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THE STUDY
ON
THE NATIONAL TRANSPORT PLAN
IN
THE ISLAMIC REPUBLIC OF PAKISTAN

FINAL REPORT

Part III-A SECTORAL STUDIES

Railways
Roads
Road Transport

March 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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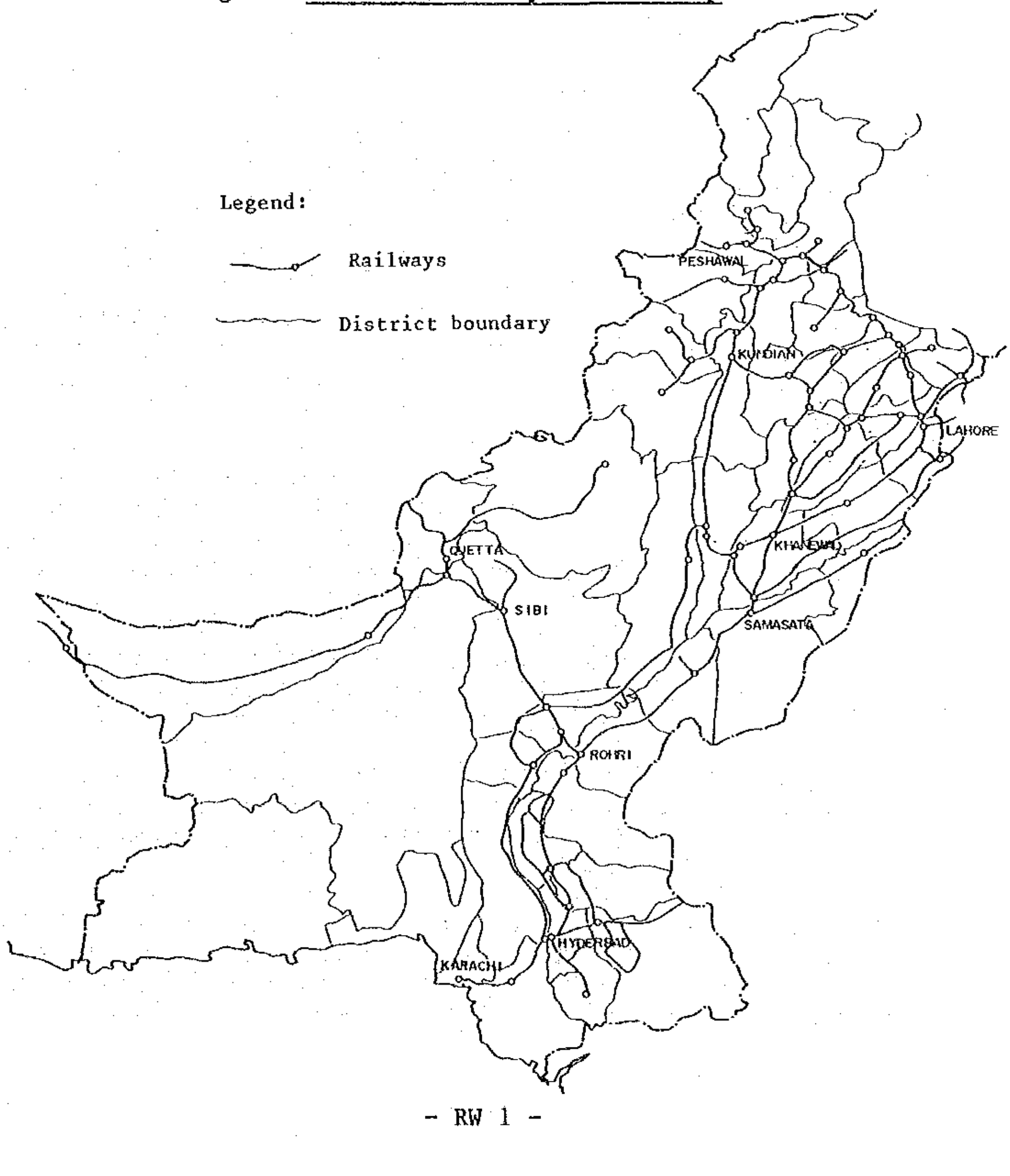
The railways in Pakistan constitute a network that links the port city of Karachi with the main inland cities, including the capital of Islamabad about 1,500 km away, as well as connecting the districts of Sind, Punjub, Baluchistan, and NWFP.

In this study, the trunk lines and interregional lines connected with them have been chosen for investigation from the network shown in the following figure.

The share of railway transport is decreasing in Pakistan. But, railway transport can still undergo futher development where its features such as safety, punctuality, capability of mass-transport and economy in long distance mass traffic can be taken advantage of.

This report discusses present condition and problems, Master Plan including physical target, and the Seventh Five Year Plan including proposed projects for the railways in Pakistan.

Figure Pakistan Railways' Route Map



CHAPTER 1 PRESENT CONDITION AND PROBLEMS

1.1 Facilities and Rolling Stock

1.1.1 Facilities

(1) Tracks

The Pakistan Railways had a total length of 12,659.7 track kilometers at the end of 1985/86. This consists of 11,378.5 km of broad gauge, 555.10 km of meter gauge, and 726.10 km of narrow gauge. Double-tracked sections accounted for 1,039 km, and the details are shown below (Table 1.1.1):

Table 1.1.1 Double-Track Length, 1985-86

Section	Route Km
Karachi City -Lodhran	839
Raiwind - Shahdara Bagh	47
Lahore - Wagah	23
Chaklala - Golra Sharif	19
Abigum - Kolpur	37
Gulistan - Chaman	59
Multan - Shershah	15
Total:	1,039

(2) Signalling System

The Interlocking systems in the Pakistan Railways are largely classified into four types: standard I, standard II, standard III, and relay interlocking. The standard I and standard II types have no direct interlocking, and train speeds are restricted to 50 km/h and 75 km/h, respectively. The standard III type is a direct interlocking system and has a higher performance in terms of efficiency and safety. The relay interlocking system enables high-speed train operation and has the highest performance among all of these systems, requiring only a small number of personnel.

Signalling facilities with colored lights are equipped at 62 stations on main lines, with further introduction in the future hoped for. The number of stations by type of signalling system is shown in App. Table 1-1.

The blocking systems on the main lines of the Pakistan Railways are largely classified into four types: token block instruments (single line), tokenless block instruments (single line), block instruments (double line) and automatic block system. The route kilometers by block signalling type are shown in detail in App. Table 1-2.

The Pakistan Railways is planning to introduce station track circuits, a color signalling system, electrical point inter-locking, and approach-locking.

1.1.2 Rolling Stock

(1) Locomotive

The Pakistan Railways has three types of locomotives: diesel-electric, electric and steam (yearly figures are shown in App. Table 1-3). Replacement of steam locomotives with diesel locomotives has been gradually in progress for motive-power modernization. The number of electric locomotives has not changed since their introduction in 1970-71, because there has been no progress in electrification (only the section between Lahore and Kanewal is electrified).

(2) Coach

Yearly figures of coaching vehicles are shown in App. Table 1-4. There are 2,515 vehicles for the conveyance of passengers on broad-gauge lines, and most of these passenger vehicles are installed with vacuum brakes, which are not suitable to the high-speed operation of trains.

P.R. had a plan to run trains at speeds of 120 km/h from August 1987 between Karachi and Lodhran. Air brakes with the necessary higher performance for the speeding up have been installed in 747 coaches.

(3) Wagon

The numbers of wagons have been on the decrease for the last five years (yearly figures of wagons are shown in App. Table 1-5). Ninety percent of the 34,184 wagons on the broad-gauge lines in 1985-86, including oil tankers, are four wheelers (2 axles).

There is a plan for increasing speed from the present 55 km/h to 90 km/h. For that purpose, the improvement of the suspension and brake systems for these 4-wheelers is planned.

1.2 Railway Transport and Operation

1.2.1 Passenger Transport

The number of passengers carried has been on the decrease since 1977-78. The result for 1985-86 was 83 million passengers, about 70% of the figure five years ago. Due to the increase in the average distance of travel per person, however, the total passenger - kilometers increased by 2% to 16,850 million in the same period. Statistical summaries are shown in Table 1.2.1.

Table 1.2.1 Pakistan Railways: Passenger Data

Year	No. of Passengers Carried (millions)	Total Passenger-Kilometers (millions)	Average Number of Kilometers Travelled per Passenger
1976-77	143	13,199	92.6
1977-78	149	15,375	103.2
1978-79	146	16,713	114.5
1979-80	144	17,316	120.5
1980-81	123	16,387	133.2
1981-82	120	16,502	137.7
1982-83	123	18,031	146.9
1983-84	107	18,287	170.7
1984-85	95	17,807	188.0
1985-86(*)	83	16,850	203.2

(*) Provisional

Source: P.R. Yearbook, 1985-86

There are three classes of passenger service:

i) Air-conditioned
ii) First Class
iii) Second Class

Since 1983-84, the number of passengers in the air-conditioned class has had a tendency to decrease. This is probably due to the 40% increase in tariff since July 1983. Second-class passengers account for 96.5% of total passengers, and the percentage has not changed during the past 10 years (App. Table 1-6).

According to the data compiled in the "Middle Plan Review of the Sixth Five Year Plan (PDD, 1986)," the railway share of the overall domestic passenger traffic decreased from 16% in 1982-83 to 14% in 1985/86, showing a shift to motor vehicles.

1.2.2 Freight Transport

Changes in freight traffic during the past 10 years are as shown in Table 1.2.2. Traffic as a whole has had a tendency to decrease. In terms of ton-km, traffic decreased from a peak of 9,375 million ton-km in 1978-79 to 7,067 million ton-km in 1981-82.

Table 1.2.2 Pakistan Railways: Freight Data

Year	Tonnage Carried (Thousands)	Ton-Kms (Thousands)	Average Kms per Ton
1976-77	14,368	7,856,662	552.8
1977-78	13,344	8,557,171	646.5
1978-79	11,958	9,374,700	791.7
1979-80	11,853	8,598,473	733.1
1980-81	11,371	7,917,739	704.9
1981-82	11,446	7,066,777	623.5
1982-83	11,836	7,323,410	621.9
1983-84	10,753	7,384,936	690.8
1984-85	10,520	7,202,861	690.1
1985-86*	11,805	8,269,811	705.0

(*) Provisional

Source: P.R. Yearbook, 1985-86

The decrease in total traffic was partly due to the influence of the establishment of the National Logistic Cell (NLC) in August 1978, and to a decrease in the import of wheat (from 2,200,000 tons for 1978-79 to 600,000 tons for 1979-80). For reference, in 1985-86, traffic increased with a rise in wheat imports.

The traffic decrease in 1981-82 was caused mainly by the large drop in kerosene and diesel oil traffic from 1,450 million ton-km in the previous year to 690 million ton-km due to the establishment of a pipeline between Karachi and Mahmud Kot in the same year.

Changes in traffic by commodity are as shown in App. table 1-7.

The major commodities handled by the Pakistan Railways include such items as wheat, oil and oil products, rice, cement, and fertilizer.

Same as in the case of the passenger traffic, the share of the railways in the total domestic freight traffic decreased from 26% in 1982-83 to 24% in 1985-86, showing the shift of traffic to road transport ("Middle Plan Review", PDD, 1986).

1.2.3 Train Operation

(1) Passenger Trains

The largest amount of passenger trains run in these past 10 years was 36 million train-km in 1980-81, with no major changes occurring throughout this period. The average train-run per train, about 240 kms in 1985-86, has been on the increase. It is considered that the number of short-distance trains is decreasing (App. Table 1-8).

(2) Freight Trains

As in the case of freight traffic, train-km have shown a tendency to decrease over the past 10 years with a peak of 14 million kms for 1978-79 and a bottom of 11 million kms for 1981-82.

The average number of wagons per train is 57 for diesel-electric locomotives and 61 for electric locomotives. It is considered that this is an efficient utilization in tractive capacities of locomotives (App. Table 1-8).

1.3 Railway Performance

1.3.1 Assets and Performance

In Table 1.3.1, financial allocation for railway compared with road traffic since the 1960-65 period is summarized. Although the absolute amount of allocation for railways has increased, the relative share against road drastically decreased.

Table 1.3.1 Financial Allocation; Land Transport Sub-sector

(Million Rs)

	1960-65	1965-70	1970-78	1978-83	1983-88
Railway	1,138 (81.1%)	1,150 (62.9%)	2,923 (33.8%)	5,566 (38.8%)	10,000 (29.9%)
Road	265 (18.9%)	678 (37.1%)	5,734 (66.2%)	8,772 (61.2%)	23,420 (70.1%)

Source: The Sixth Five Year Plan 1983-88 (PDD, 1983)

In Table 1.3.2, assets and performance of Pakistan Railways is shown. Expenditure on railways in the 5th and 6th Five Year Plan showed that more than 50% was for rehabilitation of the track and replacement of rolling stock. In terms of locomotives the number of 978 in 1977-78 decreased by 99 to 879 in 1985-86. Replacement of steam to diesel locomotives progressed considerably in those years, however, reduction in the total locomotive will decrease the efficiency of the transport service.

A large amount of expenditure on replacement and rehabilitation will result in a smaller allocation for investments to improve efficiency, capacity and services within the limited amount of the budget.

Table 1.3.2 Assets and Performance of Pakistan Railways

	NON Plan period year end 1977-78	5th plan end 1982-83	6th on way 1985-86*	Remarks
Funds allocation Rs. (million Rs)	(1970 - 1978) 2,923	(1978 - 1983) 5,566	(1983 - 1988) 7,033	In terms of five year plan
(Assets)				
Route - km	8,815	8,774	8,774	
Track - km	12,515	12,583	12,660	
Number of Locomotives	978	979	879	
Steam	481	446	338	
Diesel	468	504	512	
Electric	29	29	29	
Number of Coaches (Passenger carriage)	2,133	2,365	2,722	
Number of wagons	36,406	35,990	35,237	
Persons employed	139,813	128,137	128,047	
(Traffic Volume) million				
Passenger	149	123	83	
Passenger - km	15,375	18,030	16,850	
Tons	13	11.8	11.8	
Tons - km	8,557	7,323	8,270	
(Revenue and expenses) million				
Revenue	2,213	3,394	4,368	
Expenses	2,192	4,491	5,714	Included D.R.F. Interest
Surplus	(+) 21	(-)1,097	(-)1,346	
Operating ratio	73.9	97.4	91.6	

Source: P.R. Year Book

1.3.2 The Review of the Sixth Five Year Plan

Under the 6th Five Year Plan, it was originally proposed to transform the freight traffic share of railways and roads from 23 : 77 in 1982-83 to 27 : 73 in 1987-88. As to passenger traffic, an increase of 4.9% per annum was planned for the railway in terms of passenger-kms with a target of 21.0 billion passenger-kms for 1987-88.

Also in the initial stage of the 6th Five Year Plan, PR's performance was proposed to achieve the following targets.

However, the targets listed below have not been achieved, and no significant changes have been observed so far.

	1985-86 Target Figures	1985-86 Actual Figures
a)	Wagon turnaround time to decrease from 18 to 14 days.	18.3 day
b)	Locomotive utilization to increase by 15% (from 255 to 300 kms per locomotive per day)	249 km
c)	Net tonnage per freight train to increase by 15% (from 578 to 650 net tons).	637 tons
d)	Systemwide loading of wagons to increase from 1,700 to 2,100 per day.	1,600 wagons
e)	The percentage of ineffective locomotives to decrease from 15% to 10%.	16 %
f)	The capacity of long distance passenger trains to increase from the present 16 to 22 coaches per train.	16 coaches

This is considered partly due to the decrease in traffic demand for PR and to the shortage of funds to achieve the 6th Five Year Plan itself.

Since the outset of the 6th Five Year Plan, traffic volume of the Pakistan Railways has been sluggish in both passenger and freight transport. As shown in Table 1.3.3, the actual results of the service for the first three years did not meet the forecast to increase.

As the railway is a complex system, increase in overall service can not be shown by a single index. When some facilities are improved, it often happens that a total system's productivity will not increase. Thus, improvement in other facilities should be made simultaneously.

Table 1.3.3 Comparison of Projected and Actual Traffic

	1982-83 Bench Mark	1987-88 Projection	Traffic 1985-86		ACGR (%)	
			Projected	Actual	Projected	Actual
i) Passenger Traffic (Million passenger-kms)	16,502	21,000	19,049	16,850	4.9	0.7
ii) Goods Traffic (Million ton-kms)	7,500	11,000	9,500	8,269	8.2	3.3

Source: Middle plan review of the 6th Five Year Plan (P.D.D)

The improvement as above always requires enormous amounts of investment cost. The railway system is a fundamental infrastructure with a long history and can still undergo further development where its feature can be realized efficiently. It is expected that the government will allocate substantial amounts for railway development while efforts by PR to improve its productivity and financial position are emphasized.

As to the Pakistan Railways, the amount from the budget to be distributed to the railways for attaining the above objectives has been reduced from the originally planned 10,000 million rupees to 7,033 million rupees due to budgetary restrictions. To serve the projected traffic, the Pakistan railways has been implementing a plan to increase the speed of some passenger trains from 95 km/h to 120 km/h and freight trains from 55 km/h to 90 km/h during the Five Year Plan. At the same time, the strengthening and renewal of existing tracks and bridges have been implemented as well as improvements in rolling stock performance, tractive power, and signalling and telecommunications systems have taken place (App. Table 1-9).

In the first three years of the Plan, 4,237 million rupees was used and the attainment ratio reached 60%.

1.4 Rates and Finance

1.4.1 Rate Structure

Table 1.4.1 shows the passenger fare table. Passenger fares are classified, according to the quality of car accommodations, into three types: air-conditioned class, first class, and second class.

Table 1.4.1 Pakistan Railways: Passenger Fare Table

Class	Paisa per Passenger per Kilometer		
	1 to 40 (km)	41 to 500 (km)	501 and above (km)
Air-conditioned (Sleeper)	120.00	70.00	56.00
Air-conditioned (Sitter)	69.00	40.25	32.20
First (Sleeper)	34.50	28.75	23.00
First (Sitter) Mail	18.70	15.80	15.15
First (Sitter) Ordinary	17.25	13.50	10.05
Second Mail	10.60	7.95	7.85
Second Ordinary	8.65	6.90	5.30

Source: P.R.

Table 1.4.2 Pakistan Railways: Freight Basic Rate Scale

Distance (Kms)	Existing Rate Scale 100	Rate per Ton-Km (Paisa)
150	43.05	28.7
200	52.38	26.2
300	71.03	23.7
400	83.33	20.8
500	95.63	19.1
600	105.88	17.6
800	126.38	15.8
1,000	146.88	14.7
1,200	167.38	13.9
1,500	198.93	13.3
1,800	228.88	12.7
2,000	249.38	12.5
3,000	351.88	11.7

Source: P.R.

For distance zones, three types are also in use: 1 to 40 km, 41 to 500 km, and 501 km or more. A deoreasing fare system based on the distance which a traveller travels is in use.

Fares for the first class are about two times those for the second class, with fares for the air-conditioned class about three times those of the first class.

For freight, based on a basic rate of 100, the rates of 27 stages ranging from 70 to 400% are applied to about 3,000 kinds of commodities. A discount or additional rate is applied according to the commodity: for example, 140% of the basic rate for wheat and 350% for oil products.

Table 1.4.2 shows these basic rates for freight transport.

1.4.2 Financial Condition

Changes in operating revenues and expenditures and traffic in the Pakistan Railways from 1976-77 to 1985-86 are as shown in App. Table 1-10. Revenue increased from Rs. 2,942 million in 1980-81 to Rs. 4,368 million in 1985-86, by some 48%. The expenses also increased from Rs. 2,491 million in 1980-81 to Rs. 4,002 million in 1985-86, for an increase of 61%.

The expenditures are divided into items as shown in App. Table 1-11. In 1985-86 the total expenditure of Rs. 4,002 million consists of 42% for repair/ maint., 28% for fuel costs, 13% for staff cost, 13% for administration, and 4% for others.

With the decreases in traffic since 1979-81, revenues came to be surpassed by expenditures in 1984-85. However, due to an increase in freight traffic and the traffic revision in January 1985, finances took a turn for the better in 1985-86.

The finances of the Pakistan Railways for the past five years are as shown in Table 1.4.3. Operating revenues before depreciation are in the surplus. However, the results go into the deficit when such factors as depreciation, interest payments, miscellaneous expenses, and improvement funds are considered.

Table 1.4.3 Pakistan Railways: Financial Statements

(Rs. million)

Item	1981-82	1982-83	1983-84	1984-85	1985-86
Gross Earnings	3,044	3,395	3,680	3,681	4,368
Operating expense	2,849	3,308	3,604	3,868	4,001
Operating ratio	93.6	97.4	97.9	105.1	91.6
Appropriation to D.R.F	420	485	631	631	845
Interest charge	142	186	284	240	259
GAIN(+)/loss(-)	(-) 803	(-) 1,097	(-) 1,332	(-) 1,596	(-) 1,346

Source: P.R. Year Book, 1985-86

1.5 Capacity Analysis of the Existing Railways

As to the capacity of the railways, that of the existing line ground facilities and the traffic volume to be carried by the existing rolling stock are discussed here.

1.5.1 Capacity of the Existing Ground Facilities

Capacity of line ground facilities is presented by the maximum number of trains which can be operated per day per line.

It can be generally calculated by the formula (Refer to 2.3.1 (1)). The line capacity and current peak number of trains in the Pakistan Railways are shown in Fig.1-5-1.

At present, the section between Karachi and Lodhran has adequate capacity. There are some sections insufficient of capacity in the single-tracked sections (Multan-Khanewel, Sahiwal-Raiwind, Lalamusa-Chaklala, Golra.Sharif-Taxila Cant. etc). More details in line capacity and utilization are shown in App. Table 1-12 and Train Operation System Diagram in App. Fig.1-1.

1.5.2 Traffic Volume to be Carried by Existing Rolling Stock

Even if there is sufficient margin in the line capacity it is impossible to increase the traffic volume if the number of rolling stock is insufficient to make the trains.

Analyses are made below to check the availability of locomotives, wagons and carriages.

(1) Locomotives

Locomotive usage is shown in Table 1.5.1.

For diesel locomotives, the engine-km per day is 2% worse than the 10-year average (302/295). For electric locomotives, it is 31% worse than the 10-year average (376/287). Considering the resultant engine-km per day, the locomotives have the potential to recover to the 10 year average.

At first, increases in train-km will be calculated.

Increase in passenger train-km
= (Diesel loco hauled passenger-train-km x 0.02) x
(electric loco hauled passenger-train-km x 0.31)
= $28,482 \times 10^3 \times 0.02 + 1,319 \times 10^3 \times 0.31$
= 977,000 train-km

Increse in freight train-km
= $10,763 \times 10^3 \times 0.02 + 1,131 \times 10^3 \times 0.31$
= 566,000 train-km in the similiar way

Fig. 1.5.1 Number of Train and Line Capacity by Section

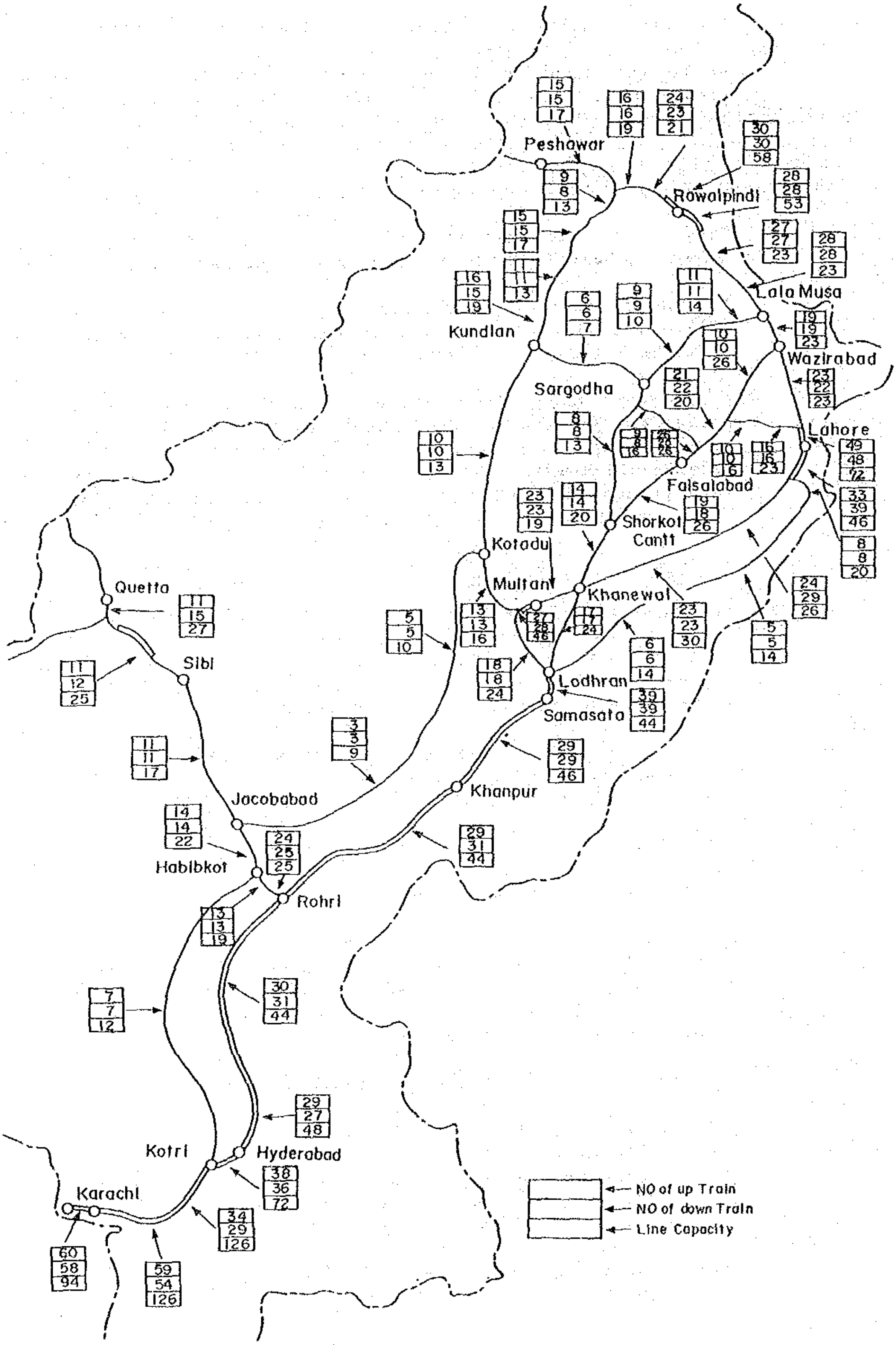


Table 1.5.1 Locomotive Usage (B.G)

	Engine-Kilometers per day per engine in use				In use/on line (%)			Average number of engines under or awaiting repairs daily to average total number on line (%)		
Year	Steam	Diesel	Electric	Steam Diesel & Electric Combined	Steam	Diesel	Electric	Steam	Diesel	Electric
1975 - 76	132	296	381	227	67	84	89	16.7	15.8	8.71
1976 - 77	131	294	414	231	65	82	81	19.5	16.9	11.3
1977 - 78	128	313	424	236	76	82	86	14.9	17.6	11.6
1978 - 79	123	315	402	233	76	83	86	16.0	16.4	13.7
1979 - 80	124	302	416	231	73	83	82	17.3	15.3	17.4
1980 - 81	126	306	391	237	69	84	83	18.8	15.4	16.6
1981 - 82	131	301	358	235	73	85	89	18.5	14.9	10.7
1982 - 83	136	298	360	243	63	84	89	23.5	15.4	11.1
1983 - 84	141	293	305	241	62	83	86	26.1	16.2	14.0
1984 - 85	141	300	311	246	65	83	85	24.0	16.5	14.7
1975 - 85(A)	131	302	376	236	69	83	86	19.5	16.0	13.0
Average 1985 - 86(B)	140	295	287	247	61	84	83	22.3	15.5	16.4
(B)/(A)%	107	98	76	105						

Source: P.R.

The ratio of the increase to the present train-km will be calculated below.

The ratio for passenger = 977,000 km ÷ 35,553,000 km = 0.028

The ratio for freight = 566,000 km ÷ 12,453,000 km = 0.046

Assuming that passenger-km and ton-km increases are in proportion to the train-km respectively, they will be calculated below.

Additional passenger-km = $16,850 \times 10^6 \times 0.028$
$= 472 \times 10^6$

Additional freight-km = $8,270 \times 10^6 \times 0.046$
$= 380 \times 10^6$

(2) Wagon

Recent turn-round time of wagons and kilometers travelled by a ton are shown in Fig. 1.5.2. The kilometers travelled by a ton in 1978-79 was 792 km, which was the highest record since 1970.

In the same period, the largest scale of traffic volume of $9,375 \times 10^6$ ton-km was carried and the turn-round time was 15.5 days.

On the other hand, average travelling hour is calculated below.
Average travelling hour = average travelling distance
÷ average travelling speed
= 705 km/17.9 km
= 39.4 hr = 1.6 day

This average travelling time is used for "Through Train" in Table 1.5.2.

Considering the resultant performance on turn-round time for wagons, turn-round time of 16 days can be assumed to be realized. For the current number of wagons, additional traffic volume can be carried.

Additional traffic volume = $8,270 \times 10^6 \times (18.3-16)/18.3$ ton-km
$= 1,039 \times 10^6$ ton-km

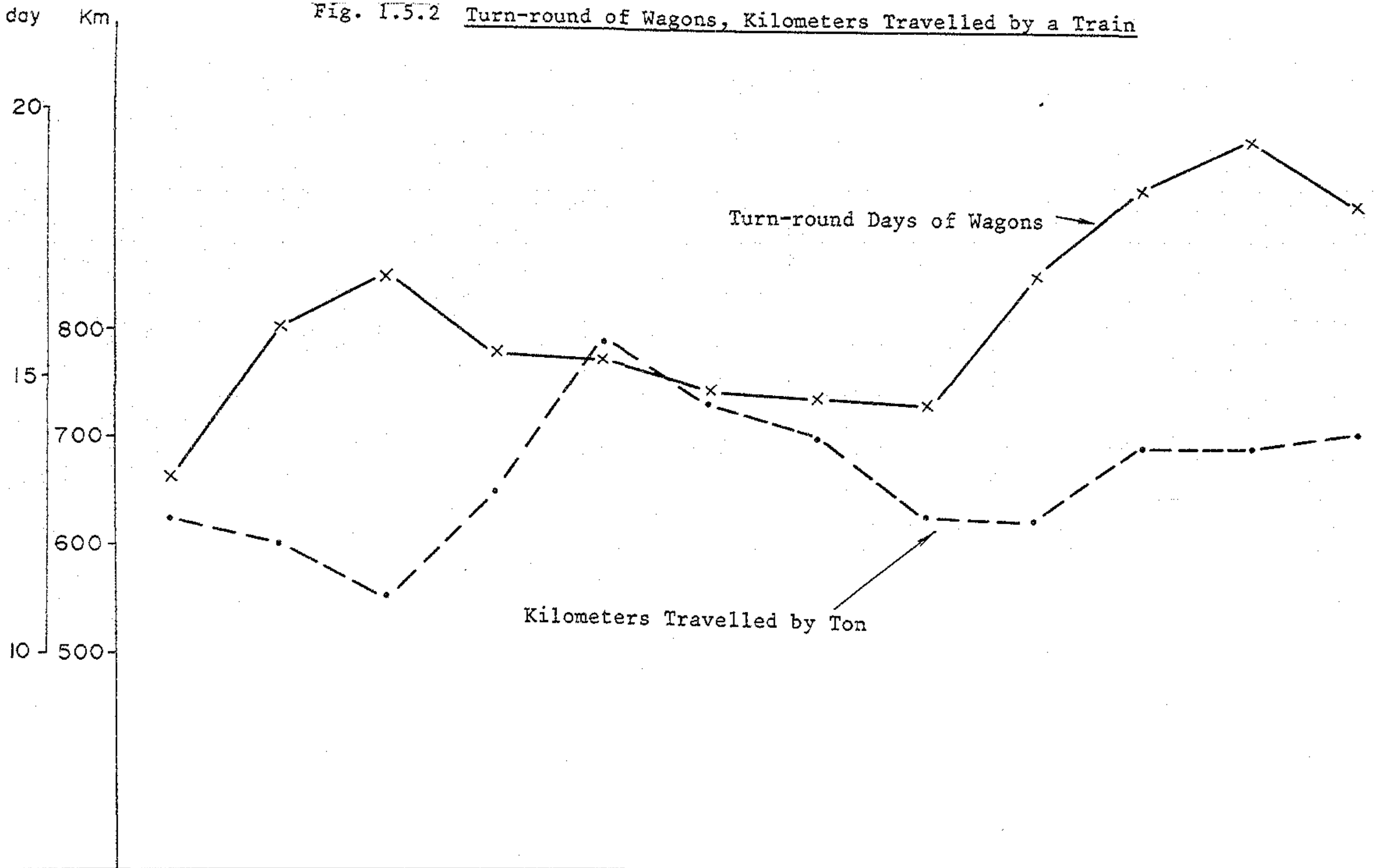
(3) Carriage

Vehicle-km/day for the passenger carriages has dropped by 3% compared with the avarage of the past 10 years (See Table 1.5.3).

Looking at the year 1982-83 which had mostly the same vehicle-km/day as the year 1985-86, vehicle-km of $18,031 \times 10^6$ was attained by 2,161 carriages.

As the traffic volume can be considered proportional to the number of carriages available, the current number of carraiges will be able to comply with the following additional passenger-km compared with the year 1982-83.

Fig. 1.5.2 <u>Turn-round of Wagons, Kilometers Travelled by a Train</u>



Turn-round of wagon (days)	13.3	16.1	17.2	15.6	15.5	14.9	14.7	14.6	17.0	18.6	19.5	18.3
Km. travelled by a train	626	603	553	647	792	733	705	624	622	691	690	705
Year	1970–75	1975–76	1976–77	1977–78	1978–79	1979–80	1980–81	1981–82	1982–83	1983–84	1984–85	1985–86

Table 1.5.2 Turn-round (Assumption)

Activity \ Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Loading																
Shunting Train																
Formation of Through Train																
Through Train																
Sorting																
Shunting Train																
Un-loading																
Shunting Train																
Formation of Through Train																
Through Train																
Sorting																
Shunting Train																
Waiting (station)																

Table 1.5.3 Passenger Carriage Usage (B.G)

Year	Passenger carriages (No.)	Vehicle - Kilometers per day per vehicle on line (In terms of 4-wheelers)	Percentage of average number of vehicles under or awaiting repairs daily (in units) to average total number on line	Total number of kilometers covered by passenger and mixed trains (Thousands)	Total Passenger-kilometers (Millions)
1975 - 76	1,882	327	19.6	34,375	12,957
1976 - 77	1,860	317	19.0	34,478	13,199
1977 - 78	1,911	327	21.7	35,650	15,375
1978 - 79	1,921	330	23.3	35,409	16,713
1979 - 80	2,011	339	21.4	35,578	17,316
1980 - 81	2,061	342	20.8	36,006	16,387
1981 - 82	2,116	343	16.9	35,349	16,502
1982 - 83	2,161	323	24.5	34,662	18,031
1983 - 84	2,201	333	19.6	34,807	18,287
1984 - 85	2,293	344	18.4	35,689	17,807
1975 - 85	2,042	333	20.5	35,200	16,257
Average 1985 - 86	2,515	324	15.8	35,553	16,850

Additional passenger-km = $18,031 \times 10^6 \times 2,515/2,161 - 16,850 \times 10^6$
= $4,135 \times 10^6$

1-5-3 Summary

(1) Capacity of line ground facilities is shown by the maximum number of trains which can be operated per day per line.

At present, the section between Karachi and Lodhran has enough room. There are some sections with shortage of capacity in the single-tracked sections (Multan-Khanewal, Sahiwal-Raiwind, Lalamusa-Chaklala, Golra.Sharif-Taxila Cant.).

(2) Rolling Stock

For locomotives, if traction motors and other needed parts for locomotives are supplied as required, the present number of locomotives seems to have an additional room of 472 million passenger-km for passenger and of 380 million ton-km for freight, that is, 2.8% and 4.5% compared with 16.9 billion pass-km and 8.3 billion ton-km of 1985-86 respectively.

For wagons, the present number of wagons seems to have an additional room of 1,039 million ton-km, that is, 13% compared with 8.3 billion ton-km of 1985-86.

For coaches, the present number of coaches seem to have an additional room of 4,135 million pass-km, that is, 24% compared with 16.9 billion pass-km of 1985-86.

1.6 Analysis on the Financial Efficiency of PR Passenger Trains

1.6.1 Load Factor by Section

An analysis was conducted to obtain section-wise load factor of PR passenger trains based on the one-day record of train-wise passenger boarding/alighting surveyed by PR in 1986. The results are summarized in Fig.1.6.1 and Fig.1.6.2 for upper and lower classes, respectively.

For the upper class, load factor is generally low at 36.8% on average. However, on the sections Karachi-Rawalpindi and Jacobabad - Quetta, it is relatively high at 40-59%.

For the lower class, the average load factor is high at 79.5%. Especially on the main lines Karachi-Lahore, Wazirabad-Rawalpindi and Jacobabad-Quetta, they are more than 80%.

1.6.2 Financial Efficiency by Train

(1) Overall Analysis

Based on the statistics of number of passengers, cost and revenue by train presented in the "Traffic Costing and Railway Structure" report (TRECON LTD), an analysis was carried out to further look into the train-wise financial efficiency. The results are shown in App.Table 1-13 and App.Table 1-14 for mail/express trains and ordinary trains, respectively.

Out of 31 mail/express trains, 12 are profitable and 16 cover the direct cost. For the entire mail/express train operation, the total earning covers the total cost. Further, the economic cost of the profitable trains is considered to be lower than road transport.

On the other hand, all the ordinary tains are not profitable, and do not cover even their direct cost.

(2) Train-wise Financial Efficiency in Relation to Train Running Distance (Mail/Express Trains)

Fig.1.6.3 and Fig.1.6.4 show the train-wise financial efficiency in relation to train running distance. From these figures, the following can be pointed out:

A. The longer the train running distance is, the more profitable becomes the operation.

B. Longer-distance trains run on the main lines.

C. Consequently, most of the long-distance mail/express trains running on the main lines can be considered to be profitable.

Fig. 1.6.1 Load Factor by Section of PR Passenger Trains, Upper Class (1986)

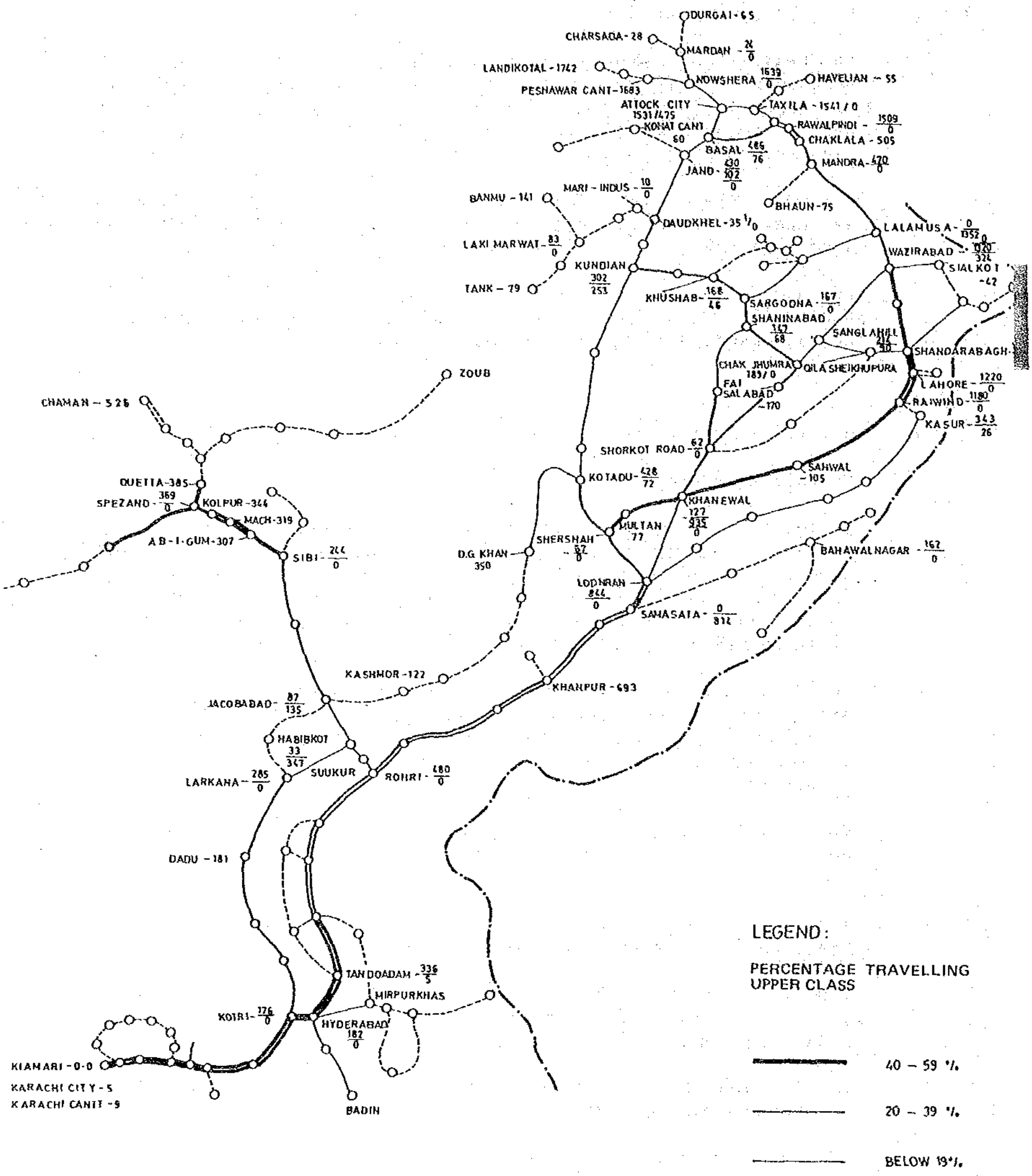


Fig. 1.6.2 Load Factor by Section of PR Passenger Trains, Lower Class (1986)

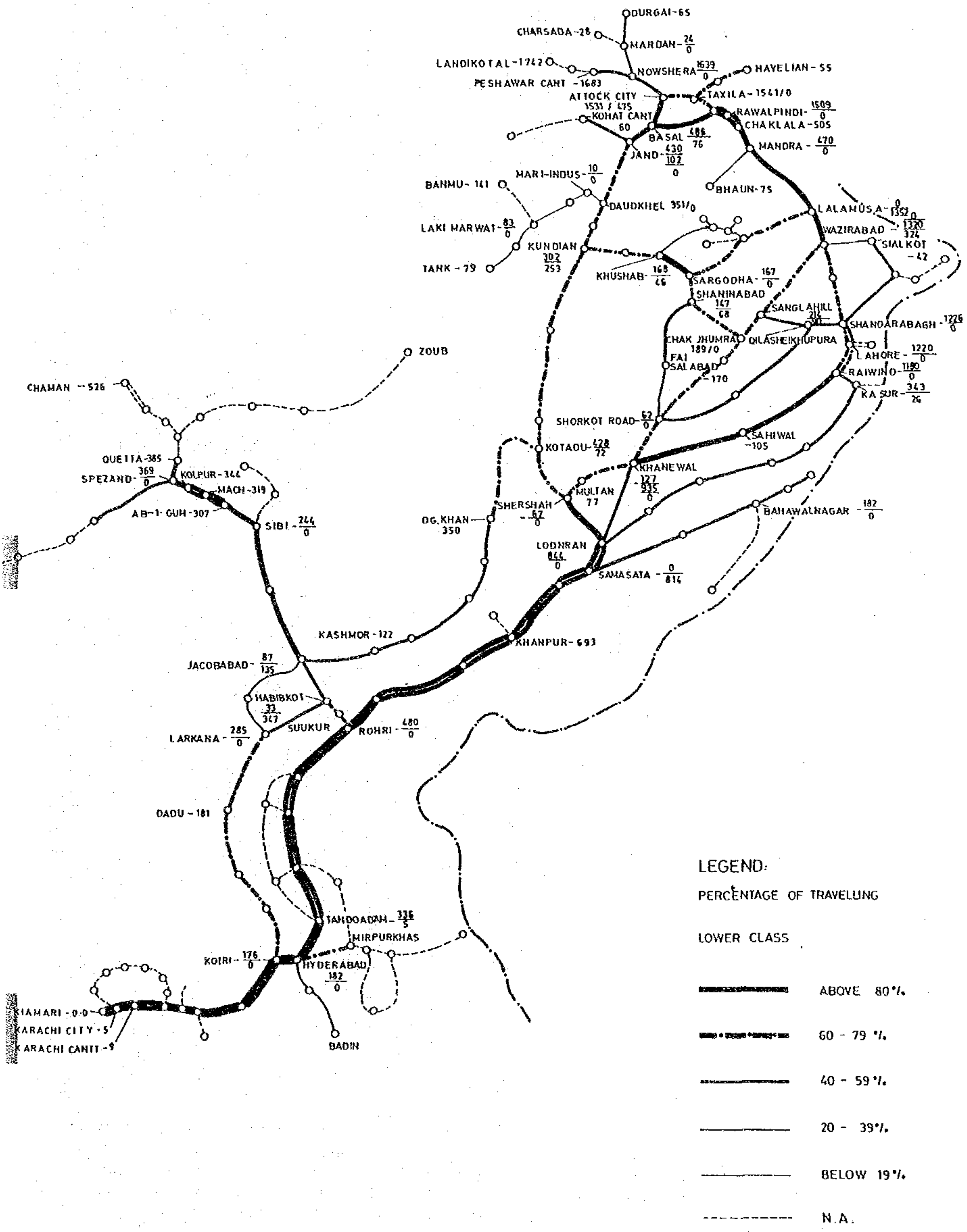


Fig. 1.6.3 Correlation between Earning Less Total Cost/pass km and Train Running Distance (oneway)

Based on TRECON REPORT

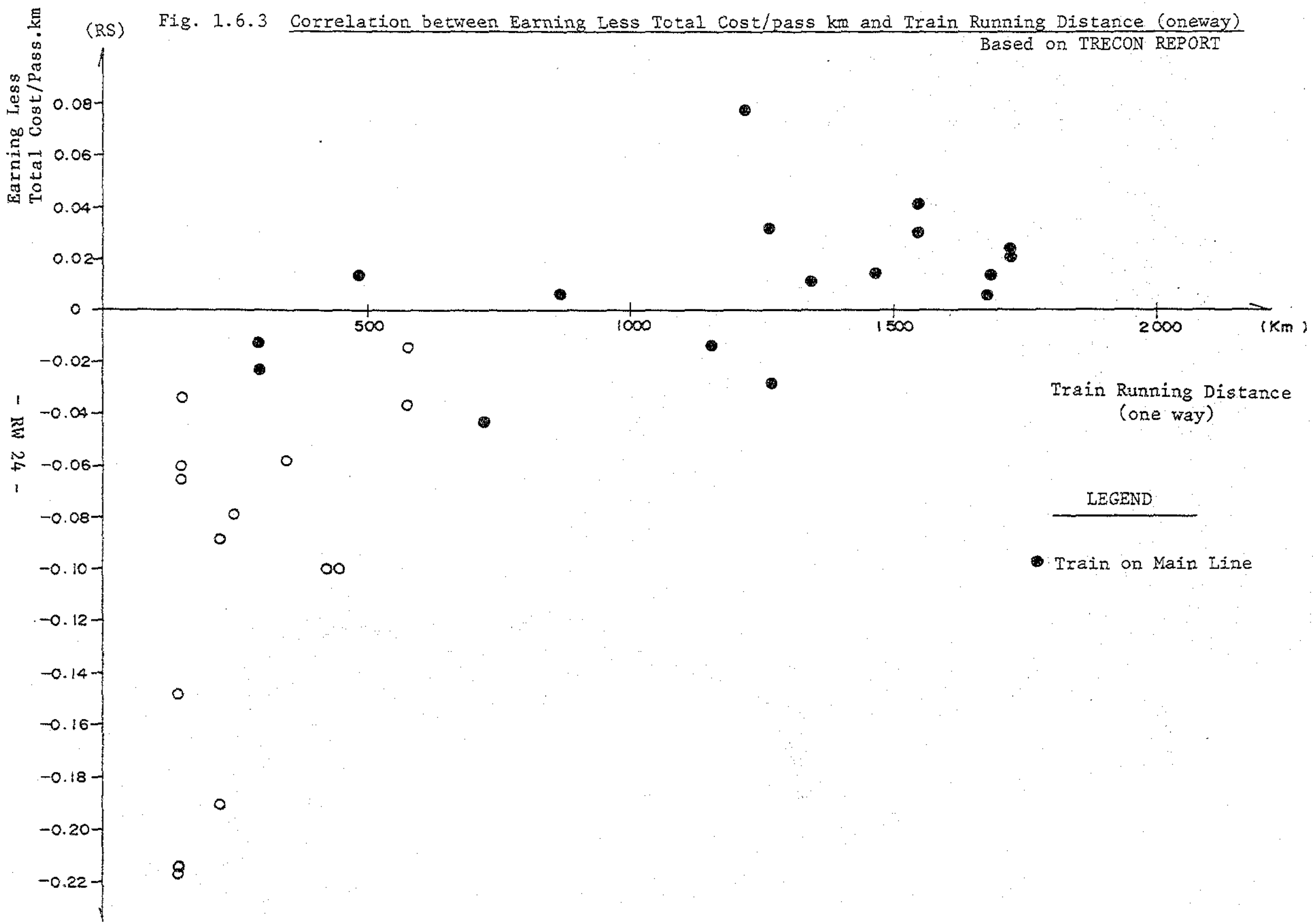
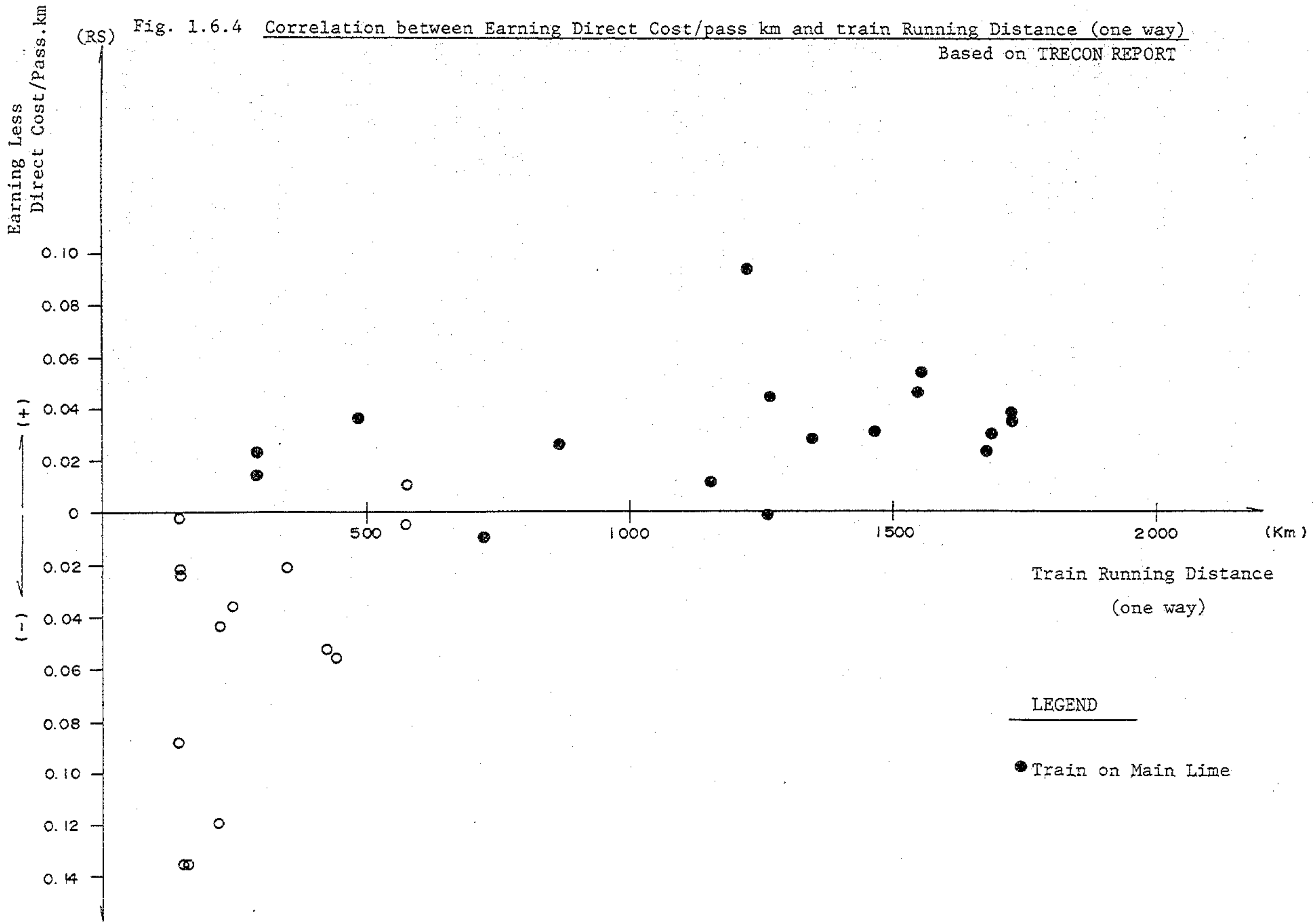


Fig. 1.6.4 <u>Correlation between Earning Direct Cost/pass km and train Running Distance (one way)</u>

Based on TRECON REPORT



Item C above can be further endorsed by Fig. 1.6.5 which shows the routes of profitable mail/express trains.

(3) Train-wise Financial Efficiency in Relation to Average Travel Distance of Passengers (Mail/Express Trains)

Fig. 1.6.6 and Fig. 1.6.7 show the train-wise financial efficiency in relation to average travel distance of passengers. When average travel distance increases, the financial efficiency of the train is raised. It seems that an average travel distance of 500 kms is the break-even point to determine whether the train is profitable or not.

(4) Section-wise Financial Efficiency of Ordinary Trains

As mentioned earlier, all the ordinary trains are not profitable for PR, presumably due to the short running distance of trains coupled with short travel distance of passengers. Actually, the average travel distance of passengers is less than 50 kms for all the ordinary trains.

Fig. 1.6.8 shows the section-wise financial efficiency of ordinary trains. Although ordinary trains are losing on every section, the amount of loss is different. The main lines show a less deficient performance while the branch lines lose more than 1 Rupee per passenger-kilometer, which is more than the fare paid.

1.6.3 Conclusion

It is considered essential for PR to carry long distance passengers. This not only improves the financial efficiency of PR but also contributes to the national economy through the lower economic cost than road transport. The break-even distance between road and railway is considered to be approximately 500 kms.

It is hoped that PR and the Government would take counter-measures to assure that the break-even distance will be attractive to railway users. The countermeasures may include:

- To rationalize fare structure of PR in such a manner that long-distance passengers are preferably tranported by the railway.

- To improve the levels of service by increasing train running speed, punctuality of operation and the service frequency.

- To curtail direct and indirect cost pertinent to short distance ordinary trains, especially of branch lines parallel to road, in order to upgrade the service efficiency of PR as a whole.

Fig. 1.6.5 Route of Profitable Mail/Express Trains

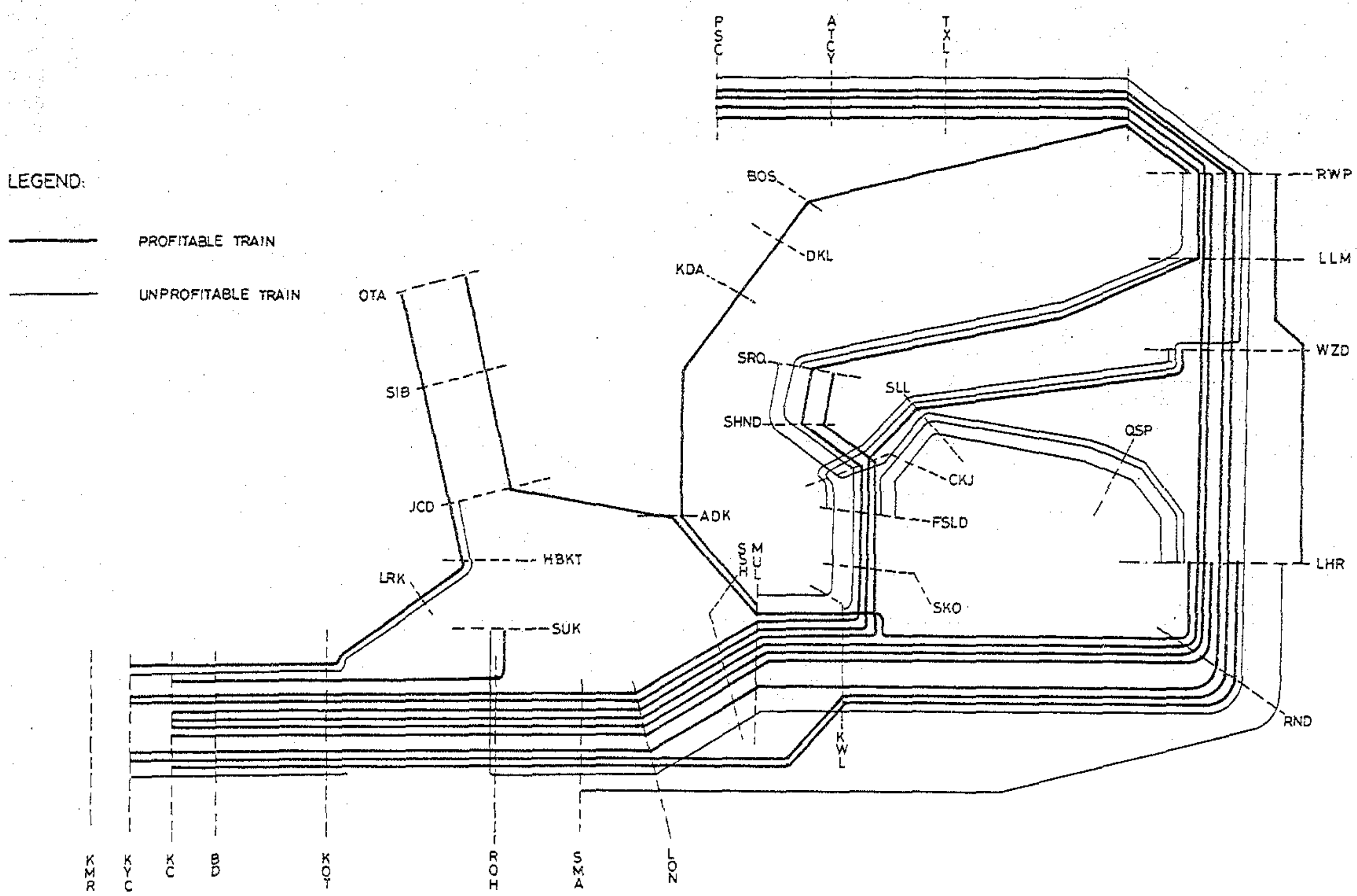


Fig. 1.6.6 Correlation between Earning Less Total Cost/Pass.km and Average Travel Distance

Based on TRECON REPORT

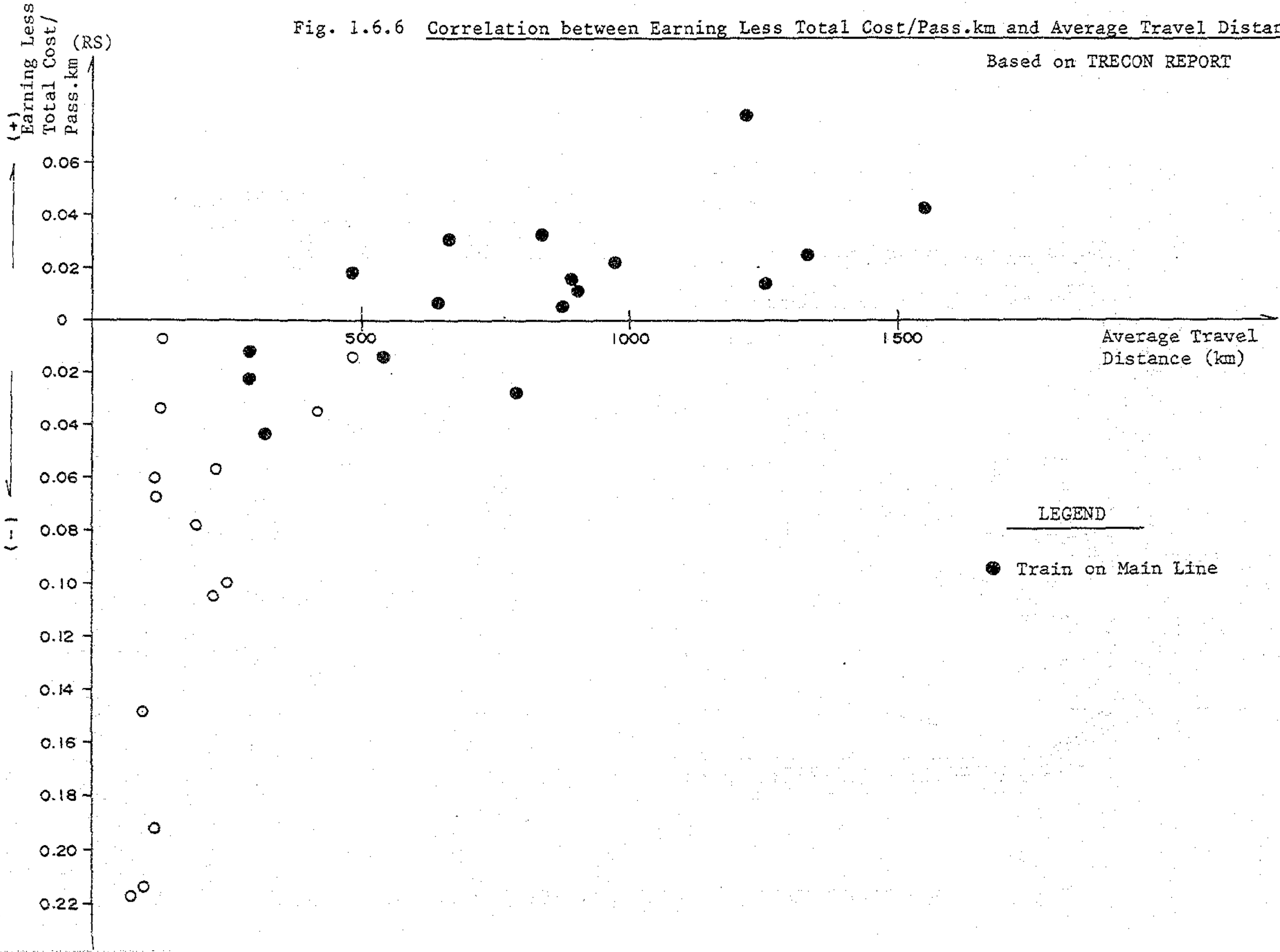


Fig. 1.6.7 Correlation between Less Earning Direct Cost/Pass·km and Average Travel Distance

Based on TRECON REPORT

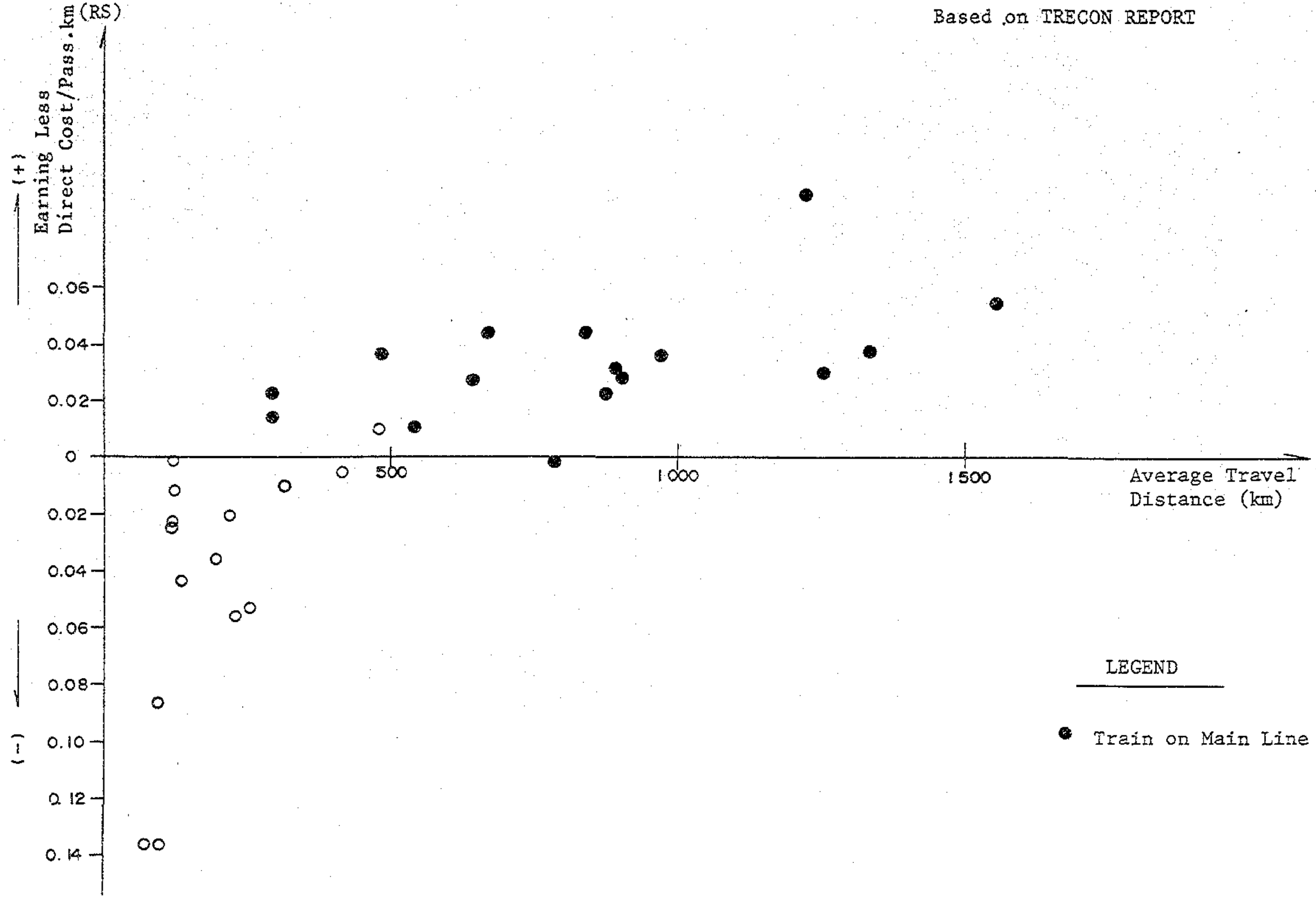
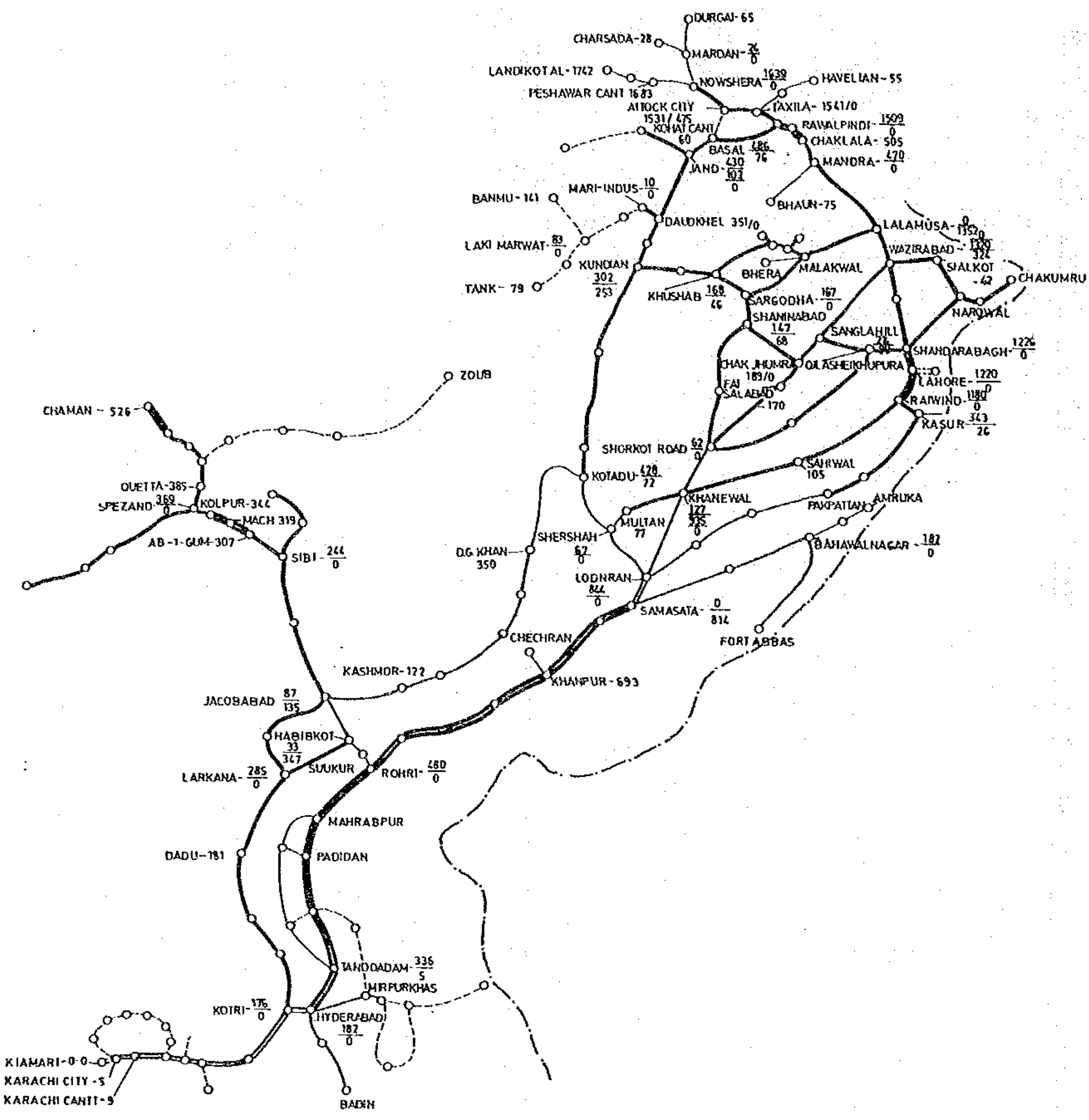


Fig. 1.6.8 Section-wise Financial Efficiency of Ordinary Trains



LEGEND

EARNING LESS DIRECT COST / PASS. km.

(thick line)	0~-0.5 Rs./Pass. km.
(line)	-0.5~-1.0 Rs./Pass. km.
(thin line)	Beyond-1.0 Rs/Pass. km
(dashed line)	N.A.

1.7 Present Problems

1.7.1 Passenger Transport

Passenger traffic has been showing a decreasing tendency in recent years. In view of the year-by-year increase in travelling distance per passenger (from 138 kms in 1981-82 to 203 kms in 1985-86), it is considered that short-distance traffic has been on the decrease. This is presumed to be a result of the shift of commuters and intercity passengers to buses for relatively short trips. For example, in the section between Karachi - Hyderabad, and Lahore - Rawalpindi, the present situation of passenger traffic between Railway and Buses is shown in Table 1.7.1.

Table 1.7.1 Comparison between Railway and Bus in Passenger Traffic

	Karachi - Hyderabad		Lahore - Rawalpindi	
	Railway	Bus	Railway	Bus
Distance (kms)	177	165	289	289
Passenger carried (person/day)	2,000	6,000	2,500	4,800
Air Conditioned Passenger Carried	100	1,000	100	800
Travelling time (hour)	2.5	2.5	6.5	5
Fare (non air - con) Rs.	15.50	15.00	24.50	28.50
(with air - con) Rs.	85.50	37.00	130.00	55.00
Frequency (No of Train, Bus/day	17	150	10	120

Source: P.R.

The following data also support a tendency of the change.

(Millions)

	1981-82	1983-84	1985-86
Metropolitan	35.5 (29.6)	25.6 (23.9)	12.4 (15.0)
Non-Metropolitan	84.3 (70.4)	81.5 (76.1)	70.5 (85.0)
Passenger Total	119.8 (100.0)	107.1 (100.0)	82.9 (100.0)

Source: P.R.

This tendency is likely to continue hereafter with improvements in the bus service such as frequency, fares, reduction of travelling time by the strengthening of highway network, and increasing the number of air-conditioned buses. To compete with the bus service, improvements in the railway service for intercity transport are expecially required.

1.7.2 Freight Transport

As stated before, the decrease in total traffic was largely due to the establishment of the National Logistic Cell (NLC) in August 1978. NLC has the authority to decide traffic shares of road and railway transport for some commodities, and, since its establishment, has been making itself a strong competitor of the railways. The traffic shares of NLC and the Pakistan Railways by major commodity are as follows.

Table 1.7.3 Shares by Railways and NLC

(%)

Commodity	Railways 1978-79	Railways 1984-85	NLC 1978-79	NLC 1984-85
Cement	98.5	80.8	1.5	19.2
Wheat	84.4	62.7	15.6	37.3
Paddy and rice	80.5	60.0	19.5	40.0

It is said that NLC, the government-owned carrier who also is authorized to allocate cargo volume among the carriers, coordinates the cargo allocation advantageously for itself. This point leads to a PR's claim that cargo allocation on railways should be given priority because the service cost is more economical than the truck carriers. Transport allocation of essential goods, if it is a government policy to determine, it should be shown with the reasons explicitly.

Concerning freight transport in the Pakistan Railways, there are other problems such as:

a. nonscheduled operation of freight trains;
b. delay of freight trains; and
c. drop in tractive power of locomotives on steep-gradient sections.

For Item a, due to the shortage of locomotives, a train starts travelling when cargo reaches the full capacity of the tractive locomotive. Accordingly it takes a long time in waiting for the cargo to be loaded fully.

As to Item b, the actual results are shown in App. Table 1-15. According to the data, there were small delays on the double-tracked section between Karachi and Samasata and the loop section between Samasata and Khanewal. However, there were long delays on the sections of single track. This is presumably due to the long waiting time to allow other trains to pass, which is caused by the operational priority given to passenger trains.

As to Item c, the drops in tractive power were as shown below.

Section	Changing Tractive Power	
Sibi-Kolpur	72 Vehicle 2,000t	35 Vehicle 600t
Lalamusa-Rawalpindi	62 Vehicle 1,800t	52 Vehicle 1,100t
Kundian-Attock city	72 Vehicle 2,000t	34 Vehicle 1,000t

1.7.3 Facilities

A problem in the Pakistan Railways concerning tracks and structures is their superannuation. On many sections, train speeds are restricted due to old sleepers, rails, bridges, and insufficient ballast, or to their being renewed or improved. This creates a major problem for train operation. An example of loss of time due to such restrictions is as follows.

Table 1.7.4 Loss of Time due to Old Tracks and Structures

Section	1st Oct. '71	15th April '85	15th March '87
Karachi-Peshawar (Main-Line Section)	61'	248'	184'
Entire Railways	166'	2,875'	1,379'

Source: P.R. Gazette
Traffic and Railways Rate Structure Report

The travelling times between major stations are shown in App. Table 1-16. Under these circumstances, the Pakistan Railways has been promoting track modernization and maintenance through such measures as the introduction of concrete sleepers and the use of heavier rails. The result can be seen in the reduced travel time on main lines from 1985 to 1987 (Refer to App. Table 1-16).

However, rail and sleeper renewal is still required for the remaining 49.6% and 42%, respectively, of the total track length. (Refer to App. Table 1-17 and 1-18).

There are 14,750 bridges including about 2,600 on main lines. Half of them have been used for more than 100 years, and require repairs or reconstruction.

1.7.4 Rolling Stock

The number and age of rolling stock for broad-gauge lines are shown in App. Table 1-19. As to locomotives, 75% of the steam locomotives, and 30% of the diesel locomotives in operation have exceeded their normal life spans of 45 years and 20 years respectively, showing obvious signs of superannuation.

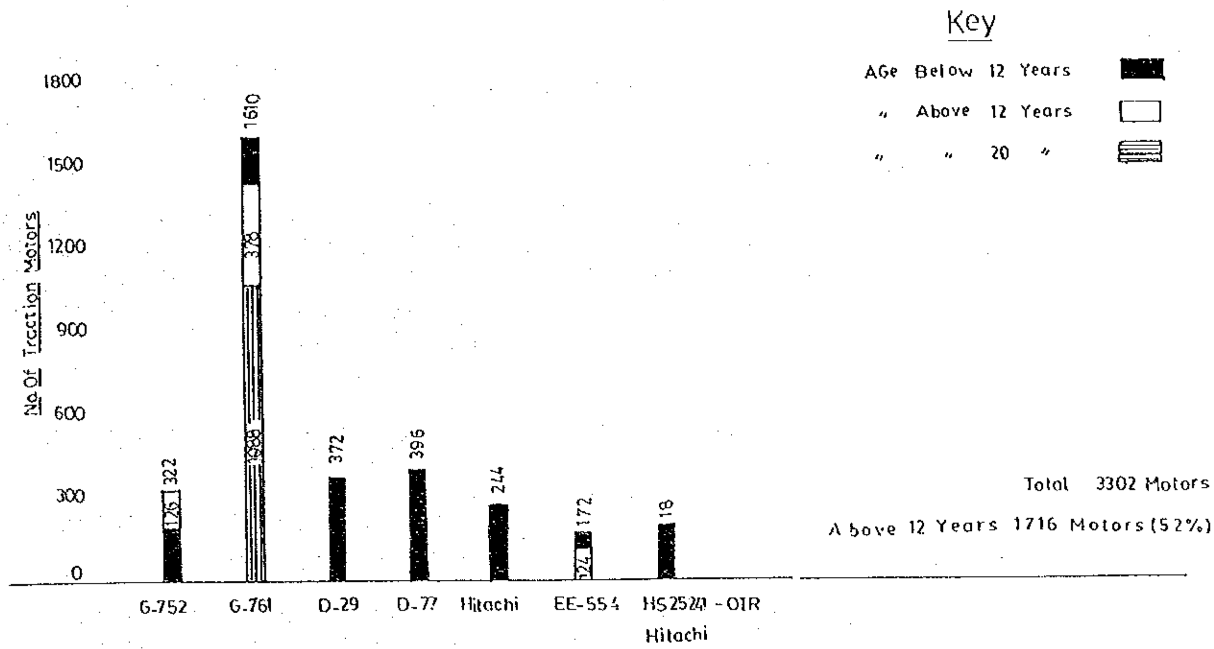
As to passenger coaches, air brakes are necessary for the 120 km/h operation between Karachi and Samasata. Since most of the coach brakes are of the vacuum type, there is the problem of replacement in order to meet the high-speed operation of trains.

As to freight wagons, 90% are four-wheelers. To increase the maximum speed of freight trains in the Pakistan Railways from 55 km/h to 90 km/h, it is necessary to improve the suspension and brake systems.

Another problem is the superannuation of traction motors, which is closely related to the tractive capacities of locomotives (Refer to Fig. 1.7.1 and Fig. 1.7.2).

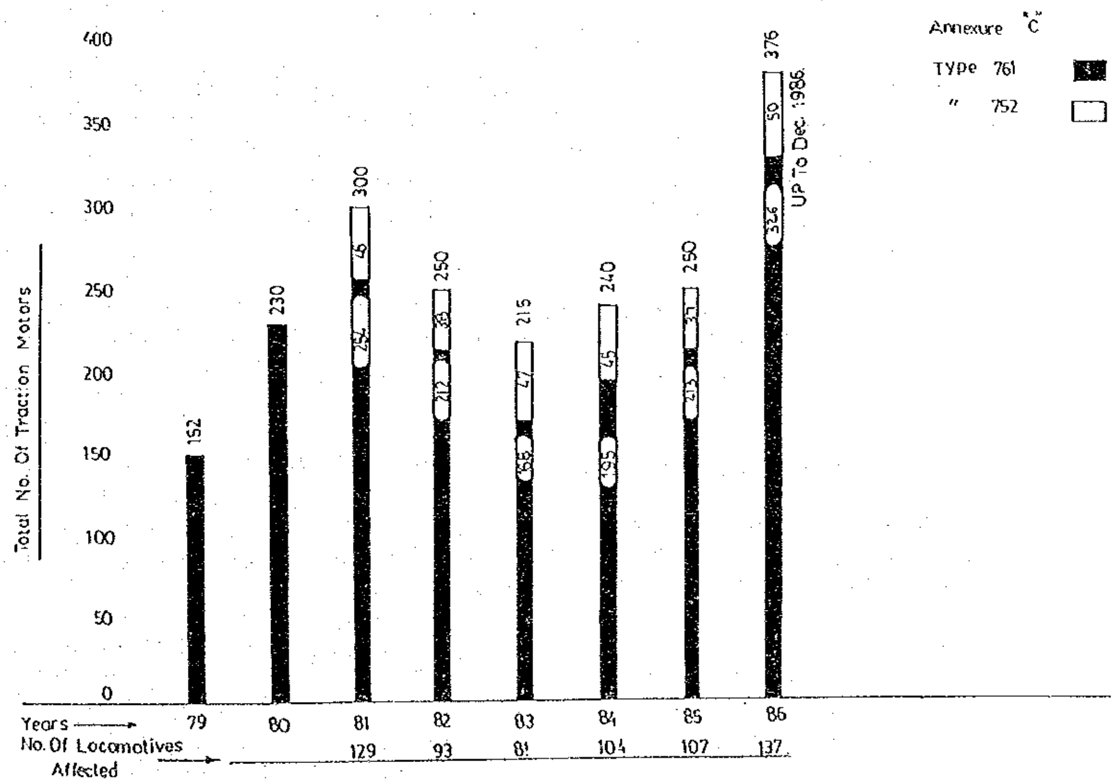
About 52% (1,715 units) of the 3,302 traction motors are old, resulting in a shortage of 376 motors, which reduce the tractive capacities of about 137 locomotives.

Fig. 1.7.1 Pakistan Railways: Traction Motor Life



Source: P.R.

Fig. 1.7.2 Pakistan Railways: Average Shortage of T/Motors in Shed



Source: P.R.

CAPTER 2 MASTER PLAN (1988/89 - 2005/06)

2.1 Future Traffic Demand for Railway Transport

2.1.1 Future Traffic Volume

Traffic demand in the year 2005-06 is estimated at 24,910 million passenger-km for passengers and 32,468 million ton-km for freight in strategic case or Case-2. Those figures are 1.58 and 3.92 times larger than the corresponding figures of 1985-86. Forecasted traffic demand is shown in Table 2.1.1.

Table 2.1.1 Forecasted Traffic Demand for Railway Transport

		1985/86	1992/93	2005/06
Passenger (million pass-km)	Total	16,657	20,184	27,498
	Inter-zonal	15,803	18,797	24,910
		(1.0)	(1.19)	(1.58)
Freight (million ton-km)	Total	8,299	12,316	32,515
	Inter-zonal	8,288	12,294	32,468
		(1.0)	(1.48)	(3.92)

Source: JICA Study Team

The railway traffic assignment was made using the railway OD tables and the network of Fig. 2.1.1. Details of the results are tabulated in Appendix 2 and Transport Demand Forecast 6.3. The assigned volumes of traffic along the main sections both in 1985-86 and 2005-06 are illustrated in Fig. 2.1.2 for passengers, and in Fig. 2.1.3 for freight.

In both cases of passengers and freight, traffic flows will be concentrated along the main line between Karachi and Peshawar.

2.1.2 Estimated Number of Trains for the year 2005-06

The total number of necessary trains by each section has been obtained by adding the number of passenger trains and freight trains. The result is shown in Fig. 2.1.4.

The procedure for the calculation of the required number of trains is given in Appendix 3.

About 40 trains are operated one way at present between Karachi and Samasata. In 2005-06, 70 to 80 trains may probably be operated. It is impossible, however, to operate such a number of

Fig. 2.1.1 Pakistan Railways' Network

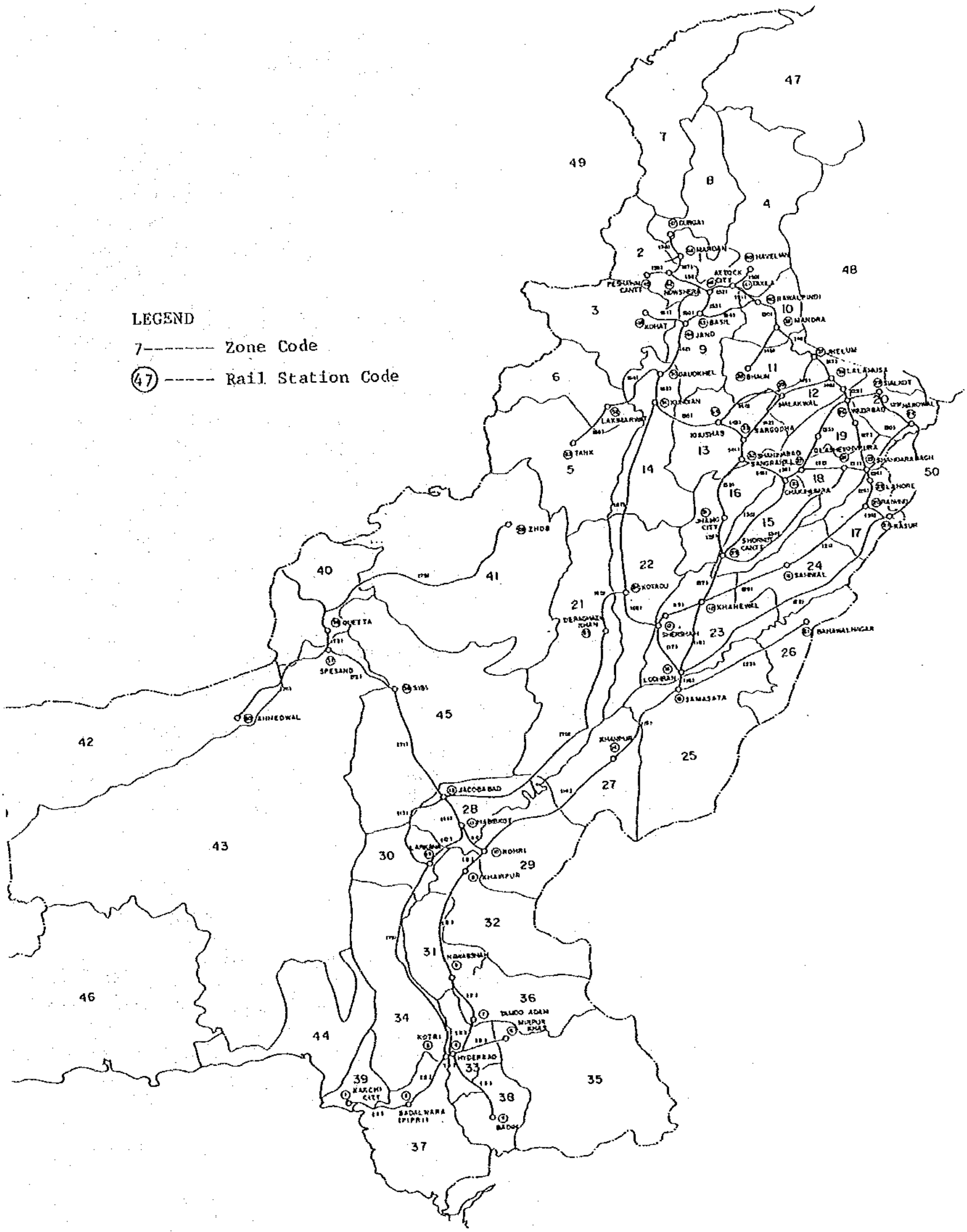


Fig. 2.1.2 Assigned Traffic Volume, Passengers

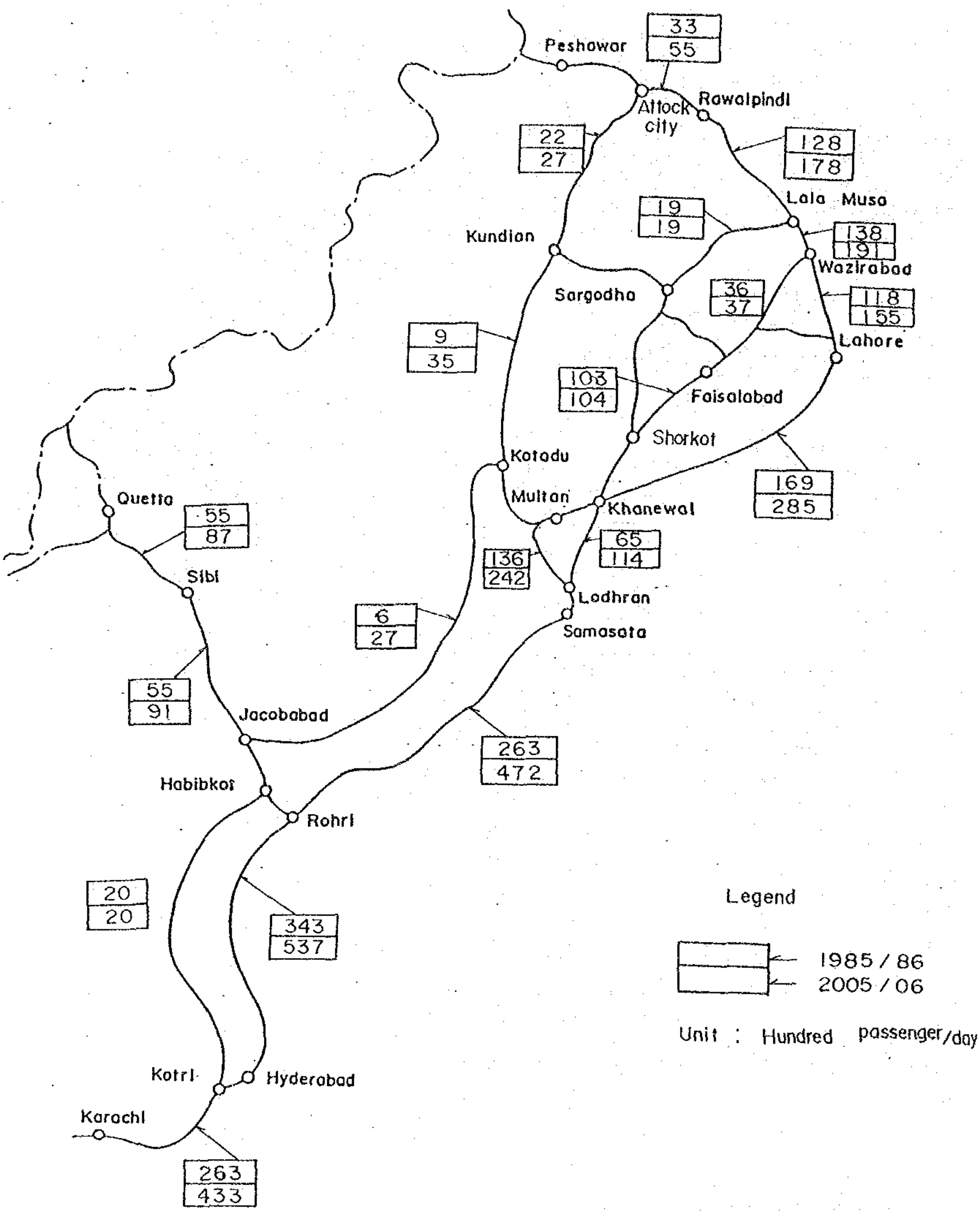


Fig. 2.1.3 Assigned Traffic Volume, Freight

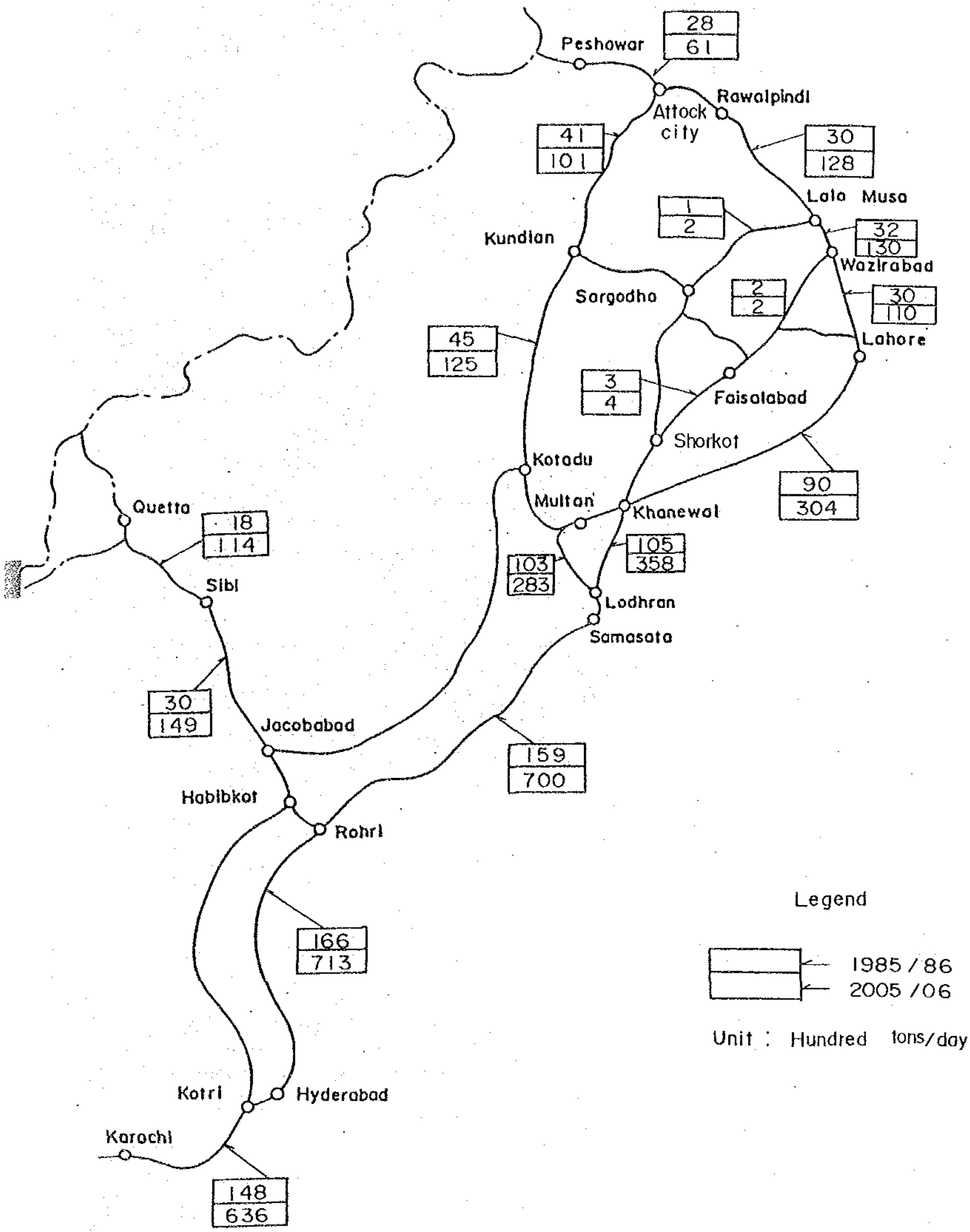
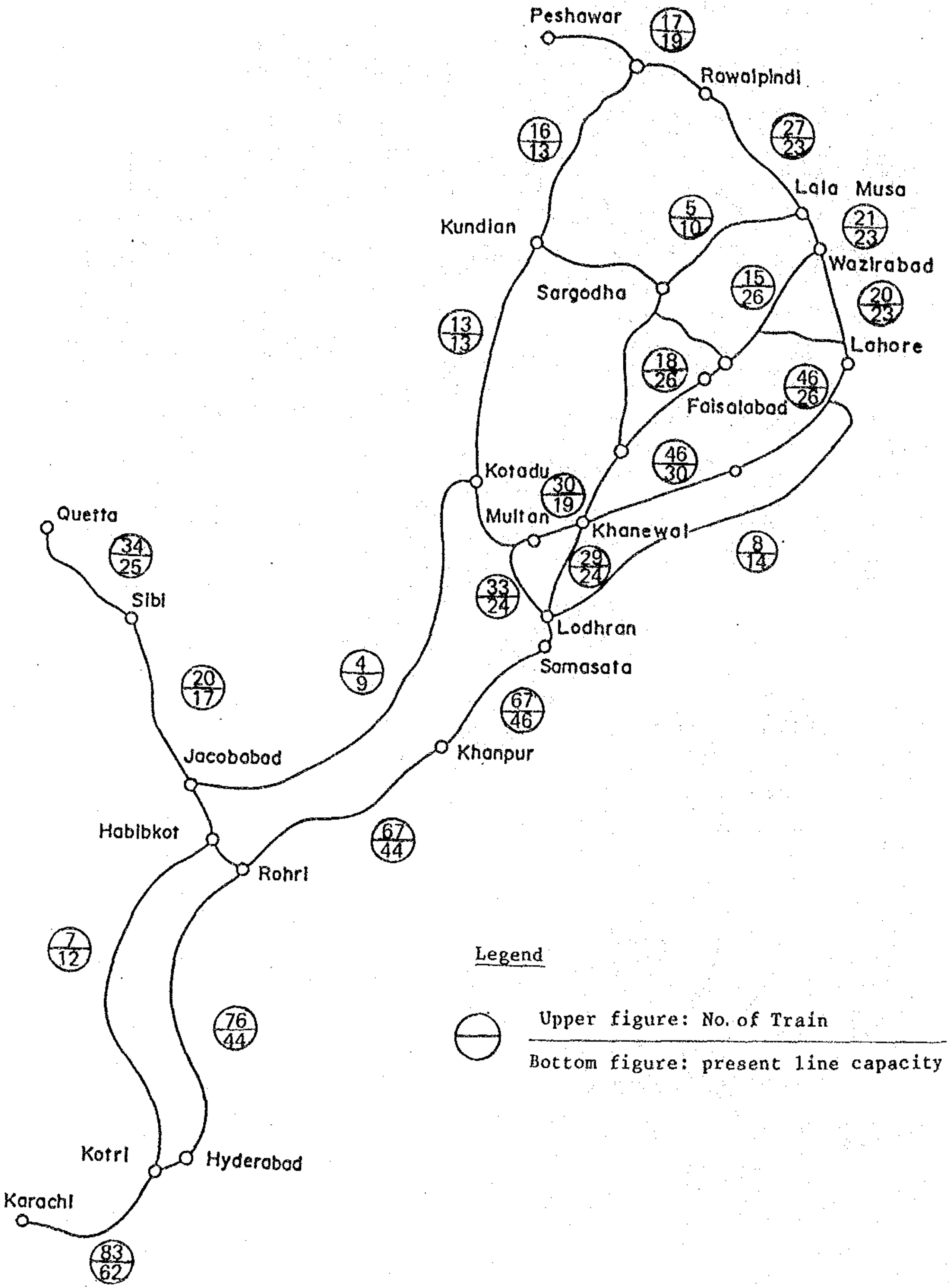


Fig. 2.1.4 Total NO. of Trains Required in the Year 2005/06



trains only with the existing traffic facilities. The same problem may be raised in other sections such as Samasata - Lahore - Rawalpindi, and Rohri - Quetta. A solution to such a problem and improvement of the railway traffic will be discussed in the subsequent sections.

2.2 Basic Concept for Railway Facilities Improvement

It is expected that railway transport has the advantegous features in mass-transport such as safety, speed, punctuality and economy. In order to realize these advantages, it would be necessary to make railways attractive enough to capture their patrons such as passengers and freight consignors.

Considering the present competitiveness against road transport and the desirable demand allocation from the economic viewpoint, the following strategies are expected to be implemented both in the long-term Master Plan and the short-term plan.

a) to fully utilize the existing line capacity with necessary supplemental measures.

b) to establish freight collection and delivery bases, and to arrange direct train operation between these bases.

c) to encourage container transport and speed-up of freight train.

d) to improve service frequency of passenger trains, and operate high-speed passenger trains.

e) to reduce detaining time at station/yards.

f) to introduce information services for passengers and freight consignors.

2.3 Planning Direction

The strong features of railway transport are safe, speedy and punctual service capacity to handle mass-transport. Despite the differences in the demand for transport throughout the world, and the decreasing trend in railway transport, there is still room for development of railway transport in areas where its features can be demonstrated efficiently.

In Pakistan, where the traffic demand and the land have developed mainly along a long corridor running from north to south, there appears to be conditions for effective use of the advantages of railway transport. To make the best use of these advantages, it would be necessary to make railway transport attractive enough to the customers. Upon reviewing the present situation and future prospects of the railway system in Pakistan, it is considered effective to take the following measures.

- Reinforce line capacity.
- Improve speed and tractive force.
- Establish freight collection and delivery bases, and prepare and improve direct connecting trains between the bases.
- Utilize container transport and improve speeds of freight trains.
- Improve service frequency of passenger trains, and operation of high-speed passenger trains.
- Reduce waiting time at stations.
- Improve information service to passengers and freight consignors.
- Modernize dispatch system.

To put such measures into practice, reinforcement, or improvement of transport facilities is necessary. Concept of improvement targets are as follows.

- Use of automatic block system and relay (electronic) interlocking system.
- Introduction of wireless block system and color light signals.
- Preparation of double track.
- Introduce Electrification.
- Adoption of larger diesel locomotives.
- Extension of usable length of track.
- Improvement of terminals, and adoption of larger rolling stock.
- Improvement of stations, and adoption of freight handling machines.
- Renewal of tracks.

- Increase in number and replacement of rolling stock.
- Improvement of information system, dispatch system, and telecommunication networks.

The effects by major items of the above are described below.

2.3.1 Reinforcement of Line Capacity

(1) Signalling System

Line capacity means the maximum number of trains to be operated in one day. Take N (number of trains per day) as the line capacity, for example, and it can be obtained by the following formula in the single track section.

$$N = 1{,}440f/(t + c)$$

where,
- t: traveling time of a train between stations (minutes per train)
- c: block handling time (minute)
- f: railway utilization factor -- coefficient, for example, for no trains which can be operative due to track maintenance, or no trains at midnight due to no demand.

As seen from the above formula, when f is constant, the line capacity can be determined by (t + c). Therefore, it is effective to make the following improvements to increase the line capacity.

- To realize a system with short block-handling time.
- To realize a system suitable for a higher train speed between stations.
- To realize a system which allows two or more trains simultaneously between two stations.

a) Block System

Major block systems include the following.

- for Single track
  - Single block between two stations
    - o token block system
    - o tokenless block system
    - o automatic block system (special)
  - Multiple blocks between two stations
    - o automatic block system
- for Double track
  - Single block between two stations
    - o tokenless block system
  - Multiple block between two stations
    - o automatic block system

Among the above, the automatic block system, which has a short block handling time and allows operation of plural trains between two stations, is effective from the viewpoint of line capacity and safety.

b) Interlocking System

The interlocking system is to select routes for smooth train operation in a station yard, and to secure safety by interlocking of signals, switches, and track circuits. The interlocking system may be classified roughly into the following two systems:

- A system having signals and switches controlled from a signal cabin.
- A system to manually operate switches in the field.

From the viewpoint of hardware, the interlocking system can be classified into the mechanical system and relay/electronic system. Considering the reduced handling time (improved operability) and improved safety, a centralized relay or electronic system is superior.

c) Centralized Traffic Control System

The centralized traffic control system is designed so that the control center collects train information and also remotely controls signalling equipment of all stations. The train-location displaying function of this system is extremely useful for controlling traffic operation.

Traffic operating conditions collected through this system makes it possible to recover a normal traffic operating schedule as quickly as possible with the smallest possible disturbance, even when the schedule may be out of order. This system, therefore, is effective in making traffic operations efficient.

(2) Track Doubling

When traffic demand is not so large, a single track line capacity can be increased by blacing train exchange loops between stations so that each block section can be made shorter to accommodate a larger number of trains. The blocking system between stations, interlocking system in stations, and the train control system to operate in linkage can be upgraded to automatic signal system or relay interlocking, to allow operation of more trains in the same duration of time. An excessive increase of trains in a single track will increase the waiting time for a passing train and decrease the train speed.

A section where trains are approaching the maximum line capacity calculated by the formula $N = 1{,}440f/(t + c)$ should be considered as to whether it should be replaced by the double track system. A careful investigation should be made, however, since the above-mentioned measures may be better in keeping the single track system.

An adoption of the double track system will have the following effect.

- The transport capacity can be greatly increased.
  A double track will allow over 3 times the number of trains that can possibly be accommodated on a single track.

- The train speed can be greatly increased.
  In case the number of trains increases on a single track, a longer stand-by time is needed to wait for a train coming from the opposite direction to switch due to less elasticity. A double track can save much time and increase the average speed of overall trains.

- Flexible traffic service can be offered.
  Since the train traffic schedule can be made with enough margin, service fitting the desires of passengers and consignors can be offered.

- Restoration of normal traffic schedule from delay is easy.
  On a single track, the delay of one train may affect not only trains in the same direction but those in the opposite direction.
  Consequently, it takes a long time for normal traffic schedule to be restored. On a double track, on the other hand, the delay of one train may affect only a few trains, and the schedule can generally be restored very quickly.

- Railway maintenance is easier.
  On a double track, so long as the number of trains is kept to under twice that on a single track, the number of trains per track will decrease, allowing more time between trains on one track for easier maintenance.

2.3.2 Electrification

(1) Effects of Electric Train Operation
(compared with diesel locomotive hauled train)

The effect of improvement on railway operation by a change from diesel to electric train operation offers a merit in energy cost through replacement of oil by electricity. This is not all that electrification can achieve: the following three effects can be pointed out as typical ones.

a) Effect through Improved Performance of Rolling Stock

- The benefit of the railway infrastructure can be raised. -

The increased tractive characteristic of an electric locomotive will increase the transportation capacity per train. Higher acceleration will shorten the headway time (to increase the traffic capacity). Such an effect can raise the volume capacity of railway transport.

b) Operation Cost Reduction Effect

- Running cost reduction of trains is possible in motive power cost, repair cost, and labor cost. -

Motive power cost and repair cost are lower in electric locomotives. This increased speed and tractive force of an electric locomotive can reduce the number of the crew.

c) Higher Profit through Improved Service

- Comfortable traffic service with high-speed and low pollution trains (no smoke, no smell, low noise, and low vibration) will raise the profitability. -

The shortening of transport time by speedup is a great benefit mainly for passenger transport, and will induce increased passenger traffic.

(2) Effect Expected from Improved Rolling Stock

a) Tractive Force Characteristics

In comparing electric locomotive (EL) and Diesel locomotive (DL), EL is far superior to DL in tractive force in the intermediate speed range. When comparing the tractive force at a constant speed (40 km/h), EL is about 1.8 times more powerful than DL. Table 2.3.1 shows the improved traveling speed. According to this, for example, the speed of EL in goods train at a gradient of 0.5% is 1.8 times faster than that of DL .

b) Speed Improvement

Improved speed through electric train operation will reduce standard operation time by 10 to 15% compared with non-electric train operation. Table 2.3.2 shows targets of scheduled speed improvement. Electric rolling stock has high acceleration characteristics, and can increase line capacity.

Table 2.3.1 Improvement of Train Speed by Electrification

	Freight Train (2,000t)			Passenger Train (800t)		
Gradient	0‰	5‰	10‰	0‰	5‰	10‰
EL	107km/h	80	55	135	110	92
DL (DL/EL)	85 (79%)	45 (56%)	28 (51%)	122 (90%)	85 (77%)	60 (65%)

Source: JICA Study Team

Table 2.3.2 Target of Train Speed-up

* Present Train Speed			Train Speed (km/h)	
Type of Train		Tractive Force	Max.	Scheduled
PC	Super Exp.	800t	105/120	80
	Exp.	800t	90	70
FW	2-axle	2,000t	65	40
Train Speed after Electrification on Main Line				
PC	Super Exp.	600t	160	120
	Exp.	800t	120	90
FW	Bogie	2,000t	100	75
	2-axle	2,000t	80	55

Source: JICA Study Team

(3) Effect by Operation Cost Reduction

a) Reduction of Motive Power

Since the motive power cost is determined by energy consumption rate and unit price of energy, these two factors should be considered in comparing motive power cost.

The energy consumption rate varies depending on various factors such as type of train, speed, track conditions, etc. For a macroscopic comparison, mean values of actual achievement by Pakistan Railways (PR) are used here. According to the data, the energy cost per km of freight train by EL is about 50% lower than that of DL. Unit cost of electric power or diesel oil is greatly affected by the price of crude oil price. The comparative relation of energy cost will change accordingly.

b) Reduction of Rolling Stock Maintenance Cost

In general, a DL has a larger number of parts including many parts subject to abrasion. In addition, since higher assembly accuracy is required on the engine and the transmission, the maintenance cost of a DL is apt to become higher than that of an EL.

Maintenance of locomotives is executed based on the inspection standard of each category. Comparing annual maintenance costs (personnel expenses, material expenses) of EL and DL based on actual data in Japan, the unit of EL maintenance cost is 50 - 70% that of DL. Consequently, it is understood that EL is extremely economical.

c) Other Effects

The effect of locomotive performance improvement through electric operation will raise the train speed and reduce the train running time. As a result, reduced number of rolling stock and rolling stock inspection workers can contribute to the integration or deletion of some locomotive bases and the reduction of maintenance workers. Such a by-product should also be evaluated.

2.3.3 Speedup

The first importance of transportation is "speed". To use the railway as an important means to support the future development of the country, it is necessary to have well-planned measures for service improvement by efficiency and speedup. Provided that the train hours between two stations can be reduced by 10% through certain measures such as higher maximum speed, improved acceleration or less curvature, the line capacity is increased by over 10%, resulting in improved efficiency with reduced number of rolling stock, train hours, and number of crew and workers.

Taking rolling stock of "Shinkansen" in Japan, for example, the unit cost is expensive. Shinkansen has a running distance of 1,500-2,000 km per day and 84 passengers per car. The conventional passenger coach has service distance of 300 km per day and 70 passengers per coach. The efficiency of a Shinkansen car is 6-8 times higher than a conventional coach in the number of passengers to be transported and distance of run.

PR currently plans to raise the maximum speed of selected trains to 120 km/h, but further improvement can be expected by means of the new speedup plan. To improve the total efficiency in passenger and freight transport, speedup of freight trains is quite effective.

2.3.4 Information System

(1) Passenger Information System

- Seat reservation system

  An assured reservation of train tickets and hotel rooms will enable a passenger to enjoy his trip without anxiety. With knowledge of seat reservation status, it is possible to make efficient use of the seats. The computerized seat reservation system is effective for this purpose. To record the reservation status, usually files of reservations should be kept at one center.

  In a small system, it is possible to manually fill files by taking reservations by phone at the reservation center. In this system, even if a certain number of clerks and telephone lines is engaged, often line congestion is encountered or there is a long delay to obtain replies.

In such a case, with a computer system, a clerk obtaining information from a customer regarding the departure data, name of the train, departure station and destination, coach class, and number of passengers, will input such data through the terminal device. Then, he can reply to the customer in about 3 seconds.

- Ticketing system

  Adoption of a printing and ticketing machine can speed up issuing single tickets (for short and intermediate distance) and commuter tickets.

- Passenger information display

  At stations, it is necessary to inform passengers of the departing platform of the train they take and its departure time. In cases where the operation system is complicated with many trains and destinations, and there are frequent arrivals and departures, it is effective to install passenger information displays at platforms and stairways.

(2) Freight Information System

What is mostly needed by a consignor when using a freight car (or a container) is exact information about the availability of a freight car (or a container), reservation of its connection to a train, departure and arrival time. An early reply to his request will enable him to systematically plan loading, unloading and shipment of products.

To a consignor's question about the location of the freight car (or a container), a quick reply is essential. It is also an important service to a consignor to inform him of the status when a problem occurs.

To comply with such requirements, adoption of the freight information system is effective. With a central computer, current location of freight cars, status, loaded freight departure and arrival stations are centrally controlled so that the following type of information can be provided.

- Request of transport
- Issue of bill of lading
- Search of freight location
- Notification of train formation
- Preparation of freight car allocation data
- Preparation of data to yard and station
- Preparation of transport performance and statistics
- Administration of inspection and repair

2.3.5 Freight Transport

(1) Improvement of Commodity Category-wise Direct Transport

For oil, cement, and wheat, exclusive direct transport for each category has been handled between major stations. This system should make further development. Besides, for such items as rice, fertilizer, etc. which are handled in large volumes, collection and distribution bases should be developed at each departure station and destination as much as possible. Expansion of direct transport service through standardization in such a manner is considered useful for clarification of departure and arrival time, and transport cost reduction.

(2) Improvement of Container Transport

Ocean container transport is playing a major role in import and export transport. To directly transport ocean containers to places of consumption in the north, an inland container depot was developed in Lahore. By providing "quick transport service with assured departure and arrival time" between Karachi on the bay and Lahore for consumption, it is possible to increase the volume of transport of import and export goods.

(3) Efficient Transport of Ordinary Freight

For ordinary freight which has a greater part of the share in transport, and in consideration of the cost compared with road, it is better to make the service efficient and punctual.

By taking Karachi and Pipri in the south, Samasata in the middle, Lahore, Lala Musa and Rawalpindi in the north, other yards in each city, development of large scale and efficient direct transport between the yards should be organized. It will be a major flow between the south and the north. Added to this, improved feeder transport networks will be helpful to the reinforcement of the transport capacity and realization of a highly punctual transport system.

(4) Review of Freight Station Location

There are many small and intermediate freight stations and freight handling facilities which are generally too old. Under the current situation where the recent increase in commodity distribution and remarkable popularization of automobiles are prevalent, the conventional and scattered location of freight stations cannot fully demonstrate the advantages of railway transport for quick and large volume handling. For improvement, it will be effective to set up freight terminals at each local commodity distribution center, and establish cooperative relationships with truck transport companies for local distribution.

2.4 Prospective Development Plan

2.4.1 Physical Target

There are two ways to increase the railway traffic capacity;
- to carry more volume per train
- to increase the number of trains.

As to the former, it is considered to operate long trains with higher power locomotives or electric multiple unit trains with power distributed throughout the train. In this case, it is necessary to improve platforms and effective length of stations. However, it is not useful for high frequency service and operation of trains during the period customers prefer.

As to the latter, one method is to increase the number and length of passing tracks or loops. In this case, it does not take much time and cost to construct them, so immediate effects on railway capacity can be obtained. But it might induce service-down in some trains with detaining time. Otherwise, the methods to lessen the period to occupy tracks exclusively, are to improve block signalling systems and speed up train operation (sometimes including improvement of rolling stock, shape of lines and tracks etc.). The method of substantial improvement of line capacity is to double track.

Considering the above, the following strategies are recommended.

a) For the existing electrified sections, if the capacity of the sections is not enough, track-doubling is effective.

b) For the existing double-tracked sections, if their capacity is not enough, automatic block signalling and electrification are effective.

c) For the sections to be electrified and/or to be double-tracked, improvement of signalling systems makes the facilities more efficient.

d) For the major trunk lines, on which traffic volume has almost reach the capacity, improvement of signalling system is useful.

e) In the circumstances where road transport is highly competitive, merely the provision of line capacity is not enough to lead traffic to the railways. Improvement of quality of service also has to be provided for customers. Information systems for passengers and consignors are indispensable.

2.4.1.1 Projects on Reinforcement of Line Capacity

(1) Automatic Block System and Interlocking System

To increase the number of trains and raise operation speed, it is necessary to prepare suitable signal and safety facilities. For the use by the Pakistan Railways, token block system, tokenless block system, and automatic block system can be applied. As to the interlocking system, the standard I, II, III and the electronic/relay interlocking system can be applied.
Among combinations of these block systems and interlocking systems, realistic combinations are as follows.

Table 2.4.1 Combinations of Major Train Control Systems

Interlocking Systems	Block system		
	Token Block	Tokenless Block	Automatic Block system
Standard I	I-a	I-b	
Standard II	II-a	II-b	
Standard III	III-a	III-b	
Electronic/Relay Interlocking		IV-b	IV-c

For increasing the number of trains and raising train operation speed, I-a has the smallest effect, and IV-c has the highest one. In the application of this table, the following are recommended (Fig. 2.4.1, Fig. 2.4.2 and Fig. 2.4.3).

a) IV-c is desirable for sections requiring a large capacity, for either single track or double track of the main line where train service frequency and operation speed have to be raised.

The following sections can be taken up as those corresponding to such a case.

-1 Karachi - Rawalpindi
-2 Rohri - Quetta

b) IV-c is desirable for sections where a large amount of traffic is expected on those major branch lines or alternative lines. But, in the case no large volume can be expected for the time being, III-b is desirable. The following sections can be considered as those which correspond to such a case.

-1 Khanewal - Faisalabad
-2 Sangrahill - Wazirbad
-3 Chakjhumra - Sargodha
-4 Sargodha - Lala Musa
-5 Attock City - Kundian
-6 Kundian - shershah

c) IV-b or III-b is desirable for the main lines which can expect future growth of traffic but now has a relatively small volume. The following sections are considered as those which correspond to such a case.

-1 Rawalpindi - Peshawar

(2) Track doubling

It is proposed to double the track at the sections between Multan and Raiwind, between Lodhran and Shershar. Where future traffic volume is expected to exceed the present line capacity substantially owing to an increase in the number of trains. Multan - Khanewal in this section was taken up in the 6th 5-year plan. In spite of the fact that the line capacity has already been exceeded, no remedy has been made yet due to the restricted budget.

The above-mentioned sections are the important ones on the trunk line, and they surely will become bottlenecks in the future if they are left as they are (Fig. 2.4.4).

2.4.1.2 Tractive Force Improvement Project

(1) Electrification

Electrification of the following sections is recommended to secure sufficient hauling tonnage at steep-gradient sections and increase the line capacity (Fig. 2.4.5).

-1 Lala Musa - Rawalpindi

This section is a continuous, steep-gradient section including the most steepest gradient of 10/1,000. It restricts the maximum train hauling load to 1,200 tons, and up trains are required to be separated at Lala Musa. Electrification and high-power electric locomotives are to be applied to secure 2,000-ton hauling load. It will secure a increased transport capacity with the single track kept as it is, and can reduce the necessary number of locomotives. Thus, the necessary transport facilities can be provided with minimum investment.

-2 Lahore - Lala Musa

This section is located between the electrification-planned section of Lala Musa - Rawalpindi and the electrified section of Khanewal - Lahore.

In this section, trains are operated to the full line capacity. Electrification of this section will realize the electric operation all through Khanewal - Rawalpindi to raise transport efficiency, and increase the line capacity.

-3 Samasata - Khanewal

In this section, Lodhran - Khanewal has a single track chord line and a single track loop line. Though single track for each, both of them are used to secure a line capacity which can compare with that of a double track facility.

Even with such a full use of the facility, a transport capacity to the maximum level of each line is required. It is proposed to electrify both lines to secure the line capacity and to improve the transport efficiency.

The completion of electrification of these 3 sections, and the sections between Khanewal and Lahore where electrification has already been completed it will achieve electrification of all the main lines in the northern area. It will realize a long distance electric locomotive operation to improve the locomotive operation efficiency and reduce the required number of locomotives.

-4 Sibi - Quetta

This section is a continuous and steep-gradient and includes the most steepest gradient of 40/1,000. Compared with the maximum hauling load of 2,000 tons at Rohri - Sibi side, only 250 - 600 ton hauling load is available on the Sibi - Quetta side. In this section, 500 ton hauling load is secured with two Diesel locomotives coupled together. Added to the low hauling load, low train speed and poor brake performance causes shortage of the line capacity.

After electrification of this section, an electric locomotive can haul a 500 ton train. With an auxiliary locomotive of the same type connected to the rear of the train, 1,000 ton hauling load can be secured. Besides, the high efficiency dynamic brake system of electric locomotives will ensure safe and faster train operation even on a downward slope section.

-5 Kiamari - Samasata

These sections are 815 km long with all the sections double-tracked. They are the highest density section in Pakistan Railways. The effects mentioned in section 2.3.2 are most useful in these sections.

2.4.1.3 Improvement of Freight Terminal

There is a heavy concentration of passengers and freight trains in the section between Karachi in the south and Lahore in the north. The greater part of the section has already been turned into double track, and some northern parts have been electrified. However, the old blocking system and other factors restrict the line capacity and make the transport planning inflexible. It causes poor punctuality in freight train operation. This is considered to be one of the factors restricting the expansion of the railway transport volume.

With regards to freight transport, the following suggestions can be made to maintain and expand the transport volume in the future.

-1 For the achievement of efficient transport in this section, reinforcement of direct transport and speedup of freight trains are necessary.

-2 "Express" transport service of export/import goods by means of ocean containers with clearly foreseeable arrival schedule should be executed.

-3 Direct mass transport of oil, cement, wheat and the like should be improved. Transport of rice and fertilizer in large quantities should be standardized so that direct transport can be expanded.

-4 For ordinary freight, transport efficiency should be raised through the improvement of yards. The feeder networks should also be improved to realize a highly punctual transport.

To achieve such an improvement as mentioned above, improvement of freight terminals, expansion of stations and yards, and increase in the number and expansion of effective lengths of departure and arrival lines should be executed as follows.

(1) Freight Terminal

Since the major industry is agriculture, there are many small and medium sized stations, with the exception of a limited number of large stations. Excepting container bases, oil bases and others for specific commodities of a large volume, freight handling facilities are generally old and obsolete.

Considering the recent development of the goods distribution system, road networks, and the popularization of automobiles, freight stations and their location in the railways will heavily disrupt the function of the modern transport system which requires speed, and make railway transport less competitive.

To solve such a problem, it is necessary to realize the above-mentioned direct transport system and an improved feeder network to link with the former. In addition, the following improvement is necessary.

- At each local distribution center, a modern freight terminal suitable for the local items to be shipped or received and adequate for their distribution should be constructed.

- The function of such a freight terminal should be not only for the conventional loading and unloading. An additional function required is, at least, to be able to store goods so that transport adjustment can be made depending on transport volume fluctuation.

- Freight stations handling extremely small volume of goods should be merged or discontinued.

- A cooperative system with road transport companies to locally handle small scale transport should be developed.

As to the concrete freight terminal development plan, it is recommended to establish distribution centers at the places near the stations of Samasata, Khanewal, Lahore, Lala musa, Rawalpindi, Peshawar, etc.

(2) Improvement of Arrival and Departure Lines at Stations and Yards

In line with the expansion of direct transport between base stations, the mission of wagon yard is becoming relatively less important. However, considering the future shortage of transport capacity particularly in the trunk line connecting Karachi in the south and Lahore in the north, which forms a heavy goods distribution flow, it is necessary to prepare more shunting tracks or new crossing loops between the two stations. In addition, it is necessary to raise the arrival and departure line capacity and extend the effective length of such lines at wagon yards so that the role of nodes can be raised.

2.4.1.4 Planning of Dry Port

(1) Existing Dry Ports

Due to the increased import/export, the work volume of the customs at Karachi Port has been steadily increasing, and will further increase owing to the expected growth in Pakistan's trade. This tends to detain cargo at the Port for loading and unloading for a longer duration and, therefore, causes a certain increase in the cargo handling cost.

In this section, an inland dry port including bonded warehouse has been under construction at Lahore since 1974 in order to mitigate the traffic congestion at Karachi Port and to accelerate the smooth transport of imported and exported goods. Since then, dry ports were constructed at Peshawar, Multan and Quetta under the control of Pakistan Railway, and at Hyderabad and Sialkot operated by HDPT (Hyderabad Dry Port Trust) and SDPT (Sialkot Dry Port Trust) respectively.

The past trends of cargo volume handled at Lahore Dry Port are shown in Table 2.4.2. Although the volume is steadily increasing year by year, the total volume still remains at only a few percent of that handled at Karachi Port. Judging from the fact that the cargo movement in Pakistan is characterized by the major transport route between Karachi Port and the Up-country including Lahore, the LDP's function is not yet efficiently utilized.

This may be attributed to the following reasons:
Lower levels of service of Pakistan Railway
- Delay
- Pilferage, etc.
- PR's inability to issue TBL (Through Bill of lading)

With regard to the TBL, however, PR will start issuing them in October 1987. This is considered to have a large influence on the operation of LDP, if coupled with other efforts to upgrade the PR's level of service.

Table 2.4.2 Number of Containers Handled by Rail at Lahore Dry Port (TEUs)

Period	Imports		Exports		Total TEUs Handled
	Loaded	Empty	Loaded	Empty	
1979-80	83	1	5	41	130
1980-81	241	14	145	31	431
1981-82	348	24	135	88	595
1982-83	525	138	201	297	1,161
1983-84	744	70	264	324	1,402
1984-85	1,018	68	304	631	2,021
1985-86	991	121	397	665	2,174
1986-87	1,012	242	323	639	2,216

Source: Lahore Dry Port.

(2) Containerization vs. Inland Transport

Containerization of marine cargo is a world-wide tendency, due to the merit of speedy through transport from inland consignors in one country to inland consignees in another country. Also in Pakistan, the demand for containers is projected to grow to 2.0 times in 1992-93 and to 4.7 times in 2005-06 as compared to 1985-86 (Refer to Port Planning 2.3).

In order to transport containerized cargo for long distances, it is considered essential for railways and roads to play each role in harmony with the entire system of container transport, i.e.; long haulage by train and feeder service by road. Further, a well coordinated system among railway, trucking carriers, and consignors/consignees will be necessary to promote quick delivery and punctuality, especially because the rental fee of containers depends on the period they are used.

(3) Future Prospects of Dry Port

Considering the distance from Karachi Port, railway network and the cargo volume handled at present, Rawalpindi, Faisalabad, Sargodha and Kundian were identified as desirable locations for candidate cargo terminal cum dry port in addition to the existing dry ports.

For these existing and candidate dry ports, a projection of the volume of containerized cargo to be handled was carried out after identifying an influence area for each dry port.
The projection of commodity-wise import/export and containerization was also taken into account. The result is presented in Table 2.4.3 and Fig. 2.4.6.

For the existing Lahore dry port, the future potential demand is considered to be high. The present container train frequency of 2/week could be increased to 4/day in 2005-06. Among the candidate dry ports, Faisalabad has the largest potential demand due to the high growth of general cargo and the projected export of sugar.

Rawalpindi has, at present, the third largest cargo handling volume next to Lahore and Faisalabad as an inland railway terminal. The future potential demand is also consistent with the current position.

Table 2.4.3 Traffic volume Handled by Rail at Dry Ports in the Future

(Thousand ton/year)

Dry Port	1985-86		1992-93		2005-06	
	Export	Import	Export	Import	Export	Import
Lahore	104	267	110	590	265	1,228 (4)
Peshawar	100	58	74	125	230	265 (1)
Multan	22	22	331	69	724 (3)	194
Quetta	10	20	57	23	178	56
Rawalpindi*	19	84	38	196	119	401 (1)
Kundian*	2	19	67	35	205 (1)	80
Sargodha*	23	16	43	49	125	126 (1)
Faisalabad*	60	49	113	105	564 (2)	284
Sialkot**	15	2	19	11	46	30

Note: 1) * : Candidate Dry Port
2) **: Belongs to Sialkot Dry Port Trust
3) Figures in parentheses indicate necessary No. of container Trains per day.

Source: JICA Study Team

As to Sargodha and Kundian, the future demand will be larger than Quetta which has already started operation, although the potential demand as of 2005-06 was estimated at 250 and 280 thousand tons including export and import, respectively. Especially for Sargodha, containers will be efficiently utilized owing to the small gap between import and export.

In conclusion, the potential demand for all these existing and proposed dry ports will account for 49% of the total containerized cargo to be handled at Karachi Port. In order to promote these dry ports, however, the following countermeasures will be necessary:

- Improvement of four railway terminals stated above through:
  - construction of container yards
  - acquisition of container handling equipment
  - construction of bonded warehouses and offices
  - construction/improvement of access roads
- Operation of container trains directly connecting dry ports and Karachi Port.

2.4.1.5 Information System

(1) Seat Reservation System

To realize an attractive railway system, it is necessary to provide passengers with information so that they can systematically use the railway service.

This system is usually furnished by a center where data is concentrated. Therefore, it is desirable to establish a center in Lahore where railway information is centralized.

One to five terminals should be installed in accordance with the necessity at large and medium-sized stations, travel agencies, and passenger dispatchers.

(2) Freight Information System

To realize an attractive railway system, it is also necessary to provide consignors and consignees with freight transport information so that they can systematically proceed with their business to reduce cost. Similar to the seat reservation system, it is desirable to establish a center in Lahore.

One to five terminals should be installed in accordance with the necessity at major freight stations, yards, forwarding agents, and freight dispatchers.

(3) Centralized Traffic Control System

If a trouble on railway transport should occur somewhere in main routes forming a framework of the railway transport by the Pakistan Railways, it would cause an extremely heavy damage to passengers and consignors. The centralized traffic control system always monitors how trains are operated. Simultaneously, it will function to quickly restore normal train operation schedule, if a trouble should happen in the operation.

This system should desirably be introduced in the section: Karachi-Rawalpindi.

It is recommended to establish CTC centers at places where commands for train operation are to be made. Accordingly, the centers should desirably be located in Karachi, Sukkur, Multan, Lahore, and Rawalpindi (Fig. 2.4.7).

(4) Communication Networks

Transmission of information needed for railway operation and business can be used for a variety of media such as telephone, telex, facsimile, CTC information system, seat reservation information system, freight information system, etc. For transmitting information, it is necessry to improve communication networks.

If a trouble should happen in the information networks, and it might take a considerable long time before the trouble can be removed to restore the scheduled condition, it would cause a serious damage to the railway operation. Therefore, main routes should desirably be equipped with back-up systems. That is, one route should be prepared with a wireless system such as SHF system, and the other with a wired system with optical fiber cables. The following section should be improved with such an information network.

Karachi - Rawalpindi

2.4.1.6 Improvement of Fundamentals of Transport

(1) Track Renewal

Track renewal has intensively been executed under the 6th Five Year Plans in the past. The achievements, however, are only 470 km in the primary "A" sections, and 1,200 km in the primary "B" sections. In the secondary sections, a large number of rails and sleepers should necessarily be replaced. The track and rolling stock are two major factors of railway transport. Old facilities would limit the speed, lengthen the train hour and the turn-around time of locomotives and freight wagons, resulting in a lower transport efficiency and depressed line capacity. It is therefore necessary to solve such a problem as soon as possible.

The sections of tracks to be renewed by 2005/06 are shown in Table 2.4.4.

Table 2.4.4 Sections of Tracks to be Renewed by 2005/06

Primary "A" Section	LENGTH IN KM	
	RAIL	SLEEPER
Karachi - Tando Adam	103	103
Kiamari - Karachi City	-	8.07
Tando Adam - Khanpur	220	220
Khanpur - Sahiwal (cord & loop)	120	120
Sahiwal - Lalamusa	27	27
Moghalpura - Lahore Cantt	3.49	3.65
Total	473.49	481.72

Primary "B" Section	LENGTH IN KM	
	RAIL	SLEEPER
Rohri - Sibi (ROH-QTA)	59.83	147.46
Khanewal - Shorkot Cantt (KWL-WED)	-	46.66
Shar shah - Kundian (SSH-ATCY)	203.79	132.82
Chak Jumra - Shahinabad (CKJ-LLM)	138.40	143.70
Shorkot - Wazirabad (KWL-WZD)	246.61	259.45
Shahinabad - Sanglahill (KWL-WZD)	85.25	55.34
Lalamusa - Peshawar Cantt (KHI-PSc)	90.59	123.07
Lalamusa - Kundian (CKJ-LLM)	131.85	230.90
Shahinabad - Malakwal (CKJ-LLM)	92.51	16.66
Kundian - Attock City (SSH-ATCY)	165.97	88.24
Total	1214.8	1244.3

"Secondary" Section	LENGTH IN KM	
	RAIL	SLEEPER
Kotri - Dadu (KOT-HBKJ)	65.44	16.09
Habib Kot - Dadu (KOT-HBKJ)	116.83	84.51
Jacobabad-Kashmore (JCD-KZLC)	119.86	89.02
Lodhran - Pakpattan (LON-KUS)	101.30	90.36
Shorekot Cantt - Qila Shei - Khupura (SKO-QSP)	217.30	199.55
Pakpattan - Kasur (LON-KUS)	135.42	86.23
Sibi - Quetta (ROH-QTA)	162.40	62.02
Shorkot - Shahinabad (SKO-SHND)	80.70	77.75
Shadara - Narowal (SDR-NWL)	70.15	66.73
Total	1069.4	772.26

"Secondary" Section	LENGTH IN KM	
	RAIL	SLEEPER
Malik Colony - Malir Cantt	8.09	4.47
Karachi - Korangi	5.95	1.77
Hyderabad - Mirpur Khas	65.69	66.87
Karachi Circular Line	25.87	26.84
Sargodha - Khushab	45.58	35.22
Daudkhel - Mari Indus	9.71	7.71
Quetta - Chaman	191.60	189.11
Total	352.49	331.99

(2) Replacement and Acquisition of Rolling Stock

a) Locomotives

The necessary number of locomotives for passenger (N_{1p}) is estimated from the following equation:

$$N_{1p} = \frac{\text{Train·km for Passenger}}{\text{Engine·km}} \times \text{factor for ineffective allowance}$$

Similarlly, N_{1f} for freight is as follows:

$$N_{1f} = \frac{\text{Train·km for freight}}{\text{Engine·km}} \times \text{factor} + N_{1s}$$

Where, N_{1s} = The number of locomotives for shunting and department further details are shown in Appendix 3.

The number of locomotives to be acquired is estimated considering the future overage of the existing locomotives.

The results of calculations are shown in Table 2.4.5.

b) Wagons

The necessary number of wagons (Nw) in estimated from the following equation:

$$Nw = Nwb \times \frac{\text{Ton·km}}{\text{Ton·km}_b} \times \frac{\text{Turn around}}{\text{Turn around}_b} \times \text{factor of inspection \& repair}$$

Where, Nwb = The base number of wagons in the base year.

Further details are shown in Appendix 3. The number of wagons to be acquired is estimated considering the future overage of the existing wagons.

The results of calculations are shown in Table 2.4.5.

c) Carriages

The necessary number of carriages (Nc) is estimated from the following equation:

$$N_c = Ncb \times \frac{\text{Passenger·km}}{\text{Passenger·km}_b}$$

Where, Ncb = The base number of carriages in the base year including factor of inspection & repair.

Further details are shown in Appendix 3. The number of carriages to be acquired is estimated considering the future overage of the existing carriages.