carried out following the Guidelines for the Economic Analysis of Projects of the Asian Development Bank (ADB) and comparing with-project and without-project scenarios using a 9% discount rate.[6] Table 4 shows the road agency and road user cost streams in the with-project and without-project cases, distinguishing time- and distance-dependent costs, and the resultant indicators of the proposed project's economic performance. The pattern of positive and negative incremental maintenance costs results from the distinction made in the analysis between the two carriageways, and the assumed slower rate of deterioration of the existing carriageway in the with-project case.

19. Table 5 shows that the additional financing project is marginal in terms of its quantifiable costs and benefits, and vulnerable to changes to key estimates and assumptions within realistic limits. It is equally true that the additional financing project's feasibility may be significantly better than the base case suggests. This may occur if upgrading (i) induces economic development on adjacent land and in the settlements along its route, beyond what is implied by the assumed scale of generated traffic; and/or (ii) allows the road to play a long-term role in the success of CPEC and the ability of Khyber Pakhtunkhwa Province to benefit from it.

F. Financial Sustainability

20. A review of the financial position of the PKHA indicates that the province should be able to allocate sufficient funds to road maintenance to ensure that both the existing carriageway and the new carriageway can be sustained. The current road maintenance budget is less than 10% of the total PKHA budget and is funded from a combination of its own revenues and allocations from the provincial government. In previous years when the length of road to be maintained under the PKHA budget increased, the provincial government increased the maintenance budget.

21. PKHA undertook a program analysis using HDM-4 that suggests that the network could be sustained at the current funding level, but the average road condition would remain poor. PKHA raises some of its revenues from tolls, but the number of sites is limited so PKHA is heavily dependent on funds allocated from the provincial budget. The introduction of toll charges on the project roads that will have been upgraded under the overall project would assist in ensuring that the roads can be properly maintained in the future. Tolling the project roads at rates currently applicable to national highways would generate enough revenue to pay for incremental routine and periodic maintenance.

Table 4: Cost and Benefit Flows (PRs million at 2018 prices)

	Road agency		Road user costs (normal traffic)						Project benefits			
			Without project			With project						
Year	Capital costs	Incremental maintenance	Distance dependent	Time dependent	Total	Distance dependent	Time dependent	Total	To normal traffic	To generated traffic	To diverted traffic	Net benefits
2018	0	0	3,139	2,222	5,361	3,139	2,222	5,361	0	0	0	0
2019	936	0	3,260	2,306	5,566	3,260	2,562	5,822	(256)	(13)	(13)	(1,217)
2020	4,468	0	3,387	2,394	5,781	3,387	2,660	6,047	(266)	(13)	(13)	(4,761)

[6] ADB. 2017. *Guidelines for the Economic Analysis of Projects.* Manila.

Year	Road agency		Road user costs (normal traffic)						Project benefits			Net benefits
			Without project			With project						
	Capital costs	Incremental maintenance	Distance dependent	Time dependent	Total	Distance dependent	Time dependent	Total	To normal traffic	To generated traffic	To diverted traffic	
2021	2,081	0	3,592	2,486	6,078	3,592	2,762	6,354	(276)	(14)	(14)	(2,384)
2022	0	24	3,800	2,581	6,381	3,648	1,880	5,528	853	43	43	914
2023	0	24	3,950	2,681	6,631	3,826	1,952	5,778	852	43	43	913
2024	0	(685)	4,179	2,785	6,964	3,978	2,028	6,005	959	48	48	1,740
2025	0	734	4,109	2,894	7,003	4,174	2,106	6,280	723	36	36	61
2026	0	24	4,273	3,008	7,281	4,229	2,188	6,417	864	43	43	926
2027	0	24	4,445	3,126	7,571	4,399	2,274	6,673	899	45	45	964
2028	0	24	4,721	3,250	7,972	4,625	2,363	6,988	984	49	49	1,057
2029	0	24	5,001	3,380	8,381	4,863	2,457	7,319	1,062	53	53	1,144
2030	0	24	5,206	3,515	8,720	5,061	2,554	7,615	1,105	55	55	1,191
2031	0	(685)	5,515	3,656	9,171	5,371	2,656	8,027	1,144	57	57	1,944
2032	0	24	5,428	3,804	9,232	5,592	2,762	8,354	877	44	44	941
2033	0	734	5,652	3,958	9,610	5,927	2,873	8,801	809	40	40	156
2034	0	24	5,887	4,119	10,006	6,003	2,990	8,993	1,013	51	51	1,090
2035	0	734	6,261	4,287	10,548	6,310	3,111	9,421	1,127	56	56	505
2036	0	24	6,641	4,463	11,104	6,389	3,238	9,626	1,478	74	74	1,601
2037	0	24	6,921	4,647	11,568	6,727	3,370	10,097	1,470	74	74	1,593
2038	0	(685)	7,342	4,839	12,181	7,011	3,509	10,520	1,661	83	83	2,512
2039	0	24	7,232	5,040	12,272	7,452	3,653	11,105	1,168	58	58	1,260
2040	(1,871)	24	7,540	5,250	12,790	7,839	3,805	11,644	1,147	57	57	3,108

Economic performance indicators		*Conclusion*
EIRR	10.0% pa	*The project is marginal, and vulnerable to assumptions about traffic growth, speed gains and passenger time values proving optimistic. However, environmental and safety benefits are excluded from the analysis.*
NPV	589 PKR million	
BCR	1.10	

Source: Asian Development Bank estimates.

Table 5: Results of Sensitivity Analysis

Item	**EIRR** (% pa)	**Switching Value**
Base case	**8.6**	NA
10% increase in capital costs	7.8	–5%
10% decrease in benefits	7.7	+5%
10% adverse change in both costs and benefits	6.9	±3%
30% decrease in expected speed gains	5.9	+6%
50% decrease in passenger time values	5.9	+9%
10% decrease in traffic volumes	7.7	+5%
Removal of generated and diverted traffic	7.8	NA
50% reduction in disruptive effect of construction	10.0	–14%
1 percentage point increase in traffic growth rates	9.8	+0.4 pts

EIRR = economic internal rate of return, NA = not applicable, pa = per annum.

Note: The switching value is the change that can take place before the net present value becomes negative.

Source: Asian Development Bank estimates.