社会開発協力部報告書

No. 7

REPORT

FOR

THE FEASIBILITY STUDY

ON

RAILWAY IMPROVEMENT PLAN OF TRANSPORT CAPACITY AND TRAIN SPEED ON THE DELHI-KANPUR SECTION

IN

INDIA

DECEMBER 1987

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

SDF
[redacted]
87-122(2/3)

REPORT FOR THE FEASIBILITY STUDY ON RAILWAY IMPROVEMENT PLAN OF TRANSPORT CAPACITY AND TRAIN SPEED ON THE DELHI-KANPUR SECTION IN INDIA
DECEMBER

107
74
SDF

REPORT

FOR

THE FEASIBILITY STUDY

ON

RAILWAY IMPROVEMENT PLAN OF TRANSPORT CAPACITY AND TRAIN SPEED ON THE DELHI-KANPUR SECTION

IN

INDIA

JICA LIBRARY
1041190[8]

DECEMBER 1987

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

国際協力事業団	
受入月日 '88. 2. 16	107
	74
登録No. 17176	SDF

PREFACE

In response to the request of the Government of India, the Government of Japan has decided to conduct a feasibility study on the upgrading project of the Delhi-Kanpur railway section and a pre-feasibility study on the construction project of a new high-speed railway corridor between Delhi and Kanpur via Agra, and entrusted the studies to the Japan International Cooperation Agency (JICA).

The JICA sent to India a study team, headed by Dr. Misao Sugawara, comprising experts from Japan Railway Technical Service, Tonichi Engineering Consultants, Inc., Yachiyo Engineering Co., LTD. and The Japan Electrical Consulting Co., LTD. four times in 1987, from February to March, June to July, September, and from October to November.

The team had a series of discussions on the Projects with the officials concerned of the Government of India including those of Railway Board and Northern Railways, and conducted field surveys.

After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Projects and contribute to promote friendly relations between our two countries.

I also wish to express my deep appreciation to all the officials concerned of the Government of India for their close cooperation extended to the team.

December, 1987

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

December, 1987

Mr. Keisuke Arita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

LETTER OF TRANSMITTAL

We have the pleasure of submitting herewith the final report for the Feasibility Study on Railway Improvement Plan of Transport Capacity and Train Speed on the Delhi-Kanpur Section of India.

The Study was conducted during the period from February 1987 to December 1987, including the field studies carried out four times in India, i.e. from February to March, from June to July, September, and from October to November.

The Study formulated the upgrading project of the Delhi-Kanpur section of the conventional trunk line, and high-speed railway construction project between Delhi and Kanpur via Agra, and analysed their techno-economical feasibility.

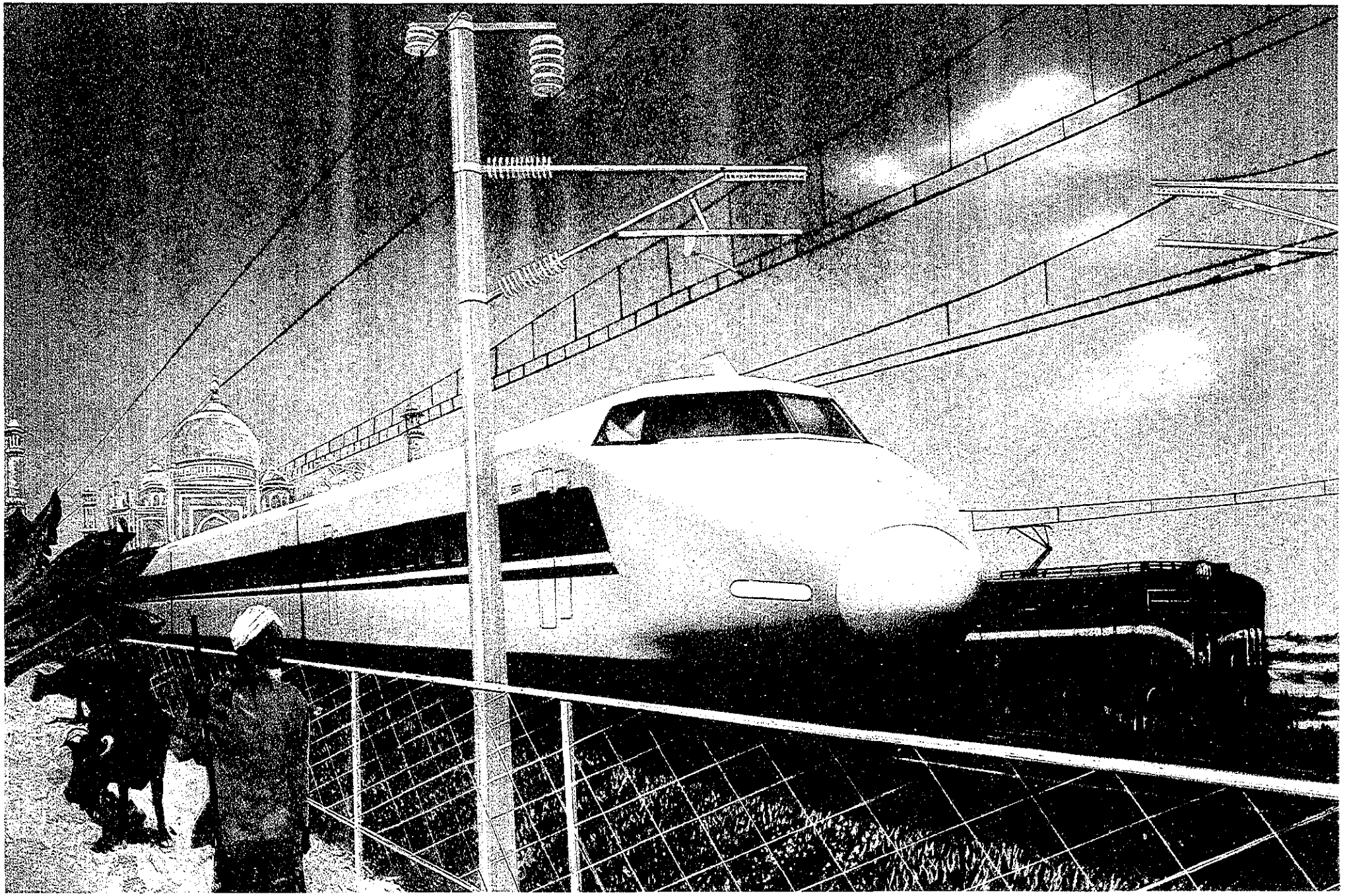
We hope that this Report will serve as a guide to the implementation of these projects, and accordingly, contribute to upgrade the nationwide railway networks which serves as an essential infrastructure for the socio-economic development of India.

We wish to express our sincere gratitude to the officials of your Agency, Advisory Committee, the Embassy of Japan in India, as well as to those concerned of the Government of India for the kind assistance and cooperation they extended to the Study Team.

Very truly yours,

Tatsuya Ishihara

Tatsuya Ishihara
President
Japan Railway Technical Service



CONTENTS

CONTENTS OF TABLES

CONTENTS OF FIGURES

Exchange Rate

1 Rs = ¥ 11.35

1 US$ = Rs 12.97

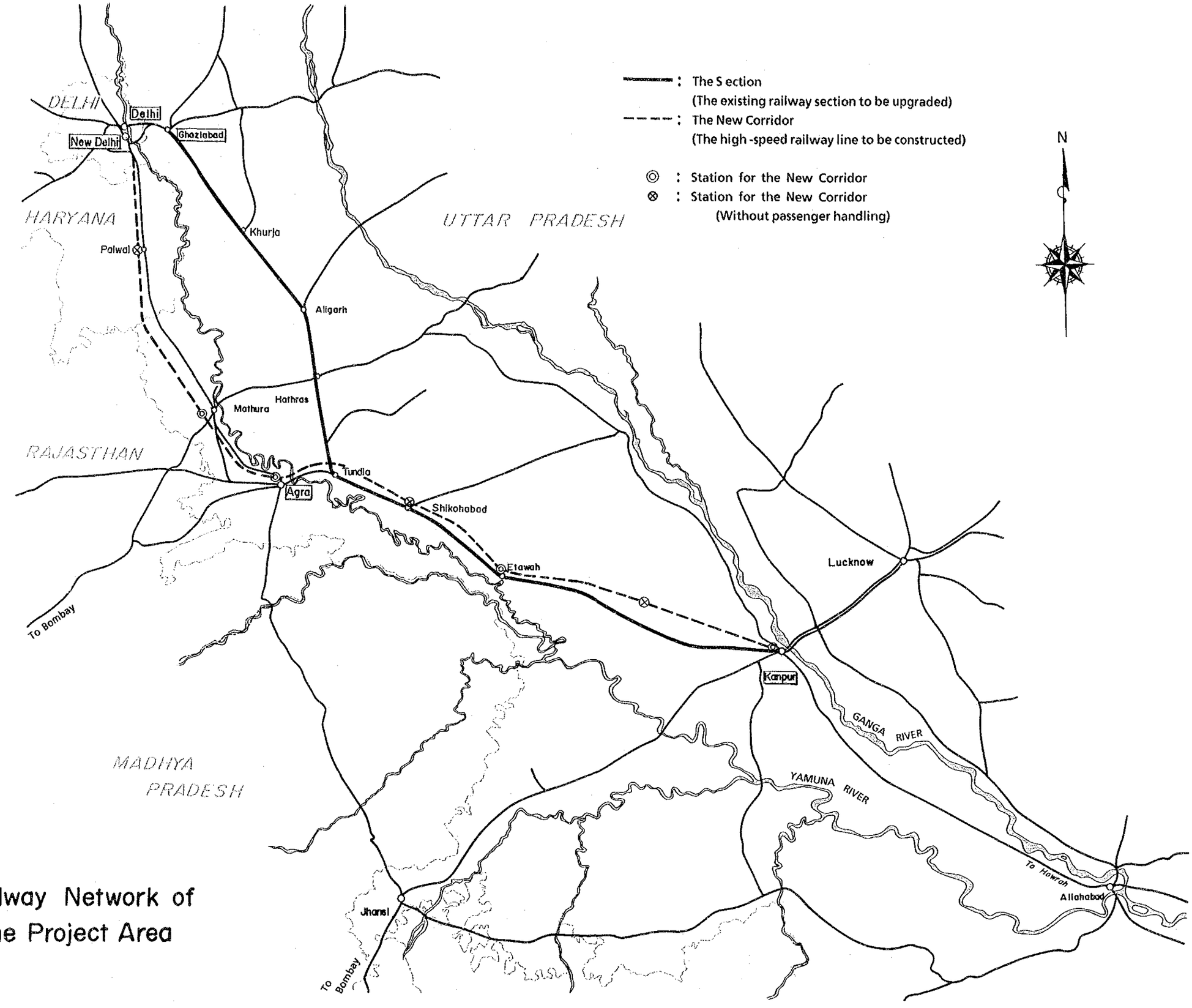
Abbreviation

A/C	Air Conditioned coach
A.F.	Audio Frequency
AT	Autotransformer
ATC	Automatic Train Control
AWS	Auxiliary Warning System
Bo-Bo	Rolling stock composed of two bogies equipped with two motors
Bo-Bo-Bo	Rolling stock composed of three bogies equipped with two motors
CB	Circuit Breaker
CC	Control Center
CIF	Cost Insurance and Freight
CSC	Centralized Substation Control
CTC	Centralized Traffic Control
Delhi U.T.	Delhi Union Territory
DN	Down line
EIRR	Economic Internal Rate of Return
EL	Electric Locomotive
EMU	Electric Multiple Unit
Exp./Mail	Express and Mail passenger train
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GTO	Gate Turn Off
IR	Indian Railways
JICA	Japan International Cooperation Agency
JR	Japan Railways

L. Exp.	Long Distance Express passenger train
LF	Low Frequency
Local	Local passenger train
OHE	Overhead Equipment
PRC (P.S.C)	Prestressed Concrete
RCC	Remote Control Center
S. Exp.	Super Express train
SP	Sectioning Post
SS	Substation
SSP	Subsectioning Post
TCR	Thyristor Control Reactor
The Section	The existing railway section between Ghaziabad and Kanpur.
The New Corridor	New high-speed railway corridor to be constructed between New Delhi and Kanpur via Agra
TTM	Tie Tamping Machine
UP	Up line
U.P.	State of Uttar Pradesh
V.V.V.F	Variable Voltage Variable Frequency
6M10T	Six motored car and ten trolley car train formation

Station Code List

Code	Station	Code	Station	Code	Station
DLI	Delhi	HNG	Hirangaon		(NDLS - AGC)
NDLS	New Delhi	FZD	Firozabad	NZM	Hazrat Nizamuddin
DLSB	Delhi Sadar Bazar	MNR	Makkhanpur	AGC	Agra Cant
VVB	Viveka Vihar Halt	SKB	Shikohabad	AGA	Agra City
TKJ	Tilak Bridge	KAA	Kaurara	MTJ	Mathura
ANVR	Anand Vihar	BDN	Bhadan	TKD	Tuglakabad
SBBB	Sahibabad	BBL	Balrai	PWL	Palwal
GZB	Ghaziabad	JGR	Jaswant Nagar		
C. Buzurg	Chipayana Buzurg	SB	Sarai Bhupat	HWH	Howrah
MIU	Maripat	ETW	Etawah	SDAH	Sealdah
DER	Dadri	EKL	Ekdil	BCT	Bombay Central
AJR	Ajaibpur	BNT	Bharthana	MAS	Madras Central
DKDE	Dankaur	SHW	Samhon	SDAH	Sealdah
WAIR	Wair	ULD	Achalda	HWH	Howrah
CHL	Chola	PTX	Pata	CABP	Calcutta (Amrit
SKQ	Sikandarpur	PHD	Phaphund		Bazar Patrika)
KRJ	Khurja	KNS	Kanchausi	ALD	Allahabado JN
DAR	Danwar	JJK	Jhinjhak	LKO	Lucknow
SOM	Somna	AAP	Ambiapur		
KLA	Kalwa	RRH	Rura	FTH	Fatuhi
MWUE	Mahrawal	RMW	Roshan Mau Halt	HRF	Harhras Qilah
ALJN	Aligarh	MTO	Maitha	ROK	Rohtak
DAQ	Daud Khan	BPU	Bhaupur	KTT	Kota
MXK	Mandrak	PNK	Panki	JAT	Jammu Tawi
SNS	Sasni	GOY	Govindpuri	ASR	Amritsar
HRS	Hathras	GMC	Juhi M. Yard	KLK	Kalka
PORA	Pora	CNB	Kanpur Central	FKD	Farrukhabad
JLS			Jalesar Road		Unchahar JN UCR
CMR	Chamorola			BSB	Varanasi JN
BRN	Barhan			JNM	Jaynagar Majlipur
MTI	Mitawali			KIUL	Kiul JN
TDL	Tundla			GHY	Gauhati
				SBG	Sahibganj



Railway Network of the Project Area

CHAPTER 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

1-1 Background of the Study

The Indian Railways, with the longest route length (61,850 km) in Asia, serves as the principal mode of inland transport in the country.

Since 1950, the Indian Railways has endeavoured to develop their railway infrastructure through successive five year plans, and consequently, during 1984-85 they attained the gigantic transport volume of 226,580 million passenger kilometers and 168,850 million ton kilometers.

Meanwhile, in the 7th Five Year Plan the Government of India has adopted the policy to accelerate the upgrading of its railway services by introduction of new technologies to meet the sharp increase in traffic demand envisaged to double within the next fifteen years. In line with the above policy, the Government has set out to upgrade the transport capability between Delhi - Kanpur (430 km) railway section, which forms bottleneck of the Delhi - Howrah (Calcutta) trunk line.

As a basic strategy to achieve this goal, the following two-staged improvement procedure is considered most pragmatic from techno-economical viewpoint; i.e. to enlarge the already fully occupied transport capacity of the conventional section in coordination with related improvements planned in the 7th Five Year Plan, and then to construct a new high-speed corridor line to cope with the further traffic demand increase envisaged from a long-range viewpoint. The major target of the former project is to increase transport capacity, improving the maximum passenger train speed to 160 km/h. That of the latter project is to provide high speed railway passenger service with the maximum speeds of 200/250 km/h, diverting the passenger traffic from the existing Section to the new Corridor.

In February, 1987, the Study Team of Japan International Cooperation Agency (hereinafter referred to as JICA) commenced studies for these two projects in accordance with the Scope of Work for "the Study on Railway Improvement Plan of Transport Capacity and Train Speed on the Delhi - Kanpur Section" agreed between the Government of India and JICA in October 1986.

1-2 Objective of the Study

(1) To conduct a feasibility study on the techno-economic aspects of the project for upgrading the ground facilities and rolling stock of the existing Delhi - Kanpur section of Indian Railways (hereinafter referred to as "the Section") for attainment of higher transport capacity and the maximum passenger train speed of 160 km/h.

(2) To conduct a pre-feasibility study on the basic techno-economic aspects and rough cost of construction and operation of the Delhi - Agra - Kanpur High Speed Railway Corridor (hereinafter referred to as "the New Corridor"), at the maximum train speeds of 200 km/h and 250 km/h.

1-3 Study Schedule

As a preliminary stage of the study, in the Interim Report I, the general guideline for implementing above two projects was set as follows:

- The Section will be upgraded in 1991 in terms of transport capacity and train speed (max. 160 km/h)
- The New Corridor connecting Delhi and Kanpur via Agra will be constructed around in 2000. The maximum train speed of the Super Exp. train will be 250 km/h and its fare will be higher than that of the existing 2nd class Mail/Exp. train to some extent.

In line with the above guideline, the feasibility study on the upgrading the Section and pre-feability study on the New Corridor were commenced as follows.

(1) Phase 1: Preparatory work in Japan

(2) Phase 2: Work in India (1)

a) Presentation of the Inception Report

b) Investigation on socio-economic framework and related development plans

c) Survey on traffic conditions of rail and other transport modes

d) Investigation on the existing railway assets

e) Conducting route selection survey for the Corridor

(3) Phase 3: Work in Japan (1)

a) Integrated analysis of the data/information obtained in India

b) Formulation of socio-economic framework

c) Establishing guide line for the improvement plan

d) Preparing basic transportation plan

e) Preparating basic standards/specifications of the railway assets

f) Preparation of the Interim I Report

(4) Phase 4: Work in India (2)

a) Presentation/discussion on the Interim I Report

b) Supplemental field investigation

(5) Phase 5: Work in Japan (2)

a) Study on traffic demand forecast

b) Preparation of train operation plan

c) Preparation of preliminary design and improvement plan of upgrading the Section

d) Preparation of a conceptual design and construction plan of the Corridor

e) Study on maintenance and management

f) Preparation of the Interim II Report

(6) Phase 6: Work in India (3)

Presentation/discussion on the Interim II Report

(7) Phase 7: Work in Japan (3)

a) Estimation of investment/operating costs

b) Economic and financial analysis

c) Preparation of an implementation plan

d) Overall evaluation of the Projects

e) Preparation of the Draft Final Report

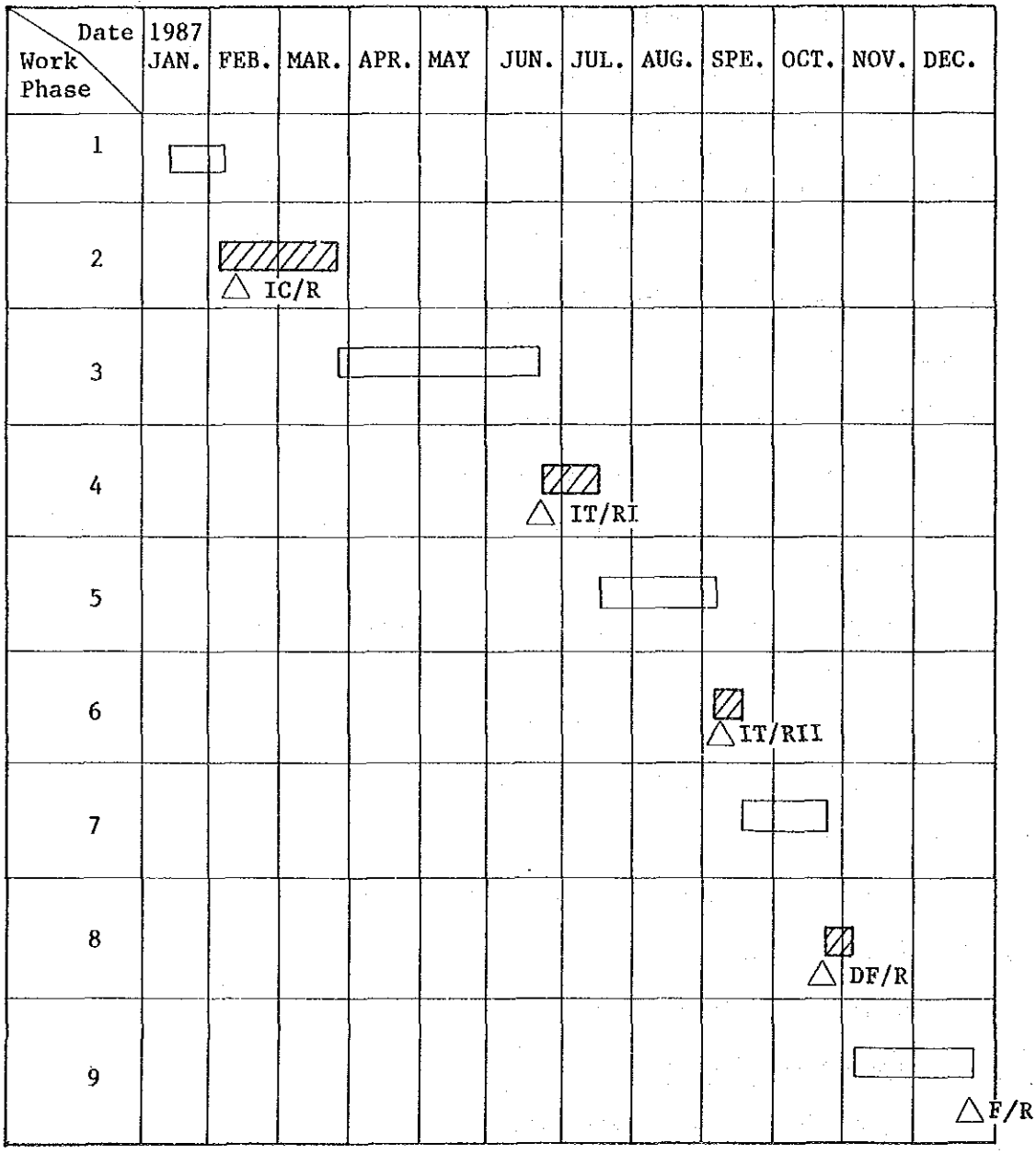
(8) Phase 8: Work in India

Presentation/discussion on the Draft Final Report

(9) Phase 9: Final work in Japan

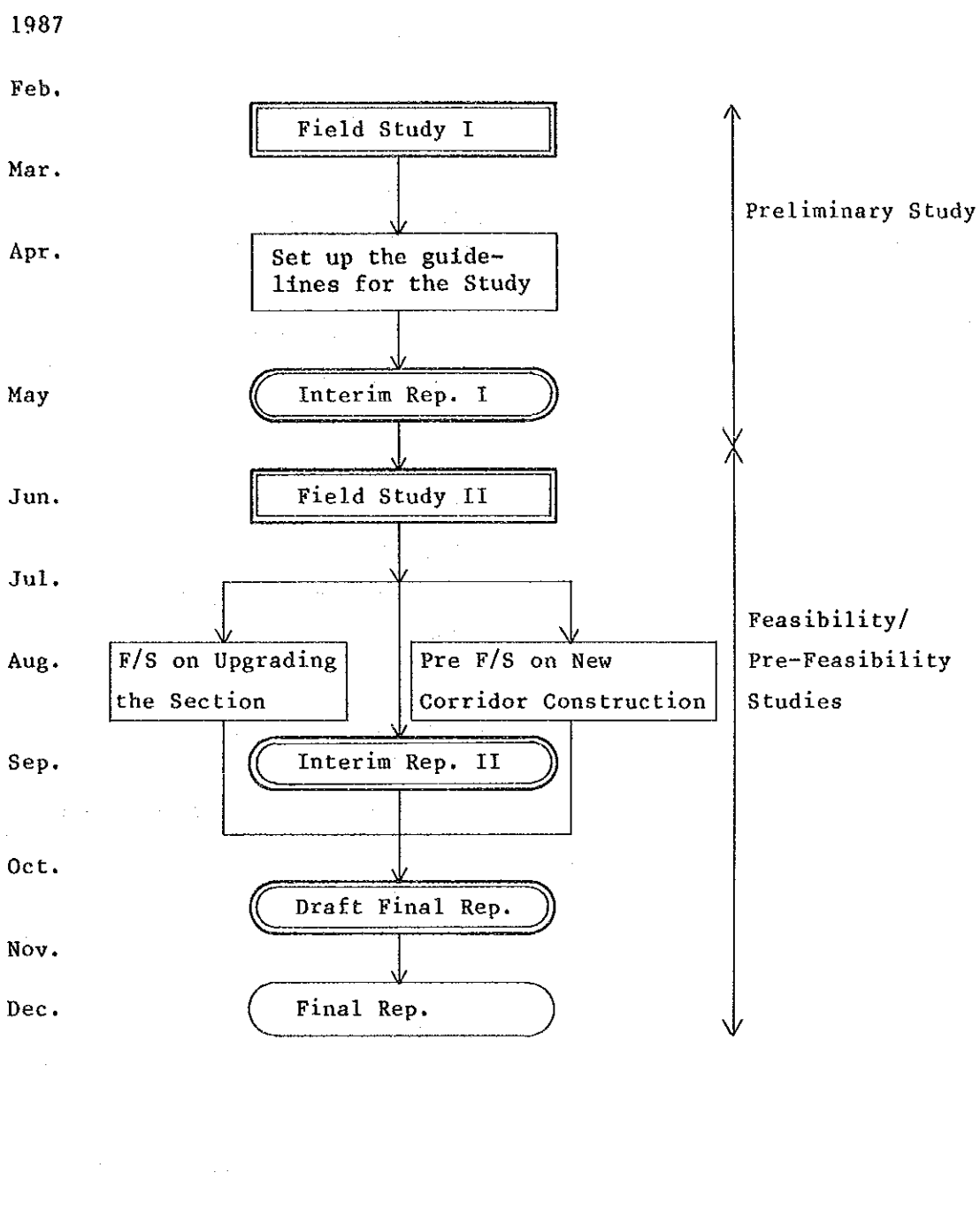
Preparing and submitting the Final Report

The study schedule and general flow of the study are outlined in Fig. 1.3-1 and Fig. 1.3-2.



△ : Submission of Report
IC/R : Inception Report
IT/RI : Interim Report I
IT/RII: Interim Report II
DF/R : Draft Final Report
F/R : Final Report

Fig. 1.3-1 Study Schedule



Legend
: Study in India
: Study in Japan
: Presentation of Report in India
: Submission of Report

Fig. 1.3-2 General Flow of the Study

1-4 Organization for the Study

1-4-1 Advisory Committee

Kiyoshi Terashima Chairman	Deputy Director-General, Secretariat to the Minister, Ministry of Transport
Shunya Shiozaki Member	Chief, Railway Facilities Division, Land Transport Engineering Department, Regional Trnsport Bureau, Ministry of Transport
Tadami Kitano Member	Assistant Director, Railway Facilities Division, Land Transport Engineering Department, Regional Transport Bureau, Ministry of Transport
Hiroshi Saito Member	Senior Research Staff, International Cooperation Division, International Transport and Turism Bureau, Ministry of Transport

1-4-2 Coordinater of JICA

Kenichi Kojima	First Development Survey Division, Social Development Cooperation Department, JICA
Toshiichi Minatani	First Development Survey Division, Social Development Cooperation Department, JICA

1-4-3 Study Team

Misoa Sugawara	Team Leader
Akira Yamaguchi	Acting Leader
Masayoshi Iwasaki	Related Development Plan
Hirotoshi Yamakawa	Traffic Demand Forecast
Makio Kasai	Transport Plan
Hisashi Sato	Construction Plan
Kiyoshi Tomura	Station Yard Plan
Eijiro Tamura	Raiway Track Plan
Hiroshi Inui	Track and Station Yard Design
Kiichi Takemura	Signalling and Telecommunication Plan
Hiroto Yasuhara	Signalling and Telecommunication Design
Yukio Chikada	Electrification Plan
Azusa Miura	Electrification Design
Susumu Shibuya	Rolling Stock Improvement Plan
Tatsuji Nakamura	High Speed Rolling Stock Plan
Nobuyoshi Ohno	Cost Estimate and Implementation Plan
Takuo Nishikawa	Economic and Financial Analysis

1-4-4 Indian Counterparts

Railway Board

R.M. Raina	Executive Director Planning
J.S. Mundrey	Executive Director (Civil Engg.)
K.R. Vij	Executive Director (Elect. Engg.)
V. Ramasamy	Executive Director (S&T)
O.P. Jain	Executive Director (S&T)
K.N. Jain	Executive Director (S&T, rule)

C.L. Kaw	Executive Director Planning (P.C.)
M.K. Rao	Executive Director (Mech. Engg.)
Ashok Kumar	Executive Director (Civil Engg.) (P)
C.M. Khosla	Executive Director (T.T.)
Mrs. Mridula Krishna	Economic Advisor
A.K. Biswas	Joint Director (PP) (Civil Engg.)
Harbans Lal	Joint Director (PP) (S&T)
A.K. Goyal	Joint Director (PP) (Transport)
Pramod Kumar	Joint Director (PP) (Mec. Engg.)

Northern Railway

R.C. Sethi	Chief Planning Officer
Vinod Sharma	Deputy General Manager
P.K. Goyal	Deputy General Manager
Vijay Kumar	Chief Marketing Superintendent
S.D. Chand	Chief Marketing Superintendent
Y.M. Garg	Chief Passenger Traffic Superintendent
R.S. Soin	Chief Engineer (E)
S.N. Kashyap	Chief Engineer (N)
Arvind Kumar	Chief Engineer (C)
Chandrika Prasad	Chief Signal and Telecommunication Engineer
V.P. Chandan	Chief Signal Planning Engineer
R.K. Srivastava	Chief Electrical Distribution Engineer
H.P. Mital	Chief Rolling Stock Engineer
A.K. Prasad	Senior Account Officer (F)

1-4-5 Related Organizations

Ministry of Finance

S. Krishna Kumar	Joint Secretary, Department of Economic Affairs
G.M. Pillai	Deputy Secretary, Department of Economic Affairs
S. Joshi	Under Secretary, Department of Economic Affairs

Transport Planning Commission

K.L. Thapar	Advisor

CHAPTER 2 GUIDELINES FOR THE STUDY

CHAPTER 2 GUIDELINES FOR THE STUDY

2-1 Establishing the Alternative Plans

As a preliminary step of the Study, the guidelines for the Study were established by selecting the optimum implementation strategies of the two projects among nine alternatives - in terms of railway section/ route, train speed, fare structure and implementation year - by estimating the generalized cost difference between 'With' and 'Without' the project cases.

Alternatives compared are as follows:

1) Case I (Alternative I)

   The Section is upgraded both in terms of transport capacity and travelling time. The maximum train speed is improved up to 160 km/h.

2) Case II (Alternative II-1, II-2, II-3, II-4)

   In addition to upgrading the Section, the New Corridor is constructed from Delhi upto Agra.

   (Existing link between Agra and Tundla is upgraded)

   In Case II, four alternative plans are set up, taking into account the combined conditions of the maximum train speed (200 km/h or 250 km/h) and passenger fare level of the New Corridor (higher fare level by 25% or 50% than that of 2nd class Exp./Mail train of the Section).

3) Case III (Alternative III-1, III-2, III-3, III-4)

   In addition to upgrading the Section, entire length of the New Corridor connecting Delhi and Kanpur via Agra is constructed.

   In case III, four alternative plans are set up for the similar conditions mentioned in Case II.

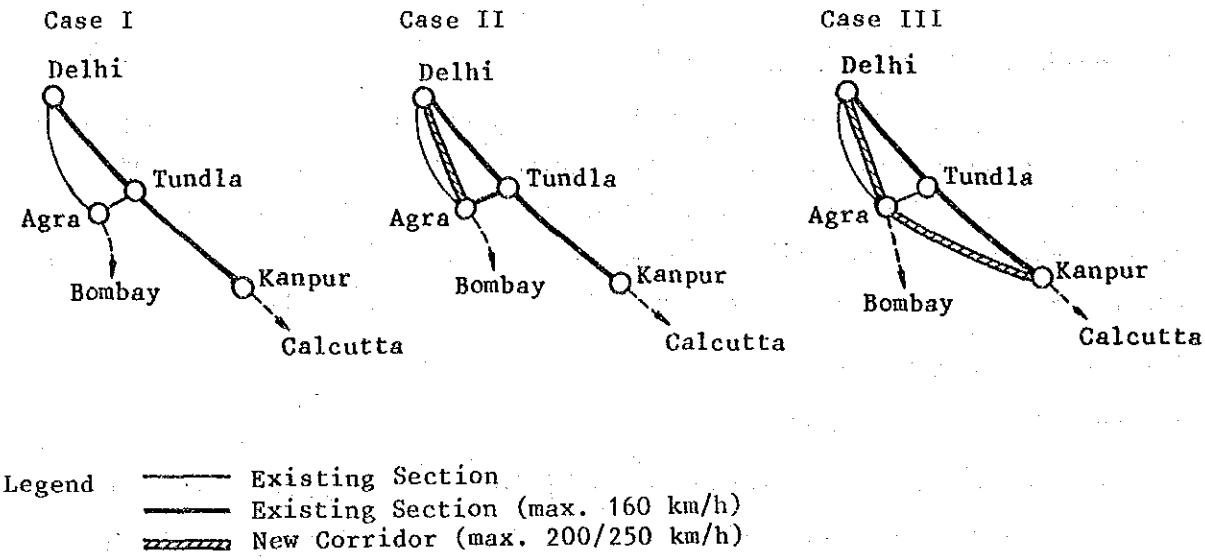


Fig. 2.1-1 Alternative Plans

2-2 Principle of Selection

The transport volume diverted from road and air to rail are calculated for each alternative plan by each sample year. And cost difference in the Generalized Cost (ΔE) between each alternative plan and without the project case are calculated based on the diverted transport volume.

Difference of the Generalized Cost (ΔE) is given by the following formula.

$$\Delta E = W\Delta T + \Delta C$$

where: W : Passenger time value

ΔT: Passenger time saving due to implementing the alternative plan

ΔC: Total cost saving (capital cost and operation cost) due to implementing the alternative plan

2-3 Calculation Result

Table 2.3-1 shows various indices in percentage figures, against those for upgrading-the-Section case (Case I).

Table 2.3-1 Comparison of the Generalized Cost Difference (△E)

Case	Alternative Plan \ Year / Benefit	1990 Time saving	1990 Cost saving	1990 Total ΔE	1995 Time saving	1995 Cost saving	1995 Total ΔE	2000 Time saving	2000 Cost saving	2000 Total ΔE	2015 Time saving	2015 Cost saving	2015 Total ΔE
I	Upgrading the existing Section	8	92	[100]	9	91	100	10	90	100	14	86	100
II	II-1 New Corridor DLI-AG 200 km/h 25% up	12	64	76	13	79	92	14	84	98	20	80	100
	II-2 New Corridor DLI-AG 200 km/h 50% up	11	66	77	12	81	93	14	85	99	19	81	100
	II-3 New Corridor DLI-AG 250 km/h25% up	13	61	74	15	78	93	16	83	99	22	80	102
	II-4 New Corridor DLI-AG 250 km/h 50% up	11	63	74	13	79	92	14	84	98	20	80	100
III	III-1 New Corridor DLI-CNB 200 km/h 50% up	38	37	75	26	68	94	26	78	104	59	80	139
	III-2 New Corridor DLI-CNB 200 km/h 50% up	20	38	58	20	70	90	21	78	99	44	78	122
	III-3 New Corridor DLI-CNB 250 km/h 25% up	41	32	73	34	71	[105]	35	79	[114]	69	78	[147]
	III-4 New Corridor DLI-CNB 250 km/h 50% up	26	34	60	24	67	91	25	78	103	55	77	132

Note: Total ΔE of Case I for each sample year is set at 100

Conditions and methods for the calculation are mentioned in the Appendix 9-1.

Comparing the alternative plans for each sample years, ΔE of the III case is greater than that of the II case after 2000.

In the III case, in the plan of maximum speed 250 km/h and fares up of 25%, ΔE becomes the maximum due to increased time saving benefit attributed to the largest transferred traffic volume.

The effect of high speed operation is most significant in the plan where the entire New Corridor is constructed and it also becomes greater for later years. This is due to an increase in the total transport volume and growth of time value.

2-4 General Guidelins for the Study

As a study result, the general guideline is set up as follows:

1) The Section will be upgraded in 1991 in terms of transport capacity and train speed (max. 160 km/h)

2) The New Corridor connecting Delhi and Kanpur via Agra will be constructed around in 2000. The maximum train speed of the Super Exp. train will be 250 km/h and its fare will be higher than that of the existing Mail/Exp. train to some extent.

In compliance with the abovementioned general guidelines, related policies, conditions and conceptual system designs attained in the preliminary study, the Team commenced the following studies.

a. F/S on Upgrading the Section

To prepare an upgrading plan of the transport capacity and train speed on the Section between Delhi and Kanpur to meet the envisaged railway traffic increase after 1991 up to the year of 2000, and evaluate its techno-economic feasibility.

b. Pre-F/S on construction plan of the New High-speed Corridor

To prepare an construction plan of the New Corridor to cope with the forecasted railway traffic increase after the year of 2000, and broadly evaluate its techno-economic feasibility.

CHAPTER 3 SOCIO-ECONOMIC FRAMEWORK AND DEMAND FORECAST

CHAPTER 3 SOCIO-ECONOMIC FRAMEWORK AND DEMAND FORECAST

3-1 Socio-economic Framework

3-1-1 Policy of Framework Estimation

The socio-economic frameworks are roughly set to the following four areas:

- Directly affected areas (Inner zone)

1. Delhi Union Territory
2. Districts of the State of Uttar Pradesh which are directly related to this study.

- Outer zone

1. Districts within the State of Uttar Pradesh excluding those mentioned above.
2. Other regions in the country

Target years of the framework estimation are the year 1985, 1990, 1995, 2000 and 2015.

Each area mentioned above has its own seventh five-year plan. In estimating socio-economic indicators during this five-year plan period (1985 - 1990) in each area, estimated values of each plan are adopted in principle.

As for estimation beyond this planned period (that is, estimation for years 1995, 2000 and 2015), the values of the Delhi Union Territory's master plan, Registrar General's estimation of future population, etc., are used. Where no estimated values is available, an self-estimation by the study team is carried out.

Fig. 3.1.1-1 shows its basic policy.

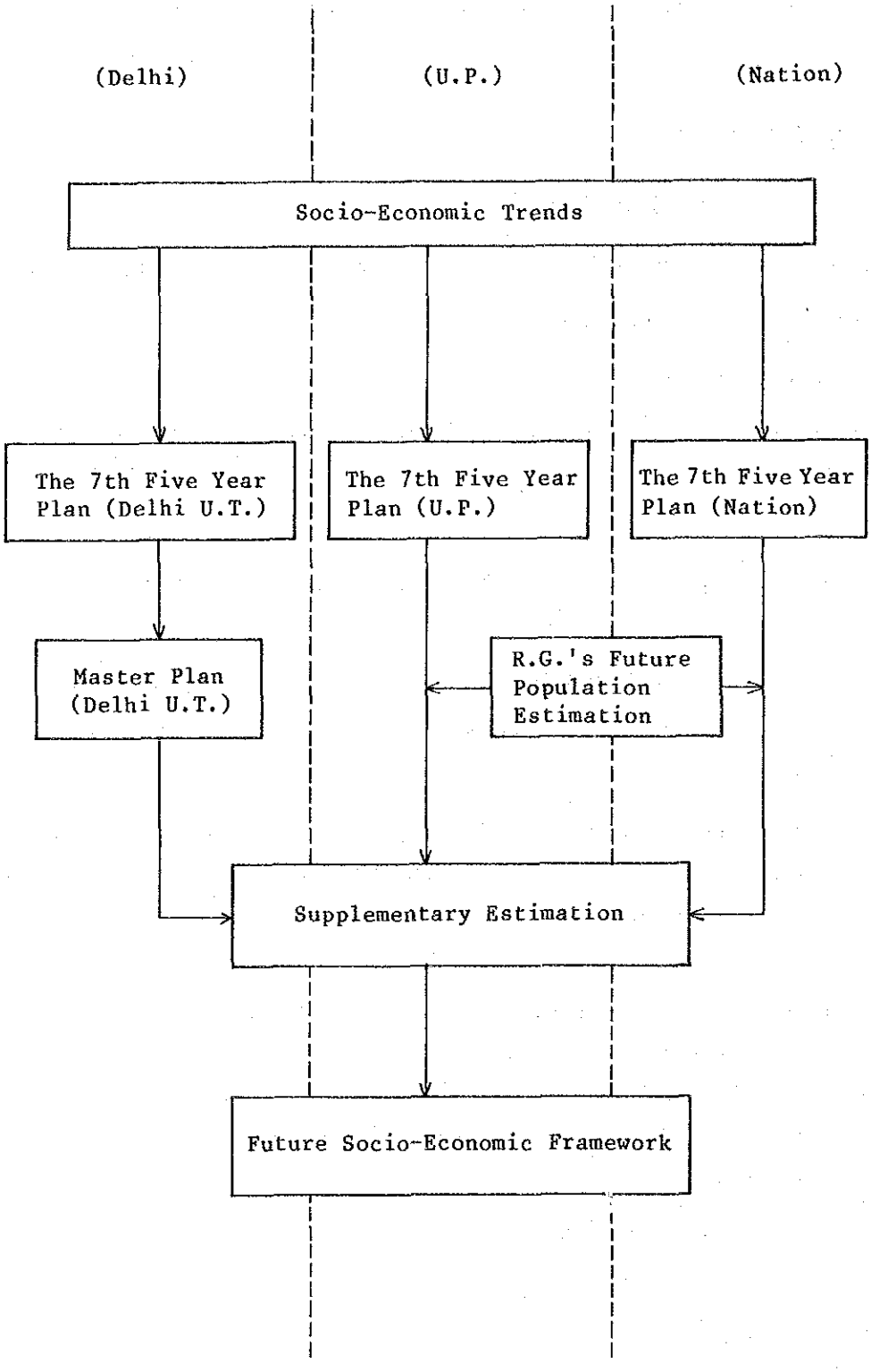


Fig. 3.1.1-1 Basic Policy of Future Socio-Economic Framework Estimation

3-1-2 Socio-economic Situations

(1) Economic trends

1) Nationwide

Since the country's independence in 1947, six five-year plans have been carried out nationwide (Refer to Table 3.1.2-1).

Due to the policy to promote heavy industries adopted in the second five-year plan, weight of the secondary industry in the net domestic product increased gradually, while the primary industry became relatively less important.

However, after reaching its peak in the latter half of the '70s the secondary industry's contribution rate to the net domestic product is becoming somewhat stagnant. On the other hand, the tertiary industry is growing so remarkably that its share in 1984/85 has reached 40%, exceeding the primary industry's share (39%). (Refer to Fig. 3.1.2-1)

As for the economy in general, irrigation systems are repleted and fertilizers and superior species of plants were introduced as part of the "Green Revolution" which began in 1976. These improvements resulted in establishment of an agricultural structure resistant to bad weather such as droughts, allowing for stable economic growth of greater than 5% ever since.

The gross domestic product of India in 1984/85 was 61,473 RS. CRORES (at 1970/71 prices) and in its industrial structure, in terms of net domestic product, the primary industry has a share of 39% (36.6% of which is agriculture), the secondary industry has 21.0% (15.0% of which is manufacturing), and the tertiary 40.0%. In the fast-growing tertiary industry, the growth of the administrative service sector and financial/insurance service sectors are especially remarkable. (The annual growth rate of the former sector accounts for 12.4% as an average over the four years from 1980/81 to 1984/85, while that of the latter is 10.4%.) (Refer to Table 3.1.2-2)

Table 3.1.2-1 Targets and Results of Past Five-year Plans

Five-year plan	Period	Target	Economic growth rate	
			Target(%)	Result(%)
1st	51/56	Control of confusion after the separation of India and Pakistan, control of inflation after the war	2.1	3.4
2nd	56/61	A socialist society is aimed at; stress is placed on the development of heavy chemical industry.	4.5	4.0
3rd	61/66	Following the policy of the 2nd Five Year Plan, stress is placed on machinery, chemical industry, etc.	5.0	2.6
4th	69/74	A socialist society is aimed at; emphasis is on the stabilization of the economy.	5.5	3.4
5th	74/79	Establishment of a self-reliant economy; improvement of living standards for people below poverty line	4.4	5.2
6th	80/85	Relief for the poor; widening of job opportunities	5.2	5.2
7th	85/90	Widening of job opportunities; increase in food production; improvement of productivity	5.0	-

Source: Basic Knowledge on India, edited by the Japanese Embassy in India

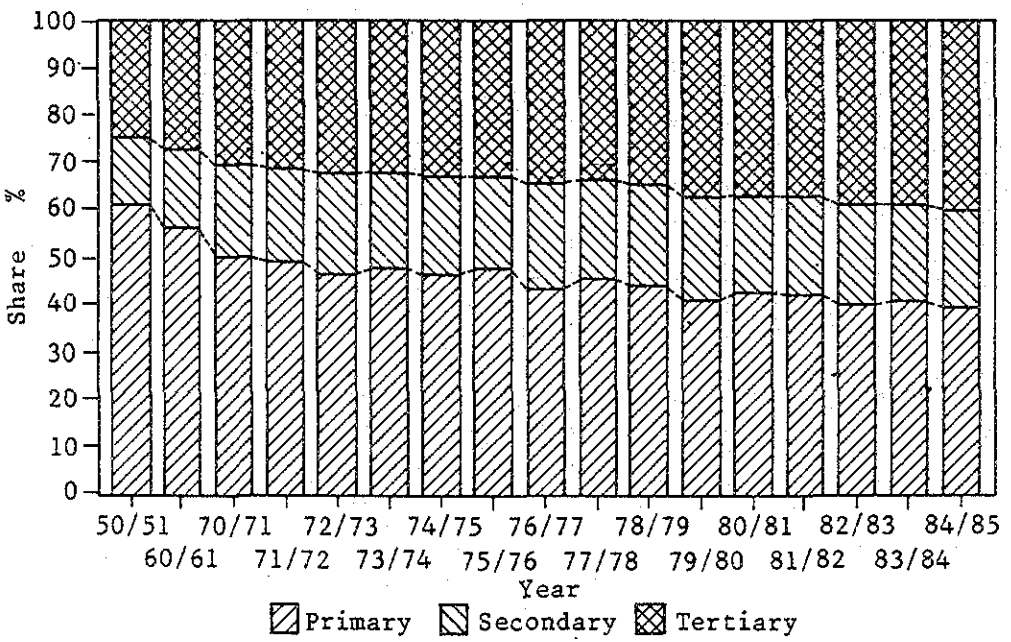


Fig. 3.1.2-1 Share of Net Domestic Product

Table 3.1.2-2 National Domestic Product (Composition)

(Unit: RS.Crores at 70/71 prices)

Industry/Year	60/61		70/71		80/81		84/85	
Primary industry	13,797	56.6%	17,307	50.1%	20,226	42.7%	22,327	39.0%
Agriculture	13,143	54.0%	16,354	47.4%	19,107	40.3%	20,962	36.6%
Forestry & logging	266	1.1%	397	1.2%	326	0.7%	260	0.5%
Fishing	166	0.7%	229	0.7%	302	0.6%	395	0.7%
Mining & quarrying	222	0.9%	327	0.9%	491	1.0%	710	1.2%
Secondary	4,138	17.0%	6,790	19.7%	9,989	21.1%	12,007	21.0%
Manufacturing	2,918	12.0%	4,619	13.4%	7,028	14.8%	8,616	15.0%
Construction	1,110	4.6%	1,853	5.4%	2,314	4.9%	2,507	4.4%
Electricity, gas & water	110	0.5%	318	0.9%	647	1.4%	884	1.5%
Tertiary industry	6,425	26.4%	10,422	30.2%	17,204	36.3%	22,952	40.1%
Transport & communication	936	3.8%	1,574	4.6%	2,856	6.0%	3,709	6.5%
Trade, hotel & restaurants	2,361	9.7%	3,880	11.2%	5,880	12.4%	7,286	12.7%
Banking & insurance	328	1.3%	644	1.9%	1,256	2.6%	1,867	3.3%
Real estate & bus services	597	2.5%	1,039	3.0%	1,534	3.2%	1,817	3.2%
Public administration	769	3.2%	1,635	4.7%	3,496	7.4%	5,576	9.7%
Other services	1,434	5.9%	1,650	4.8%	2,182	4.6%	2,697	4.7%
Total: Net domestic product	24,360	100.0%	34,519	100.0%	47,419	100.0%	57,286	100.0%
Consumption of fixed capital	1,174		2,217		3,317		4,187	
Total: Gross domestic product	25,534		36,736		50,736		61,473	

Source: Basic economic information, 1986

On the other hand, even in the secondary industries which are somewhat stagnant as a whole, shares of the manufacturing sector and the utility sector for electricity, water, etc. are increasing. The latest Economic Survey Report (1986/87) reveals that the growth of the manufacturing sector's production index through new series (1980/81 base) is basically recovering, accounting for 8.0% in 1984/85 and 9.7% in 1985/86.

However, taking a general view of the trends of the Indian economy's industrial structure at present, the general tendency moving towards the service industry is noticed.

The average growth rate of the net national product per capita, which represents the nation's average income level, attained about 2.5% a year in the 1980's. Considering that it was about 0.5% a year in the 1970's, it can be said that the national income level has undoubtedly improved in recent years. As a matter of fact, the substantial growth has been made in the past ten years, that is from 617 RS in 1974/75 to 772 RS in 1984/85 (at 1970/71 prices), thus representing an increase of about 25% (2.3% per year).

However, expenditures per capita, which directly reflect the nation's quality of life, stayed at an annual growth average of only 1.9% during the 1980's, and considering a steady increase in income, the standard of living has not improved as much.

2) Delhi Union Territory

The gross regional domestic product of Delhi Union Territory (hereinafter called Delhi), the capital of India and the economic center of the northern states, is estimated at 1,004 RS. CRORES (at 1970/71 prices) in 1983/84, which corresponds to 1.8% of India's net domestic product.

Table 3.1.2-3 Trends in per Capita Income and Expenditure (At 1970-71 prices)

Year	Per Capita			
	Income		Expenditure	
	Rupees	Index (1970-71=100)	Rupees	Index (1970-71=100)
1950-51	466	73.6	410	74.3
1960-61	559	88.3	488	88.6
1970-71	633	100.0	552	100.0
1971-72	627	99.1	554	100.5
1972-73	603	95.3	531	96.3
1973-74	621	98.1	533	96.7
1974-75	617	97.5	526	95.4
1975-76	664	104.9	534	100.4
1976-77	652	103.0	537	97.4
1977-78	695	109.8	580	105.2
1978-79	717	113.3	594	107.7
1979-80	664	104.9	552	100.1
1980-81	700	110.6	603	109.3
1981-82	715	113.0	601	109.0
1982-83P	721	113.9	605	109.5
1983-84P	761	120.2	651	117.9
1984-85Q	772	121.9	650	117.7

Source: National accounts statistics, 1985;
Quick estimates, 1986

Note: P: Provisional
Q: Quick estimates

The growth rate of Delhi's gross regional domestic product (in real terms) in the past ten years (1973/74 - 1983/84) was 6.3% a year, which proves that Delhi is one of the regions enjoying the highest growth rate in the country. As for its national share in the net domestic product, while it was only 1.4% in 1970/71, it also has increased steadily during the 1970's and has remained at 1.8% since 1980.

Delhi's economy is characterized by its industrial structure depending entirely on tertiary industries whose net regional domestic product accounts for as much as 75.6% of the total of all the industries in fiscal 1983/84. In the breakdown of this share, the administrative service sector (22.9%), the transportation sector (14.1%) as well as financial and insurance service sector (9.1%) account for a high percentage as compared with the national average.

The secondary industries account for 20.8% of the total labor force in the year 1983/84, showing the same ratio as its national share. However, setting up large-scale industries which may cause environmental pollution is regulated by ordinance, and of late, Delhi has rapidly changed to one of the country's biggest commercial centers of small-sized and handicraft industries.

In the year 1983/84, Delhi's gross domestic product per capita was 3,928RS/person (1,448 RS/person at 1970/71 prices), which corresponds to the country's second highest level after the state of Punjab (1,524 RS). However, though its gross domestic product has shown a growth rate of 6.3% per year during the last ten years, an increase of real income is offset by the sharp increase in the urban population, and Delhi's real income shows therefore a growth rate of only 1.9% a year which is nearly equivalent to the national average. (See Table 3.1.2-4)

Table 3.1.2-4 Net State Domestic Product (U.T. of Delhi)

(Unit: RS. LAKHS at 1970/71 prices)

Ind. Sector/Year	1970/71		1971/72		1972/73		1973/74		1974/75		1975/76		1976/77	
I. Primary industry	3321	6.96%	3472	6.77%	3358	6.37%	3058	5.60%	3555	6.24%	3299	5.27%	3507	5.20%
1. Agriculture	3250	6.81%	3349	6.53%	3274	6.22%	2934	5.37%	3469	6.09%	3220	5.15%	3399	5.04%
2. Forestry & fishing	7	0.01%	8	0.02%	8	0.02%	8	0.01%	11	0.02%	13	0.02%	15	0.02%
3. Mining & quarrying	64	0.13%	115	0.22%	76	0.14%	116	0.21%	75	0.13%	66	0.11%	93	0.14%
II. Secondary industry	12264	25.70%	12718	24.78%	12949	24.58%	12815	23.47%	13230	23.23%	14339	22.92%	14873	22.06%
4. Manufacturing	8588	17.99%	9032	17.60%	9326	17.70%	9231	16.91%	9478	16.64%	10284	16.44%	10776	15.98%
4.1 Registered	4069	8.53%	4311	8.40%	4391	8.34%	4076	7.47%	4090	7.18%	4654	7.44%	4892	7.26%
4.2 Unregistered	4519	9.47%	4721	9.20%	4935	9.37%	5155	9.44%	5388	9.46%	5630	9.00%	5884	8.73%
5. Construction	2765	5.79%	2700	5.26%	2604	4.94%	2382	4.36%	2329	4.09%	2528	3.72%	2254	3.34%
6. Electricity, gas & water supply	911	1.91%	986	1.92%	1019	1.93%	1202	2.20%	1423	2.50%	1727	2.76%	1843	2.73%
III. Tertiary industry	32144	67.35%	35129	68.45%	36369	69.04%	38725	70.93%	40160	70.52%	44919	71.80%	49047	72.74%
7. Transport, storage & commnctn	6335	13.27%	6713	13.08%	7244	13.75%	7603	13.93%	8083	14.19%	9083	14.52%	9378	13.91%
7.1 Railways	1249	2.62%	1261	2.46%	1310	2.49%	1334	2.44%	1363	2.39%	1521	2.43%	1588	2.36%
7.2 Other transport & storage	3215	6.74%	3486	6.79%	3854	7.32%	3989	7.31%	4431	7.78%	5080	8.12%	5305	7.57%
7.3 Communication	1871	3.92%	1966	3.83%	2080	3.95%	2280	4.18%	2289	4.02%	2482	3.97%	2685	3.96%
8. Trade, hotels & restaurants	4950	10.37%	5330	10.39%	5645	10.72%	5919	10.04%	6365	11.18%	6852	10.95%	7023	10.42%
9. Banking & insurance	2867	6.01%	3512	6.84%	3167	6.01%	3580	6.56%	2794	4.91%	3446	5.51%	6419	9.52%
10. Real estate & busi. services	4304	9.02%	4406	8.59%	4481	8.51%	4578	8.38%	4983	8.75%	5406	8.64%	5763	8.55%
11. Public administration	7315	15.33%	8521	16.60%	8810	16.72%	9639	17.65%	10228	17.96%	12207	19.51%	12209	18.11%
12. Other services	6373	13.35%	6647	12.95%	7022	13.33%	7406	13.56%	7707	13.53%	7925	12.67%	8255	12.24%
13. Net state domestic product	47729	100.00%	1319	100.00%	5676	100.00%	5498	100.00%	5695	100.00%	6255	100.00%	67427	100.00%
14. Per capita income (RS.)	1199		1236		1216		1206		1209		1274		1316	

Ind. Sector/Year	1977/78		1978/79		1979/80		1980/81		1981/82		1982/83		1983/84	
I. Primary industry	3382	4.68%	3383	4.39%	3190	3.97%	3498	4.24%	3364	3.85%	3562	3.82%	3595	3.58%
1. Agriculture	3225	4.47%	3264	4.24%	3059	3.81%	3103	3.76%	3006	3.44%	3198	3.43%	3318	3.30%
2. Forestry & fishing	19	0.03%	24	0.03%	45	0.06%	45	0.05%	59	0.07%	63	0.07%	67	0.07%
3. Mining & quarrying	138	0.19%	95	0.12%	86	0.11%	350	0.42%	299	0.34%	301	0.32%	210	0.21%
II. Secondary industry	16531	22.89%	17768	23.08%	18791	23.38%	17763	21.53%	19541	22.34%	20680	22.16%	20909	20.83%
4. Manufacturing	12353	17.11%	13484	17.51%	14462	17.99%	13556	16.43%	15338	17.53%	16089	17.24%	16399	16.33%
4.1 Registered	6205	8.59%	7058	9.17%	7748	9.64%	6539	7.93%	8005	9.15%	8425	9.03%	8391	8.36%
4.2 Unregistered	6148	8.51%	6426	8.35%	6714	8.35%	7017	8.51%	7333	8.38%	7664	8.21%	8008	7.98%
5. Construction	2214	3.07%	2212	2.87%	2287	2.85%	1833	2.22%	1844	2.11%	1585	1.70%	1572	1.57%
6. Electricity, gas & water supply	1964	2.72%	2072	2.69%	2042	2.54%	2374	2.88%	2359	2.70%	3006	3.22%	2938	2.93%
III. Tertiary industry	52305	72.43%	55847	72.53%	58390	72.65%	61242	74.23%	64566	73.81%	69099	74.03%	75891	75.59%
7. Transport, storage & commnctn	10165	14.08%	10273	13.34%	10898	13.56%	11118	13.48%	12064	13.79%	12287	13.16%	14172	14.12%
7.1 Railways	1779	2.46%	1815	2.36%	911	1.13%								
7.2 Other transport & storage	5505	7.62%	5349	6.95%	6623	8.24%								
7.3 Communication	2881	3.99%	3109	4.04%	3364	4.19%								
8. Trade, hotels & restaurants	7564	10.47%	7947	10.32%	8439	10.50%	9150	11.09%	9996	11.43%	11080	11.87%	11484	11.36%
9. Banking & insurance	7067	9.79%	8093	10.51%	8055	10.02%	8148	9.88%	8010	9.16%	8389	8.99%	9173	9.14%
10. Real estate & busi. services	5861	8.12%	6070	7.88%	6251	7.78%	6463	7.83%	6631	7.58%	6851	7.34%	7091	7.06%
11. Public administration	12978	17.97%	14675	19.06%	15650	19.47%	16781	20.34%	17885	20.45%	20094	21.53%	22951	22.86%
12. Other services	8670	12.01%	8789	11.41%	9097	11.32%	9582	11.61%	9980	11.41%	10398	11.14%	11100	11.06%
13. Net state domestic product	72218	100.00%	76998	100.00%	80371	100.00%	82503	100.00%	87471	100.00%	93341	100.00%	100395	100.00%
14. Per capita income (RS.)	1352		1382		1383		1361		1372		1404		1448	

Source: Estimates of state domestic product, 1985, C.S.O.

3) The State of Uttar Pradesh

The economy of the state of Uttar Pradesh (hereinafter called the state of U.P.) is supported by agriculture, which accounts for 52.7% of gross regional domestic product (at the prices of 1983/84), and its work force constitutes 3/4 of the total working population in the state of U.P.

Gross regional domestic product was 6,340 RS. CRORES (at prices of 1970/71) in 1983/84, representing 11.6% of net national product. The growth rate of the gross regional domestic product in the past ten years was 4.6% a year, which somewhat exceeded the national average (4.3%). This result is due largely to growth in the secondary industries (6.0%), especially manufacturing (7.0%), rather than the growth in agricultural production (4.2%). (See Table 3.1.2-5)

As for the distribution of the number of factories and factory workers within the state of U.P., Kanpur (11.2% of the total), Ghaziabad (9.7%) and Agra (6.0%) are the top three in the number of workers, and Ghaziabad (12.0%), Kanpur (10.5%) and Agra (10.4%) in the number of factories. The factories in Ghaziabad are large and medium-sized and those in Agra small-sized.

Concerning the contribution of the industries of the state of U.P. to the national economy, agriculture has a share of 15.9%, and manufacturing about 8.8%. As for agricultural productivity, grain production per hectare is about 80% compared with that of the states of Punjab and Haryana, the leading grain production states. The situation is the same with the state's main crops, oil seeds and sugarcane. On the other hand, regarding the state's manufacturing productivity, the production amount is 12,571 RS. per factory worker in 1980/81, which is lower than the national average of 21,831 RS/worker showing that the State of U.P. is backward in industrial productivity.

Gross regional domestic product per person is 1,567 RS/person by the actual price of the year 1983/84 and 533 RS/person by the constant price of the year 1970/71, which corresponds to about 70% of the national average (749 RS/person). This difference has not lessened in the past ten years.

Gross regional domestic product per person in the year 1973/74 was 436 RS. Therefore, the actual growth in average income during the last ten years is 1.22 times with average annual rate of 2.03%.

Income differential with adjoining Delhi has not changed last ten years and the average income in the state of U.P. is around 36% of that in Delhi, which is considered a remote cause of the rapid increase in Delhi's urban population.

(2) Population

National population of 685 million in 1981 shows a growth of 1.25 times in ten years with an average annual rate of 2.3%.

This population growth is largely due to the decrease in the death rate during the period, caused by the improvement in medical and public health management system. (See Table 3.1.2-6)

With the steady economic growth since the 5th Five-year Plan, the rate of urban population to national population has increased conspicuously at annual rate of 3.9% during the period from 1971 to 1981. (See Fig. 3.1.2-2)

Table 3.1.2-5 Net State Domestic Product (Uttar Pradesh)

(Unit: RS. LAKHS at 1970/71 prices)

Ind. Sector/Year	1970/71		1971/72		1972/73		1973/74		1974/75		1975/76		1976/77	
I. Primary industry	256478	60.26%	232229	57.82%	247128	58.10%	229420	56.53%	246495	58.18%	269824	58.52%	272264	57.38%
1. Agriculture	248597	58.40%	224261	55.83%	238844	56.15%	221696	54.62%	239306	56.48%	262616	56.95%	265587	55.97%
2. Forestry & logging	6415	1.51%	6660	1.66%	7005	1.65%	6357	1.57%	6019	1.42%	5879	1.27%	5305	1.12%
3. Fishing	536	0.13%	557	0.14%	578	0.14%	599	0.15%	623	0.15%	685	0.15%	704	0.15%
4. Mining & quarrying	930	0.22%	751	0.19%	701	0.16%	768	0.19%	547	0.13%	644	0.14%	668	0.14%
II. Secondary industry	63558	14.93%	62145	15.47%	66937	15.74%	66942	16.49%	64098	15.13%	70966	15.39%	76584	16.14%
5. Manufacturing	37925	8.91%	35838	8.92%	38156	8.97%	37484	9.24%	37376	8.82%	42862	9.30%	45507	9.59%
5.1 Registered	18694	4.39%	17222	4.29%	17703	4.16%	18185	4.48%	16666	3.93%	21208	4.60%	22973	4.84%
5.2 Unregistered	19231	4.52%	18616	4.63%	20453	4.81%	19299	4.57%	20710	4.89%	21654	4.70%	22534	4.75%
6. Construction	23286	5.47%	23907	5.95%	26226	6.17%	27177	6.70%	24159	5.70%	24883	5.40%	27249	5.74%
7. Electricity, gas & water supply	2347	0.55%	2400	0.60%	2555	0.60%	2281	0.56%	2563	0.60%	3221	0.70%	3828	0.81%
III. Tertiary industry	105614	24.81%	107282	26.71%	111303	26.17%	109511	26.98%	113072	26.69%	120321	26.09%	125658	26.48%
8. Transport, storage & communctn	16825	3.95%	18486	4.60%	19182	4.51%	18451	4.55%	18851	4.45%	20589	4.47%	21838	4.60%
8.1 Railways	7307	1.72%	7745	1.93%	8330	1.96%	7548	1.86%	7446	1.76%	8681	1.88%	9477	2.00%
8.2 Other transport & storage	7889	1.85%	9000	2.24%	9111	2.14%	9207	2.27%	9590	2.26%	9983	2.16%	10181	2.15%
8.3 Communication	1629	0.38%	1741	0.43%	1741	0.41%	1696	0.42%	1815	0.43%	1925	0.42%	2180	0.46%
9. Trade, hotels & restaurants	38376	9.02%	36387	9.06%	37921	8.91%	36034	8.88%	38261	9.03%	42278	9.17%	44382	9.35%
10. Banking & insurance	4778	1.12%	5249	1.31%	5592	1.31%	5438	1.34%	5117	1.21%	5913	1.28%	7768	1.64%
11. Real estate & busi. services	12959	3.04%	13157	3.28%	13358	3.14%	13559	3.34%	13769	3.25%	13980	3.03%	14190	2.99%
12. Public administration	11348	2.67%	12310	3.06%	13038	3.07%	13043	5.21%	13822	3.26%	13830	3.00%	13453	2.84%
13. Other services	21328	5.01%	21693	5.40%	22212	5.22%	22986	5.66%	23252	5.49%	23731	5.15%	24027	5.06%
14. Net state domestic product	425650	100.00%	401656	100.00%	425368	100.00%	405873	100.00%	423665	100.00%	461111	100.00%	474506	100.00%
15. Per capita income (RS.)	486		450		467		436		446		474		477	

Ind. Sector/Year	1977/78		1978/79		1979/80		1980/81		1981/82		1982/83		1983/84	
I. Primary industry	296084	57.45%	299177	55.80%	223135	48.33%	311358	54.69%	310291	53.98%	324471	53.79%	343330	54.16%
1. Agriculture	289123	56.10%	291918	54.45%	215808	46.74%	303598	53.33%	302120	52.56%	315491	52.30%	334262	52.73%
2. Forestry & logging	5501	1.07%	5499	1.03%	5686	1.23%	5406	0.95%	5041	0.88%	5046	0.84%	5152	0.81%
3. Fishing	724	0.14%	741	0.14%	785	0.17%	820	0.14%	849	0.15%	1051	0.17%	1092	0.17%
4. Mining & quarrying	736	0.14%	1019	0.19%	856	0.19%	1534	0.27%	2281	0.40%	2883	0.48%	2824	0.45%
II. Secondary industry	86727	16.83%	95320	17.78%	96668	21.37%	107862	18.95%	107729	18.74%	113687	18.85%	119543	18.86%
5. Manufacturing	52336	10.15%	58796	10.97%	56872	12.32%	62058	10.90%	62055	10.80%	69040	11.44%	73738	11.63%
5.1 Registered	23946	4.65%	27788	5.18%	26006	5.63%	25670	4.51%	23698	4.12%	25546	4.23%	26082	4.11%
5.2 Unregistered	28390	5.51%	31008	5.78%	30866	6.68%	36388	6.39%	38357	6.67%	43494	7.21%	47656	7.52%
6. Construction	30714	5.96%	32369	6.04%	32501	7.04%	36120	6.34%	35579	6.19%	33169	5.50%	33485	5.28%
7. Electricity, gas & water supply	3677	0.71%	4155	0.78%	9295	2.01%	9684	1.70%	10095	1.76%	11478	1.90%	12320	1.94%
III. Tertiary industry	132576	25.72%	141618	26.42%	139928	30.31%	150083	26.36%	156757	27.27%	165103	27.37%	171074	26.99%
8. Transport, storage & communctn	23921	4.64%	25142	14.69%	26369	5.71%	28848	5.07%	29642	5.16%	30886	5.12%	31912	5.03%
8.1 Railways	10403	2.02%	9979	1.86%	10393	2.25%	11749	2.06%	11560	2.01%	11976	1.99%	12207	1.93%
8.2 Other transport & storage	11283	2.19%	12820	2.39%	13528	2.93%	14451	2.54%	15191	2.64%	16093	2.67%	16664	2.63%
8.3 Communication	2235	0.43%	2343	0.44%	2448	0.53%	2648	0.47%	2891	0.50%	2817	0.47%	3041	0.48%
9. Trade, hotels & restaurants	47477	9.21%	49979	9.32%	42559	9.22%	50166	8.81%	52464	9.13%	55534	9.21%	58300	9.20%
10. Banking & insurance	8326	1.62%	9789	1.83%	10354	2.24%	9394	1.65%	10475	1.82%	12708	2.11%	13334	2.10%
11. Real estate & busi. services	14410	2.80%	17248	3.22%	19779	4.28%	20406	3.58%	21052	3.66%	21735	3.60%	22416	3.54%
12. Public administration	13915	2.70%	14137	2.64%	14652	3.17%	14948	2.63%	15879	2.76%	16827	2.79%	17069	2.69%
13. Other services	24527	4.76%	25324	4.72%	26215	5.68%	26321	4.62%	27245	4.74%	27413	4.54%	28043	4.42%
14. Net state domestic product	515387	100.00%	536115	100.00%	461731	100.00%	569303	100.00%	574777	100.00%	603261	100.00%	633947	100.00%
15. Per capita income (RS.)	506		514		432		519		510		522		533	

Source: Estimates of state domestic product, 1985, C.S.O.

Table 3.1.2-6 Growth of Population

(Unit: 1,000 persons)

Area/Year	1911	1921	1931	1941	1951	1961	1971	1981
U.T. of Delhi	414	488	636	918	1,744	2,659	4,066	6,220
(YR. GR. rate)		1.66%	2.69%	3.74%	6.63%	4.31%	4.34%	4.34%
Uttar Pradesh	48,155	46,672	49,780	56,535	63,220	73,755	88,341	110,862
(YR. GR. rate)		-0.31%	0.06%	1.28%	1.12%	1.55%	1.82%	2.30%
India Total	252,093	251,321	278,977	318,661	361,088	439,253	548,160	685,185
(YR. GR. rate)		-0.03%	1.05%	1.34%	1.26%	1.98%	2.24%	2.26%

Source: India 1985, Ministry of Information & Broadcasting

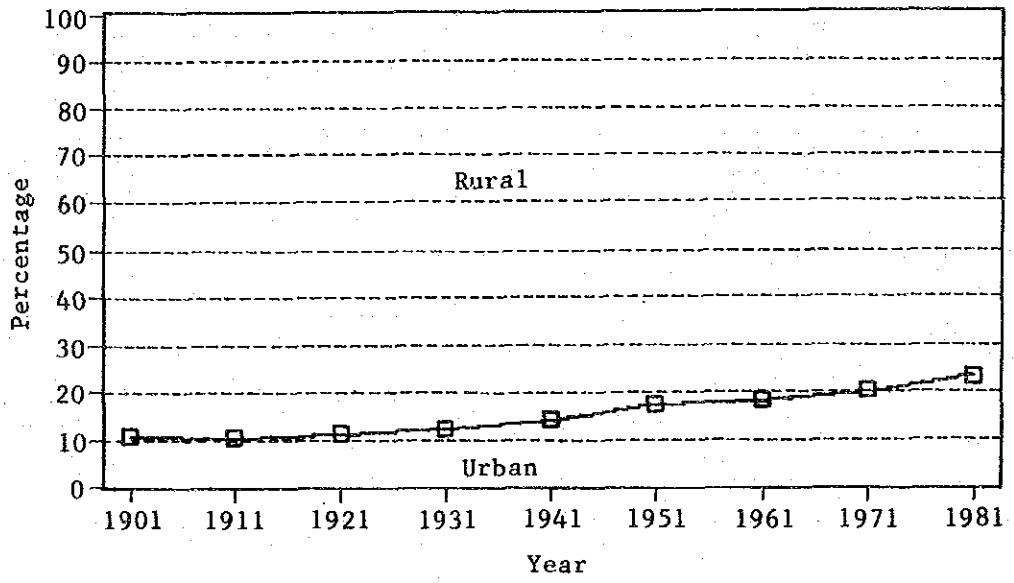


Fig. 3.1.2-2 Growth of Urban Population

The population in 1981 of the state of U.P., which constitutes the main part of the study area, is 111 million and it is the most populated state in the country. The population growth here from 1971 to 1981 is 1.25 times, with an annual rate of 2.3% which is about the same as the national average. The state of U.P. recorded a constant population outflow, with 3,461,000 in 1971 and 4,856,000 in 1981. The net social movement was -1,795,000 in 1971 and -2,876,000 in 1981, with the highest number in the country.

The state of U.P. has a high population density of 377 persons/km^2 (1981). Its low rate of urban population of 18.0% shows that the population is mostly distributed in rural areas.

Within and around the study area, the main cities whose population has greatly increased in the last decade (1971 to 1981) are: besides Delhi, Faridabad Complex (annual rate of 10.4% - the state of Haryana), Bulandshahr (5.7% - the state of U.P.), Firozabad (4.2% - the state of U.P.), Ghaziabad (8.0% - the state of U.P.), Muzaffarnagar (4.1% - the state of U.P.), Sitapur (4.3% - the state of U.P.), etc.

The population of Delhi Union Territory in 1981 is 6,220,000 and the annual average increase rate of the last decade (1971 to 1981) is 4.3%, one of the second largest rate among the big cities around the country, next to Bangalore. (See Table 3.1.2-7)

More than half of this increased population is the inflow from the nearby states of U.P., Haryana, Punjab and Rajasthan, resulting in the most densely populated city area of 4,194 persons/km^2.

Table 3.1.2-7 Population Share of Major Cities

Name of city	State	Population		Share		Population gr.rate
		1971	1981	1971	1981	
Hyderabad	Andhra Pradesh	1,618,484	2,187,262	0.30%	0.32%	3.06%
Ahmedabad	Gujarat	1,612,453	2,159,127	0.29%	0.32%	2.96%
Faridabad Complex	Haryana	122,817	330,864	0.02%	0.05%	10.42%
Bangalore	Karnataka	1,540,740	2,628,592	0.28%	0.38%	5.49%
Greater Bombay	Maharashira	5,970.575	8,243,405	1.09%	1.20%	3.28%
Nagpur		866,076	1,219,461	0.16%	0.18%	3.48%
Pune		856,105	1,203,351	0.16%	0.18%	3.46%
Jaipur	Rajasthan	615,258	977,165	0.11%	0.14%	4.73%
Madras	Tamil Nadu	2,572,967	3,276,622	0.47%	0.48%	2.45%
Agra	Utter Pradesh	591,917	694,191	0.11%	0.10%	1.61%
Allahabad		492,445	619,628	0.09%	0.09%	2.32%
Aligarh		252,314	320,861	0.05%	0.05%	2.43%
Amroha		82,702	112,682	0.02%	0.02%	3.14%
Bareilly		299,756	394,938	0.05%	0.06%	2.80%
Bulandshahr		59,505	103,436	0.01%	0.02%	5.68%
Dehradun		169,827	220,530	0.03%	0.03%	2.65%
Etawah		85,894	112,174	0.02%	0.02%	2.71%
Firozabad		133,863	202,338	0.02%	0.03%	4.22%
Farrukhabad		102,768	145,793	0.02%	0.02%	3.56%
Faizagad		102,835	101,873	0.02%	0.01%	-0.09%
Gorakhpur		230,911	307,501	0.04%	0.04%	2.91%
Ghaziabad		128,169	275,815	0.02%	0.04%	7.97%
Hardwar		79,277	115,513	0.01%	0.02%	3.84%
Hapur		71,266	102,837	0.01%	0.02%	3.74%
Jhansi		173,292	246,172	0.03%	0.04%	3.57%
Jaunpur		80,737	105,140	0.01%	0.02%	2.68%
Kanpur		1,158,321	1,486,522	0.21%	0.22%	2.53%
Lucknow		749,239	916,954	0.14%	0.13%	2.04%
Mathura		132,028	147,493	0.02%	0.02%	1.11%
Meerut		282,339	417,395	0.05%	0.06%	3.99%
Mizapur		105,939	127,787	0.02%	0.02%	1.89%
Moradabad		258,590	330,051	0.05%	0.05%	2.47%
Muzaffarnagar		114,783	171,816	0.02%	0.03%	4.12%
Rampur		161,417	204,610	0.03%	0.03%	2.40%
Sahanrapur		225,396	295,355	0.04%	0.04%	2.74%
Shahjahanpur		135,604	187,934	0.02%	0.03%	3.32%
Sambhal		86,323	108,232	0.02%	0.02%	2.29%
Sitapur		66,715	101,210	0.01%	0.01%	4.26%
Varanasi		588,608	720,755	0.11%	0.11%	2.05%
Calcutta	West Bengal	3,148,806	3,305,066	0.57%	0.48%	0.49%
Chandigarh	Chandigarh	218,743	379,660	0.04%	0.06%	5.67%
Delhi M. Corp	Delhi	3,287,883	4,884,234	0.60%	0.71%	4.04%
New Delhi M.C.		301,801	273,036	0.06%	0.04%	-1.00%
Pondicherry	Pondicherry	133,570	162,639	0.02%	0.02%	1.99%
	India Total Population	548,160,000	685,180,000	100.00%	100.00%	

Source: Statiscal Abstract, 1984

3-1-3 Estimation of Future Indicators

(1) Estimated value of the Seventh Five-year Plan

The Indian economy after 1974/75 showed a comparatively high rate of growth of 5% which is mostly attributable to the success of the 6th Five-year Plan. The economic growth attained during the 6th Five-year Plan period is attributed, as shown in the Table 3.1.3-1, to the growth of the agricultural and service industry sectors.

Following the successful 6th Five-year Plan, the 7th Five-year Plan has been put into effect for the period from April 1985 to March 1990.

Its major objectives are:

1) To create productive employement opportunities for the additional 12 million people expected by the year 2000.

Table 3.1.3-1 Sector Wise Growth Rate of the 6th Five Year Plan

(Unit: Annual Rate in %)

Sector	Target	Achievement (79/80-84/85)
1. Agriculture	3.8	4.3
2. Mining & Manufacturing	6.9	3.7
3. Others	5.5	6.6
Total	5.2	5.2

Source: 7th Five-year Plan, Vol. I

2) To increase production of food so as to maintain self-sufficiency and provide employment opportunities in agricultural areas.

3) To improve industrial as well as agricultural productivity.

The annual average economic growth during the period is estimated to be 5% in total, more precisely, 4% for the agricultural production (2.5% in terms of value added base) and 8% for the industrial production (6.8% in terms of value-added base).

Growth rate of national population in the 1961/71 period was 2.22% on average and 2.25% during 1971/1981 period, while that in the 7th Five-year Plan period is estimated to increase by 2.1% and 1.5% during the period from 1996 to 2001.

Now, the social and economic indicators estimated for the 7th Five-year Plan are outlined in Table 3.1.3-2:

Table 3.1.3-2 Future Socio-Economic Indications

Frame work	Unit/Year	1971	1981	1986	1991	1996	2001	2016
Population	1000 P.		685,159	761,070	837,249	913,246	986,199	
YR.GR.Rate				2.12%	1.93%	1.75%	1.55%	
Labor force	1000 P.		1980	1985	1990	1995	2000	2015
over 15 YR.Age			253,940	287,820	326,610		407,730	
15-59 YR.Age			237,680	269,810	306,080		379,850	
YR.GR.Rate (15-59)					2.57%	2.55%		2.18%
GDP	RS.CRORES AT 84/85 PR.			84/85	89/90		99/00	
				193,428	246,881		402,143	
YR.GR.Rate					5.00%		5.00%	
Per capita GDP	RS.AT 84/85 PR.			2,616	3,027		4,163	
YR.GR.Rate					2.96%		3.24%	
Employment	Mill. Standard Person Years			187	227		318	
YR.GR.Rate					3.95%		3.43%	

Source: 7th Five-year Plan

(2) Economic Framework

1) Outlook for gross domestic product

Gross domestic product for the next 15 years until the year 2000 is expected, according to the 7th National Five-year Plan, to grow by 5% annually. This rate nearly corresponds to the actual rate attained during the former Five-year plan period and is considered attainable provided that the agricultural productivity will not be affected by bad weather and that the nation's efforts to improve manufacturing productivity will be maintained without interruption.

The same economic growth rate of 5% is, therefore, adopted for this Study up to the year 2000, while its rate is assumed to slightly decline to 4% from the year 2000 to 2015.

As seen from the Table 3.1.3-3, the gross domestic product of India of the year 2000 is estimated to be 137,000 RS.CRORES based on 1970/71 prices, roughly 2.7 times more than that of 1981, and in the year 2015, 246,765 RS.CRORES, 4.9 times more.

Table 3.1.3-3 Future Gross Domestic Product

(Unit: RS.CRORES at 1970/71 prices)

Item/Year	1980/81	1985/86	1990/91	1995/96	2000/2001	2015/16
Gross domestic product	50,736	65,906	84,119	107,359	137,020	246,814
GDP per capita (RS)	700	884	1,023	1,195	1,411	2,066

As concerns the industrial structure, it is expected in view of the latest tendency that shares of the service industry and manufacturing sectors will grow, while that of the agricultural sector will relatively reduce. Based on the target value

established for the 7th Five-year Plan, as shown in the Table 3.1.3-4, the share of the manufacturing sector is estimated to grow to 19.8% in the year 2000 from 14.6%, in 1984/85, and the service industry sector to 35.5% from 31.2%, while that of the agricultural sector to decline to 25% from 36.9%.

The annual growth rate of the manufacturing sector is expected to attain 5.5% during the period the 7th Five-year Plan, and 7.8% thereafter. In the same manner, the service industry sector, 6.1% and 5.8%, while the agricultural sector, 2.5% and 2.4%, respectively. Shown in the Table 3.1.3-5 is the estimated output of staple commodities.

Table 3.1.3-4 Future Transition of Industrial Structure (GDP Base)

Sector/Year	1984/85	(GR. Rate)	1989/90	(GR. Rate)	1999/2000
Agriculture	36.9%	2.5%	32.7%	2.4%	25.5%
Mining & Manufacturing	18.1%	6.8%	19.7%	6.9%	23.6%
- Mining	3.5%	11.7%	4.7%	3.5%	3.8%
- Manufacturing	14.6%	5.5%	15.0%	7.8%	19.8%
Electricity, gas & water supply	2.0%	7.9%	2.3%	7.7%	2.9%
Construction	6.2%	4.8%	6.2%	4.9%	6.1%
Transport	5.6%	7.1%	6.2%	5.3%	6.4%
Services	31.2%	6.1%	32.9%	5.8%	35.5%
Total	100.0%	5.0%	100.0%	5.0%	100.0%

Source: 7th Five-year Plan

Table 3.1.3-5 Projected Output of Principal Commodities & Service

Commodities	Unit/Year	1984/85	Yr.gr. rate	1989/90	Yr.gr. rate	1999/ 2000
Foodgrains	Mill. tonnes	150	4.8%	181	2.8%	238
Coal	Mill. tonnes	147.44	11.3%	226	6.3%	417
Lignite	Mill. tonnes	7.8	18.2%	15.2	7.0%	30
Iron ore & Concentrates	Mill. tonnes	42.2	8.3%	58.1	3.9%	85
Cloth	Mill. meters	11950	5.0%	14500	4.1%	21600
Paper and paper board	Thousand tonnes	1361.2	7.2%	1800	5.0%	2930
L.D. polyethylene	Thousand tonnes	107.1	14.8%	186	10.2%	490
H.D. polyethylene	Thousand tonnes	38.9	33.9%	125	6.5%	235
Polypropylene	Thousand tonnes	27.3	30.4%	79	8.6%	180
P.V.C.	Thousand tonnes	84	29.1%	233	6.9%	455
Nitrogenous fertilisers (N)	Thousand tonnes	3917	13.8%	6560	5.7%	11400
Phosphatic fertilisers	Thousand tonnes	1264	14.7%	2190	6.7%	4180
Cement	Mill. tonnes	30.1	13.0%	49	5.9%	87
Saleable steel	Mill. tonnes	8.77	9.6%	12.64	5.2%	21
Aluminum	Thousand tonnes	276.5	15.9%	499	5.5%	850
Copper refined	Thousand tonnes	33.5	6.3%	42.7	11.8%	130
Zinc	Thousand tonnes	57.6	11.5%	89	5.4%	150
Lead	Thousand tonnes	14.2	17.4%	27	8.3%	60
Electricity generation	Bill. KWH	167	15.3%	295.4	6.6%	559
Railways originating traffic	Mill. tonnes	263	6.6%	340	4.3%	520

Source: 7th Five-year Plan

Taking the future population growth into consideration, gross domestic product per capita is considered to be 1,411 RS/person in the year 2000, twice as much as that in 1980/81 (700 RS/person) based on 1970/71 prices.

2) Estimation on gross regional domestic product

The gross regional domestic product is estimated by share assignment method on the basis of the gross domestic product and the general tendency in the past. Table 3.1.3-6 shows the results of the estimation.

Gross regional domestic product in Delhi is estimated to reach 2,526 RS.CRORES in 2000, three times more than that attained in 1980/81 (825 RS.CRORES), whereas gross product per capita may not exceed 2,002 RS/person, namely, 1.5 times as much as that in 1980/81 (1,361 RS/person based on 1970/71 prices), due to rapid growth of population.

Gross regional domestic product in the state of U.P., on the other hand, is estimated to reach 17,433 RS.CRORES in the year 2000, three times as much as that in 1980/81. Gross product per capita is estimated to reach 1,068 RS/person in the year 2000, twice as much as that in 1980/81. Therefore, it is presumed that the differential in the income standard the state of U.P. sustains as compared with that of Delhi, or the national average, will be improved to a certain extent.

Table 3.1.3-6 Future Gross Regional Domestic Product

(Unit: RS.CRORES at 1970/71 prices)

Item/Year	1980/81	1985/86	1990/91	1995/96	2000/2001	2015/16
G.R.D.P.						
Delhi Union Territory	825	1,215	1,551	1,979	2,526	4,550
Uttar Pradesh	5,693	8,385	10,702	13,659	17,433	31,396
G.R.D.P. per capita (RS.)						
Delhi Union Territory	1,361	1,625	1,707	1,807	2,001	2,485
Uttar Pradesh	519	695	799	921	1,068	1,499

(3) Population framework

Estimates are made by the Registrar General on the future population growth for each state in India for every 5 years until the year 2001 (i.e. in 1986 - 1991, 1991 - 1996, 1996 and 2001). In this Study, the medium estimated value employed by the 7th five-year plan is also adopted. Shown in the Table 3.1.3-7 are demographic factors applied as a prerequisite to the making of estimates.

However, as for the population of Delhi in 2000, the value established by the Delhi Development Authority for the year 2001 in line with its urban growth control policy is adopted making necessary modifications.

Under the above conditions, a future population growth are estimated for two separate areas, inner zones, directly related to the Study: (1) Delhi Union Territory, (2) related districts of the state of U.P.,

and outer zones ((1) non-related districts in the state of U.P., (2) other regions throughout the country), as shown in the Table 3.1.3-8.

The national population of 686,188,000 in 1981 is estimated to increase to 822,019,000, by 1.2 times by 1990, and 971,085,000, 1.4 times by 2000.

As concerns the population after the year 2000, it is estimated to grow to 1,194,446,000 by 2015 extrapolating a gradual declining tendency until the year 2000.

Population in the inner area zone, on the other hand, showed a higher growth rate. The population of 65,574,000 in 1981, is estimated to increase to 80,863,000, 1.2 times more, in 1990, and 99,952,000, 1.5 times more, by 2000.

Table 3.1.3-7 Basic Demographic Indicators

Item/Year	1984/85	1989/90	1999/2000
Life expectancy male	56.1	58.6	63.3
(In terms of YR) female	57.0	59.7	64.7
Infant mortality rate (per thousand birth)	106	90	60
Death rate (per thousand)	11.9	10.4	8.2
Birth rate (per thousand)	32.6	29.1	23.1
Fertility rate (per thousand)	152	132	99

Source: 7th Five-year Plan

Table 3.1.3-8 Population Forecast

Zone No.	State	District	Population (1000 P.)					
			1981	1985	1990	1995	2000	2015
(Inner zone)								
Zone 1	Delhi		6,220	7,476	9,087	10,954	12,621	18,310
Zone 2	U.P.	Ghaziabad	1,843	2,005	2,227	2,467	2,713	3,482
Zone 3	U.P.	Bulandshar	2,358	2,565	2,850	3,156	3,471	4,455
Zone 4	Haryana	Faridabad	1,001	1,125	1,251	1,356	1,443	1,697
Zone 5	U.P.	Aligarh	2,575	2,801	3,112	3,446	3,790	4,865
Zone 6	U.P.	Mathura	1,560	1,697	1,885	2,088	2,296	2,948
Zone 7	U.P.	Agra	2,853	3,103	3,448	3,818	4,199	5,391
Zone 8	U.P.	Etah	1,859	2,022	2,247	2,488	2,736	3,512
		Mainpuri	1,726	1,877	2,086	2,310	2,540	3,261
	Total		3,585	3,900	4,333	4,798	5,277	6,774
Zone 9		Etawah	1,743	1,896	2,107	2,333	2,565	3,293
		Farrukhabad	1,949	2,120	2,356	2,608	2,869	3,683
	Total		3,692	4,016	4,462	4,941	5,434	6,976
Zone 10	U.P	Kanpur	3,742	4,070	4,523	5,008	5,508	7,070
		Unnao	1,823	1,983	2,203	2,440	2,683	3,444
	Total		5,565	6,053	6,726	7,448	8,191	10,515
Inner Zone Total			31,252	34,740	39,381	44,472	49,434	65,412
YR. GR. Rate				2.68%	2.54%	2.46%	2.14%	1.88%
(Outer zone)			654,936	711,144	782,638	853,578	921,651	1,129,034
YR. GR. Rate				2.08%	1.93%	1.75%	1.55%	1.36%
Grand Total (All India)			686,188	745,884	822,019	898,050	971,085	1,194,446
YR. GR. Rate				2.11%	1.96%	1.78%	1.58%	1.39%

Table 3.1.3-9 Gross Domestic Product Forecast

Zone No.	State	District	Gross Domestic Product (Unit: Rs. CRORES at 1970/71 prices)					Gross Domestic Product per Capita (Unit: Rs. at 1970/71 prices)				
			1985	1990	1995	2000	2015	1985	1990	1995	2000	2015
1	Delhi		1,215	1,551	1,979	2,526	4,550	1,625	1,707	1,807	2,001	2,485
2	U.P.	Ghaziabad	311	397	506	646	1,164	1,551	1,783	2,051	2,381	3,342
3	U.P.	Bulandshar	211	269	344	439	791	823	944	1,090	1,265	1,775
4	Haryana	Faridabad	154	197	251	321	578	1,369	1,575	1,851	2,225	3,407
5	U.P.	Aligarh	211	282	360	460	829	789	906	1,045	1,214	1,703
6	U.P.	Mathura	102	130	166	211	380	601	690	795	919	1,289
7	U.P.	Agra	181	231	294	376	677	583	670	770	895	1,256
8	U.P.	Etah	132	169	216	275	495	653	752	868	1,005	1,410
		Mainpuri	113	145	185	235	423	602	695	801	925	1,298
		Total	245	314	400	510	919	628	725	834	966	1,356
9		Etawah	119	152	194	248	447	628	721	832	967	1,357
		Farrukhabad	106	135	173	220	396	500	573	663	767	1,076
		Total	225	287	367	468	843	560	643	743	861	1,208
10	U.P	Kanpur Unnao										
		Total	502	641	818	1,044	1,881	829	953	1,098	1,275	1,783
Inner Zone Total			3,367	4,299	5,485	7,001	12,611	969	1,092	1,233	1,416	1,928
Outer zone			62,539	78,820	101,874	130,019	234,203	879	1,020	1,193	1,411	2,074
Grand Total (All India)			65,906	84,119	107,359	137,020	246,814	884	1,023	1,195	1,411	2,066

3-2 Demand Forecast

3-2-1 Current Situation

Tables 3.2.1-1 and 3.2.1-2 show the current situation and trends of passenger and freight traffic in India.

The percentage of railway transportation to total transportation was 32.8 percent in 1970, 25.9 percent in 1975, 27.3 percent in 1980 and 19.7 percent in 1985, showing a tendency of gradual decline. This decline would be attributed to the increase in the availability of road transportation for local transportation. As for the long distance transportation, on the other hand, it is considered that the railway is playing a key role as yet.

The percentage of the freight transport, which was 67.2 percent in 1970, 52.9 percent in 1980 and 41.4 percent in 1985, also shows a gradual decline although it keeps higher figure than that of passenger. Like the case of passenger transportation, enlarged inter-regional truck transportation and insufficient railway transport capacity would be attributed to the decline.

(1) Present condition of railway traffic

Keeping step with the nation-wide economic growth, the Indian Railways (IR) has made a steady progress in transport volume. Financially, it produced a large profit recovering from deficit in 1985/86. (See Table 3.2.1-3)

1) Passenger transportation

Fig. 3.2.1-1 and 3.2.1-2 and Table 3.2.1-4 show the number of passengers and passenger-kilometers. The total number of passengers, reached a peak in 1980/81 and has shown no increase since then. This is attributed to the stagnated suburban transport volume.

Table 3.2.1-1 Road and Rail Passenger Traffic (Billion Passenger-km)

Item / Year	Rail	Road	Total	Per Capita RRPK (pass.-km)	GNP at factor cost (1970-71) prices (Rs. Crores)	Population (million)	Per Capita GNP (Rs.)	Per Capita RLPK (passenger-km)	Per Capita RTPK
1951	66.5	40.4	106.9	296.16	17,469	360.950	484	184.2	111.9
1952	63.1	42.3	105.3	298.16	17,841	368.097	485	171.4	114.9
1953	59.7	49.0	108.7	289.57	18,483	375.385	492	159.0	130.5
1954	59.9	53.2	113.1	295.94	19,660	382.176	514	156.7	139.2
1955	61.7	56.7	118.4	303.28	20,190	390.397	517	158.0	145.2
1956	62.4	66.0	128.4	322.53	20,854	389.097	524	156.7	165.8
1957	67.9	60.7	128.6	316.77	21,988	405.979	542	167.3	149.5
1958	69.7	57.8	127.5	307.96	21,593	414.018	522	168.4	139.6
1959	68.3	82.4	150.7	356.93	23,413	422.215	555	161.8	195.2
1960	73.8	90.5	164.3	381.58	23,802	430.575	553	171.4	210.2
1961	77.7	104.0	181.7	413.83	25,424	439.073	579	177.0	236.9
1962	82.3	110.7	193.0	430.10	26,293	448.733	586	183.4	246.7
1963	84.4	121.1	205.5	448.10	26,834	458.605	585	184.0	264.1
1964	88.9	133.5	222.4	474.51	28,210	468.694	602	189.7	284.8
1965	93.9	146.7	240.6	502.29	30,399	479.005	635	196.0	306.3
1966	96.8	158.1	254.9	519.67	28,791	490.499	587	197.4	322.3
1967	102.6	174.1	276.7	551.98	29,081	501.290	580	204.7	347.3
1968	107.5	195.5	303.0	591.43	31,590	512.318	617	209.8	381.6
1969	106.9	212.8	319.7	610.59	32,460	523.589	620	204.2	406.4
1970	113.4	233.8	345.2	645.10	34,518	535.108	645	211.9	436.9
1971	118.1	262.8	380.9	694.82	36,452	548.200	665	215.4	479.4
1972	125.3	283.3	408.6	729.21	36,999	560.335	660	223.6	505.6
1973	133.5	282.7	416.2	726.35	36,629	572.999	639	233.0	493.4
1974	135.6	322.3	457.9	781.47	38,486	585.950	657	231.4	550.0
1975	126.3	361.7	488.0	813.40	38,958	599.950	650	210.5	602.9
1976	148.8	381.2	530.0	864.97	42,694	612.737	697	261.4	641.1
1977	163.8	401.7	565.5	902.51	43,076	626.586	687	261.4	641.1
1978	176.6	486.3	662.9	1034.57	46,823	640.748	731	275.6	759.0
1979	192.9	507.2	700.1	1068.48	49,573	655.230	757	294.4	774.1
1980	198.6	528.0	726.6	1084.41	47,180	670.040	704	296.4	788.0
1981	208.6	661.3	869.9	1269.58	50,824	685.185	742	304.4	965.1
1982	220.8	724.4	945.2	1350.16	53,166	700.672	759	315.1	1033.9
1983	226.9	742.4	969.3	1352.81	54,084	716.507	755	316.7	1036.1
1984	222.9	836.8	1059.7	1446.44	58,112	732.628	793	304.2	1142.2
1985	226.6	918.7	1145.3	1528.88		749.112			

Source: Estimation of total road transport freight and passenger movement in India (Surface Transport)

Table 3.2.1-2 Road and Rail Freight Traffic (Billion ton-km)

Item / Year	Rail	Road	Total	GNP at factor cost (1970-71) prices (Rs. Crores)	Population (million)	Per capita freight moved (TK)	Per capita GNP (Rs.)	Per capita railway freight (TK)	Per capita road transport freight (TK)
1951	44.12	12.1	56.2	17,469	360.950	155.7	484	122.2	33.5
1952	47.40	13.9	61.3	17,841	368.097	166.5	485	128.8	37.8
1953	47.30	15.1	62.4	18,483	375.385	166.2	492	126.0	40.2
1954	48.29	16.3	64.6	19,660	382.176	169.0	514	126.4	42.7
1955	52.47	17.6	70.1	20,190	390.397	179.6	517	134.4	45.1
1956	59.58	19.5	79.1	20,854	398.097	198.7	524	149.7	49.0
1957	65.71	20.7	86.4	21,988	405.979	212.8	542	161.9	51.0
1958	74.58	22.4	97.0	21,593	414.018	234.3	522	180.0	54.1
1959	76.47	24.2	100.7	23,413	422.215	238.5	555	181.1	57.3
1960	82.01	26.3	108.3	23,802	430.575	251.5	553	190.5	61.1
1961	87.68	29.8	117.5	25,424	439.073	267.6	579	199.7	67.9
1962	91.22	31.7	122.9	26,293	448.733	273.9	586	203.3	70.6
1963	100.69	34.4	135.1	26,834	458.605	294.6	585	219.6	75.0
1964	106.84	37.5	144.3	28,210	468.694	308.0	602	228.0	80.0
1965	106.57	40.8	147.4	30,399	479.005	307.7	635	222.5	85.2
1966	116.94	52.8	169.7	28,791	490.499	346.0	587	237.7	107.6
1967	116.61	48.3	164.9	29,081	501.290	329.0	580	232.6	96.4
1968	118.86	52.5	171.4	31,590	512.318	334.6	617	232.0	102.5
1969	125.14	57.4	182.5	32,460	523.589	348.6	620	239.0	109.6
1970	128.25	62.5	190.8	34,518	535.108	356.6	645	239.7	116.8
1971	127.35	80.7	208.1	36,452	548.200	379.7	665	232.3	147.2
1972	133.27	88.3	221.6	36,999	560.335	395.5	660	237.8	157.6
1973	136.50	75.3	211.8	36,629	572.999	369.6	639	238.3	131.4
1974	122.35	80.9	203.3	38,486	585.950	347.0	657	208.8	138.1
1975	134.30	85.9	220.2	38,958	599.950	367.0	650	223.9	143.2
1976	148.22	91.9	240.1	42,694	612.737	391.8	697	236.6	150.0
1977	156.76	103.4	260.2	43,076	626.586	415.3	687	250.2	165.0
1978	162.69	110.0	272.7	46,823	640.748	425.6	731	253.9	171.7
1979	154.82	126.8	281.6	49,573	655.230	429.8	757	236.3	193.5
1980	156.00	139.0	295.0	47,180	670.040	440.3	704	232.8	207.5
1981	158.47	161.2	319.7	50,824	685.185	466.6	742	231.3	235.3
1982	174.20	183.0	357.2	53,166	700.672	509.8	759	248.6	261.2
1983	167.78	203.5	371.3	54,084	716.507	518.2	755	234.2	284.0
1984	166.83	219.7	386.5	58,112	732.628	527.6	793	227.7	299.9
1985	172.63	243.5	416.1						

Source: Estimation of total road transport freight and passenger movement in India (Surface Transport)

Table 3.2.1-3 Financial Results of the Indian Railways for some Representative Years

(Rs. in Crores)

Item	1950-51	1955-56	1960-61	1965-66	1973-74	1982-83	1983-84	1984-85	1985-86
Capital-at-charge	827.0	969.0	1520.9	2680.3	3893.4	7251.09	7567.80	8285.65	9078.07**
Gross traffic receipts	263.01	316.29	456.80	733.57	1137.89	4376.21	4986.24	5358.77	6428.10
Working expenses	210.48	258.22	358.24	583.06	1066.33	3883.35	4661.46	5142.17	5823.14
Net traffic receipts	52.53	58.07	98.56	150.53	71.56	492.86	324.78	216.60	604.96
Miscellaneous transactions	4.97	7.73	10.69	15.69	16.15	61.43	54.17	53.50	80.91
Net revenue receipts	47.56	50.34	87.87	134.84	55.41	554.29	378.95	270.10	685.87
Dividend and other payments	32.51	36.12	55.86	103.78 (12.50)*	170.92	435.98	423.70	466.69	507.04
Surplus (+) deficit (-)	+15.05	+14.22	+32.01	+18.56	-115.51	+118.31	-44.75	-195.59	+178.83
Percentage of net revenue to the capital-at-charge	5.75	5.20	5.77	5.03	1.42	7.6	5.0	3.3	7.6
Operating ratio (percent)	81.0	81.9	78.8	78.3	93.7	88.3	93.4	96.3	90.6

* Payment to States in lieu of tax on passenger fare.
** Excludes capital-at-charge of Metropolitan Transport projects (Rs.445.34 crores)
@ Includes payment in lieu of passenger Fare Tax and contribution to Railway Safety Works Fund.

Source: Year Book of Railway

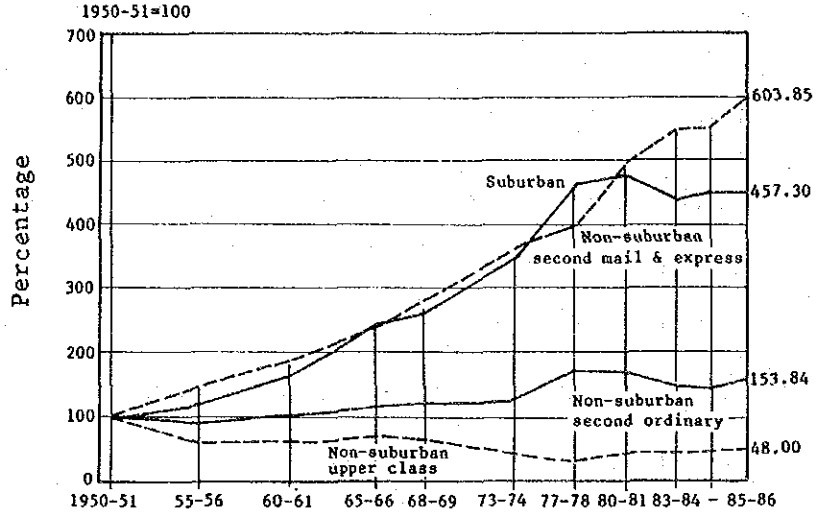


Fig. 3.2.1-1 Passengers Originating

Source: Year Book of Railway

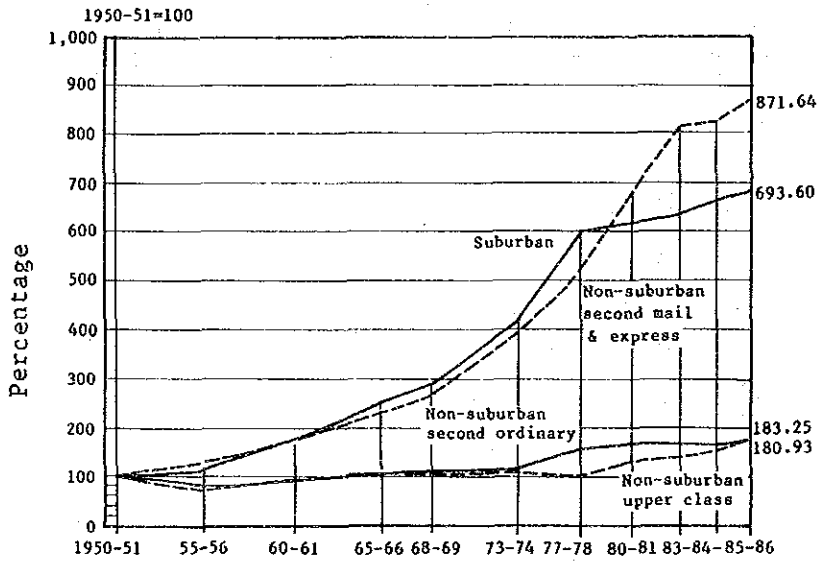


Fig. 3.2.1-2 Passengers-Kilometres

Source: Year Book of Railway

Table 3.2.1-4 Number of Passengers Originating
(Number of Passenger Journeys)

(In millions)

Year	Suburban (all classes)	Non-suburban					Grand total
		Upper class	Second class			Total non-suburban	
			Mail/Exp.	Ordy.	Total		
1950-51	412	25	52	795	847	872	1,284
1955-56	495	15	76	689	765	780	1,275
1960-61	680	15	96	803	899	914	1,594
1965-66	1,018	17	125	922	1,047	1,064	2,081
1968-69	1,084	16	139	974	1,113	1,129	2,213
1973-74	1,437	11	188	1,018	1,206	1,217	2,654
1977-78	1,928	8	209	1,359	1,568	1,576	3,504
1980-81	2,000	11	260	1,342	1,602	1,613	3,613
1983-84	1,834	11	288	1,192	1,480	1,491	3,325
1984-85	1,884	11	288	1,150	1,438	1,449	3,333
1985-86	1,884	12	314	1,223	1,537	1,549	3,433

Source: Year Book of Railway

The non-suburban transportation in recent years, except in 1984/85, has shown a remarkable increase. The number of passengers in 1985/86 increased by 604 percent from that in 1950/51, which is equivalent to a yearly growth of 5.1 percent. However, the number of upper class passengers has been stagnant.

The passenger-kilometers have substantially increased, exceeding the increase rate of passenger number. That of non-suburban second class Mail & Express trains, from 1950/51 to 1985/86, was as large as 871 percent, equivalent to a yearly growth of 6.2 percent. The growth rate of passenger-kilometers of the suburban traffic, on the other hand, have been larger than that of non suburban traffic by the year 1977/78, but has declined since then. The growth rates of upper class passengers-kilometers in the non suburban traffic is also low.

Thus, the passenger traffic, as a whole, has been growing satisfactorily, although the suburban traffic and upper class passenger traffic have not.

2) Freight traffic

Fig. 3.2.1-3 and Table 3.2.1-5 show the freight traffic trends in tonnage and tonne-kilometers. The freight tonnage has shown an increase of 353 percent, from 1950/51 to 1985/86, which is equivalent to a yearly growth of 3.7 percent. The freight tonne-kilometers increased by 523 percent during the same period, equivalent to an annual growth of 4.8 percent. These growth ratios are a little lower than those of passenger traffic.

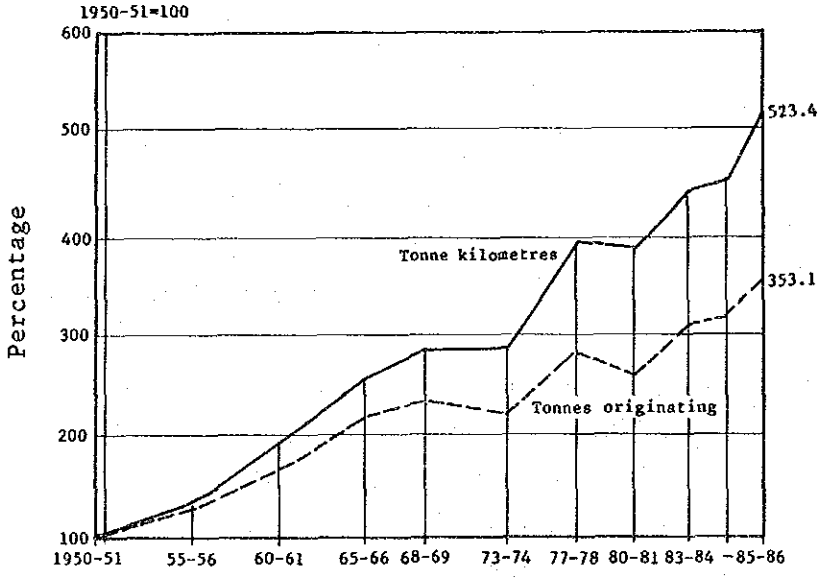


Fig. 3.2.1-3 Freight Traffic Trends

Source: Year Book of Railway

Table 3.2.1-5 Revenue Earning Freight Traffic

Year	Tonnes (Million)	Index	Tonne Kms. (Million)	Index	Lead Kms.	Index
1950-51	73.2	100.0	37,565	100.0	513	100.0
1955-56	92.2	126.0	50,435	134.3	541	105.5
1960-61	119.8	163.7	72,333	192.6	603	117.6
1965-66	162.0	221.3	98,978	263.5	611	119.1
1968-69	170.8	233.3	108,129	287.8	633	123.4
1973-74	162.1	221.5	109,391	291.2	675	131.6
1977-78	210.8	288.0	150,250	400.0	713	139.0
1980-81	195.9	267.6	147,652	393.1	754	147.0
1983-84	230.1	314.3	168,849	449.5	734	143.1
1984-85	236.4	322.9	172,632	459.6	730	142.3
1985-86	258.5	353.1	196,600	523.4	760	148.1

Source: Year Book of Railway

Ninety percent of the freight is bulky commodities such as grain, ore and cement which are suited for railway transport; in which the coal has the share of 39 percent. (See Fig. 3.2.1-4)

Table 3.2.1-6 shows the freight commodities of major traffic between Delhi and Kanpur. It indicates that most of the freight is bulk commodities, which are suited for railway transport such as the coal, ore, grain and fertilizers.

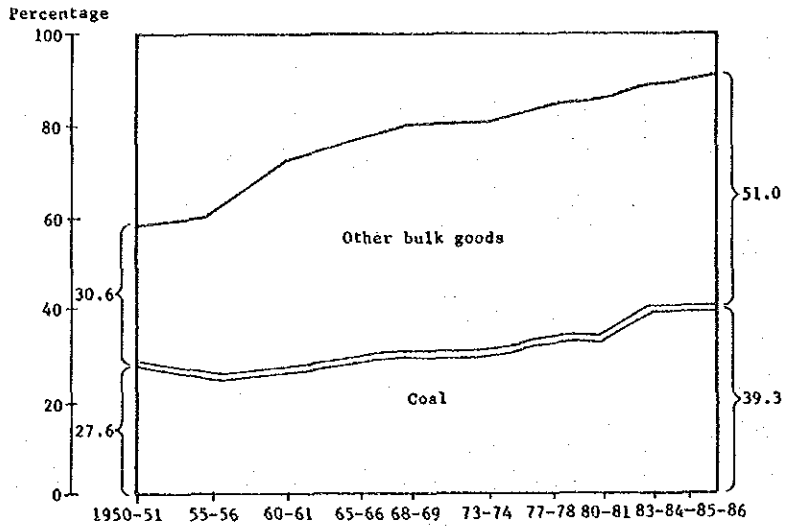


Fig. 3.2.1-4 Share of Bulky Commodities in Freight Traffic (Tonnes)

Source: Year Book of Railway

Table 3.2.1-6 Major Freight Traffic between Delhi Div. and Allahabad Div. through Ghaziabad during the Month of January 1987

From Allahabad Division	Ton/month
1 Coal	1,213,641
2 Iron Steel	123,420
3 Cement	24,192
4 Fertilizers	20,570
To Allahabad Division	
1 Food grains	15,911
2 Fertilizers	3,740
Total	1,401,474

Source: Northern Railway

Table 3.2.1-7 shows a shift of shares of railways and highways in the total inter-regional traffic throughout the country, from 1978/79 to 1986/87, in which the highway's share in both tonnage and tonne-kilometers show an increase of approximately 8 to 9 percent, implicating a large development of road traffic in medium and short distance traffic.

Table 3.2.1-7 Inter-regional Traffic - A Comparative Picture

Mode/Year	Tonnes (Million)	Percentage share	Tkms (Billion)	Share (Percent)	Average lead (kms)
Railways					
1978-79	185.0	65.6	149.6	80.6	810
1986-87	225.4	57.6	198.6	71.7	778
	(38.05)		(32.75)		(-4.11)
Highways					
1978-79	96.0	34.1	33.7	18.2	353
1986-87	182.8	41.2	69.2	25.0	378
	(90.42)		(105.34)		(7.08)

Source: RITES

Fig. 3.2.1-5 shows the share of railway traffic for the transportation of major commodities. In each commodity, the railway traffic shows the largest share in the long distance traffic of more than 500 kilometers.

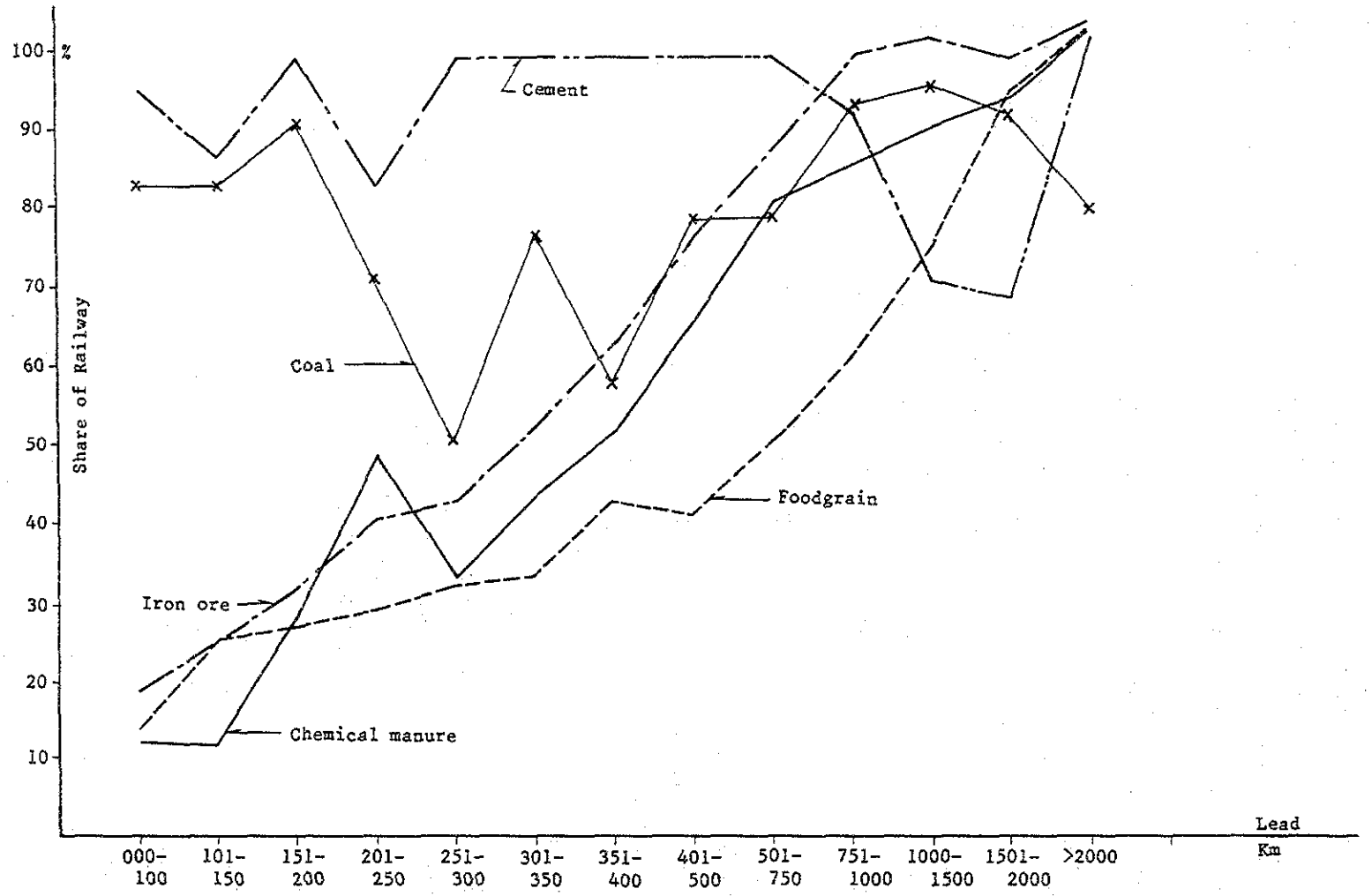


Fig. 3.2.1-5 Share of Railway Freight Traffic by Lead

Source: RITES

It is supposed that considerable volume of cement and coal carried by road in the traffic distance range of 1000 to 1500 kilometers be attributed to the insufficient railway transport capacity. If railway transport capacity should increase, such commodities would be transported by rail.

3) Railway traffic volume in the Study area

Table 3.2.1-8 shows traffic volume of the Section in the past 6 years. According to this, both passenger and freight traffic have achieved a high growth rate. Passenger traffic growth in the period of 1980/81 - 1985/86 is nearly 140% with about 7% annual growth. Freight traffic grew in the same period to nearly 230% with about 18% annual growth. Recently, however, the traffic volume has reached its transport capacity, and has become difficult to raise the traffic volume without making a fundamental improvement.

Table 3.2.1-8 Link Traffic in the Last 6 Years between Ghaziabad and Kanpur

(1) Coaching vehicle per Day

Year	Section							
	Ghaziabad-Tundla				Tundla-Kanpur			
	up		down		up		down	
1980/81	418	100.0%	421	100.0%	456	100.0%	455	100.0%
1981/82	422	101.0%	428	101.7%	451	98.9%	455	100.0%
1982/83	472	112.9%	462	109.7%	470	103.1%	474	104.2%
1983/84	475	113.6%	480	114.0%	470	103.1%	472	103.7%
1984/85	537	128.4%	542	128.7%	531	116.4%	533	117.1%
1985/86	584	139.7%	581	138.0%	616	135.1%	673	147.9%

(2) Net ton per Day

Year	Section							
	Ghaziabad-Tundla				Tundla-Kanpur			
	up		down		up		down	
1980/81	19,432	100.0%	7,480	100.0%	26,711	100.0%	9,641	100.0%
1981/82	28,554	146.9%	11,317	151.3%	34,529	129.3%	13,269	137.6%
1982/83	30,499	157.0%	15,424	206.2%	36,753	137.6%	17,377	180.2%
1983/84	31,926	164.3%	15,891	212.4%	38,142	142.8%	17,065	177.0%
1984/85	36,173	186.2%	16,421	219.5%	40,259	150.7%	17,947	186.2%
1985/86	44,171	227.3%	21,000	280.7%	54,581	204.3%	21,392	221.9%

Source: Northern Railway Density Chart

(2) Road traffic

As shown in Tables 3.2.1-1 and 3.2.1-2, both share and transport volume of road traffic have increased, presumably due to the increase in transport volume of urban and non suburban traffic as well as short distance general goods transport.

Table 3.2.1-9 shows the change in number of buses, cars and trucks. The number of cars has shown a remarkable increase in the recent years with a yearly increase ratio of 7.5 percent. The increase ratios of the number of trucks and buses are also getting larger.

Fig. 3.2.1-6 shows the traffic volume of the National Highways near the railway line of this study. Most sections of National Highway No. 2, parallel to the railway line have the traffic volume of 6000 pcus to 9000 pcus. The bypassing National Highway No. 24, has a traffic volume of 5000 to 7000 pcus.

Table 3.2.1-10 shows the traffic volume at each location of National Highways Nos. 2 and 24. The bus traffic is 2000 buses per day at the busiest location and 150 buses per day at the lightest traffic location.

Table 3.2.1-9 Number of Road Vehicles

Year	Bus	Car	Truck			Population (Thousand)
			Total	LCVs	HCVs	
1951	34,411	105,263	81,888		81,888	360,950
2	34,637					368,097
3	38,728					375,385
4	40,276					382,176
5	40,987					390,397
6	46,461	203,184	119,097		119,097	398,097
7	38,415					405,979
8	35,595					414,018
9	48,026					422,215
1960	53,674					430,575
1	56,792	309,576	167,649	15,193	152,456	439,073
2	59,560					448,733
3	62,560					458,605
4	66,513					468,694
5	70,470					479,005
6	73,135	455,821	258,977	25,314	233,663	490,499
7	76,033					501,290
8	82,729					512,318
9	86,570					523,589
1970	91,582					535,108
1	93,907	682,505	342,577	42,178	300,399	548,200
2	99,394	739,865	363,889	46,713	317,176	560,335
3	94,619	708,587	308,462	51,734	256,728	572,999
4	104,873	767,597	323,291	57,296	265,995	585,950
5	113,586	766,408	335,506	63,455	272,051	599,950
6	114,934	779,112	350,393	70,276	280,117	612,737
7	118,905	877,655	383,082	77,831	305,251	626,586
8	124,479	918,749	402,573	90,600	311,973	640,748
9	133,163	995,835	443,632	95,200	348,432	655,230
1980	140,346	1,054,404	472,093	103,800	368,693	670,040
1	153,757	1,116,703	526,608	113,800	412,808	685,185
2	163,964	1,207,338	586,692	125,000	461,692	700,672
3	177,768	1,351,204	647,633	143,000	504,633	716,507
4	191,768		705,000	161,000	544,000	732,628
5	206,268		763,000	182,000	581,000	749,112

Source: Surface transport
LCVs: Low capacity vehicles
HCVs: High capacity vehicles

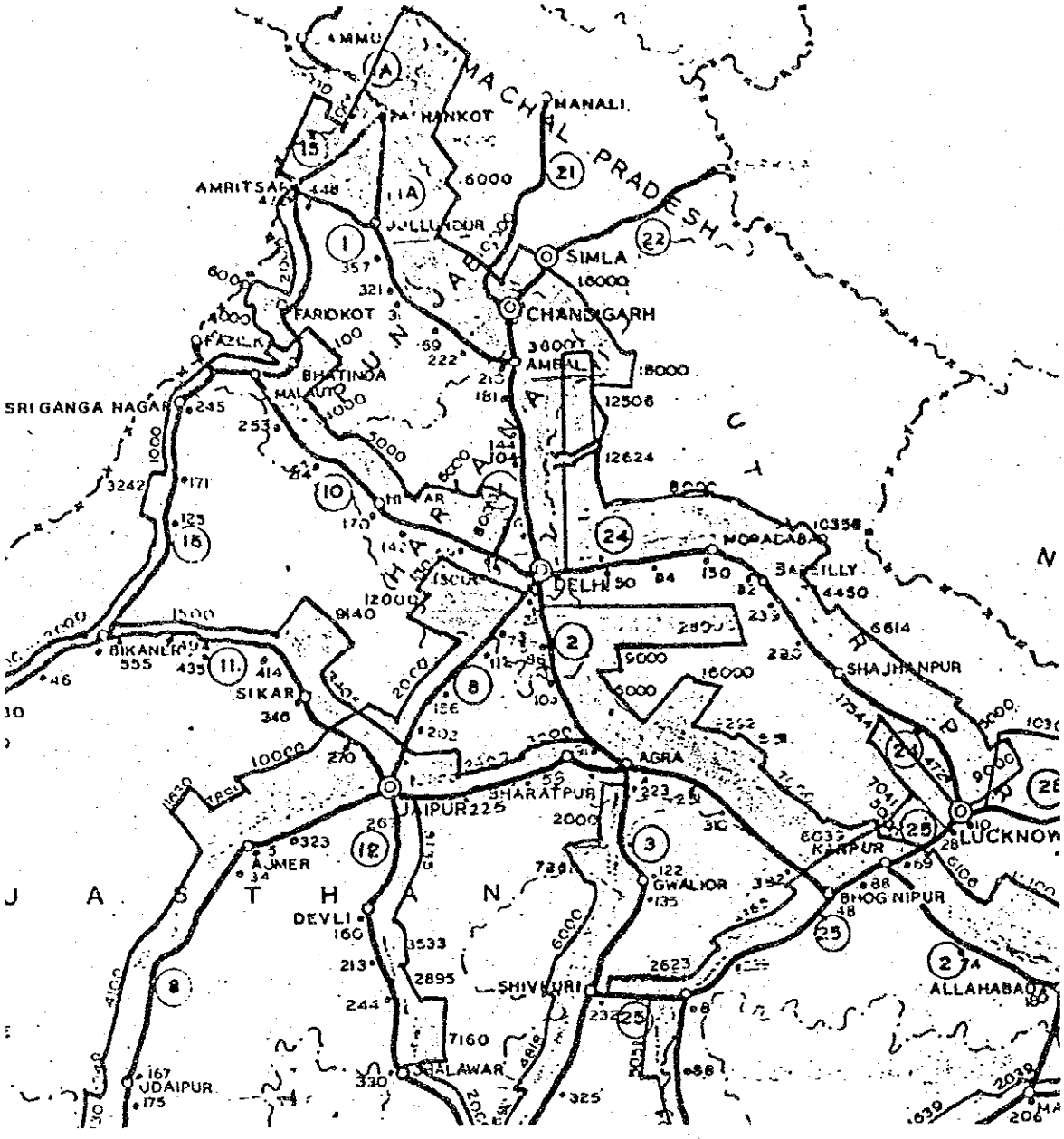


Fig. 3.2.1-6 Traffic Volume (in pcus) along National Highways (For Fast Moving Vehicles, 1983)

Source: ROADSWING, Ministry of Surface Transport

Table 3.2.1-10 Traffic Census Data (Per Day) (1984/85)

Location and nearest town (in kms)	Car	Bus	Truck	Motor-cycle Scooter	Cycle	Animal drawn	Others
Delhi-Agra-Kanpur (N.H.2)							
0 Delhi							
22 Faridabad	4,772	1,604	4,266	4,255	8,551	286	333
22	6,113	2,343	5,325	5,642	13,348	422	384
56	1,489	410	2,593	887	2,421	404	348
80	720	319	1,663	189	1,045	123	190
191 Agra	3,606	1,784	5,169	3,149	5,322	1,176	1,086
223 Tundla	1,382	1,678	4,711	1,176	3,303	346	302
257 Shikohabad	875	754	2,950	504	2,496	340	152
310	295	188	1,153	178	1,170	123	42
382 Auriya	189	159	1,771	236	2,657	132	168
452	400	258	1,886	200	1,116	82	
Delhi-Sitapur-Lucknow (N.H.24)							
0 Delhi							
50	782	340	1,279	833	917	134	916
84	604	512	1,173	135	625	64	48
150 Moradabad	954	757	2,278	469	2,056	393	69
182 Rampur	803	545	1,686	445	2,374	355	358
239 Bareilly	968	1,158	2,135	542	1,706	259	178
290	280	272	1,992	120	676	109	22
330 Sitapur	239	174	2,692	264	1,898	22	151
Lucknow-Kanpur (N.H.25)							
0 Lucknow							
69 Kanpur	282	692	1,742	212	1,664	140	41

N.H.: National Highway

Source: Surface transport

The average number of truck is approximately 2000 per day, but becomes substantially large near large cities such as Delhi and Agra.

(3) Air traffic

The number of airlines passenger has increased in recent years with an annual increase ratio of 11 percent. However, the number of flights and passengers among the airports concerned with the study area, airports of Delhi, Agra, Kanpur and Lucknow is small. Although air traffic increase is expected to some extent with the future rise of nation's income level, it will not largely affect the railway traffic between Delhi and Kanpur.

Table 3.2.1-11 Airline Passengers

Year	Passenger-km (in Million)	Growth rate
1984/85	6,676.492	11.4%
1983/84	5,994.262	10.8%
1982/83	5,408.180	10.3%
1981/82	4,902.652	13.4%
1980/81	4,323.158	3.0%
1979/80	4,199.140	2.9%
1978/79	4,081.360	20.4%
1977/78	3,388.804	15.8%
1976/77	2,926.833	12.2%
1975/76	2,609.180	

Source: Annual Report

Table 3.2.1-12 Weekly Flight Number among Airports Concerned with the Study Area

(Flight/week)

O \ D	Delhi	Agra	Kanpur	Lucknow	Bombay	Calcutta
Delhi		7		28	39	14
Agra	7					
Kanpur	7					3
Lucknow	21		7		4	
Bombay	39					14
Calcutta	14		3		14	

Source: Indian Airline Flight Timing

3-2-2 Demand Forecast

(1) Modes analyzed

In the railway traffic demand forecast, the competitive relation between the railway and other means of transportation is counted.

In the study area, railway, buses and air transport share the inter-city passenger traffic, and the railway and truck transport mainly share the freight traffic. (Taxis and cars are supposed to cover the urban passenger traffic only.)

The passengers of Mail and Express Train represent the railway mode, while passengers of long distance express like "Rajdhani Express" are treated as railway passengers of independent mode.

(2) Data used

The demand forecast this time is totally based on the data provided by the Indian side.

1) Passenger traffic

a) Railway

The flow of railway passenger between areas was estimated by assuming the OD traffic volume based on the OD pattern among

the major cities and the data of passengers at each station, calculating the cross sectional traffic volume, checking it and finally correcting the OD traffic volume.

b) Long distance bus

The OD traffic is estimated based on the traffic volume among major cities, inter-city bus routes and their operational frequency, then calculating the cross sectional traffic volume, and correcting it.

c) Airline

The data for passenger traffic among the related airports is used.

2) Freight traffic

OD survey results on the nationwide freight OD traffic by transport mode and commodity, studied by RITES, are recompiled to apply to the area subjected to the study.

3-2-3 Forecasting Method

(1) Zoning

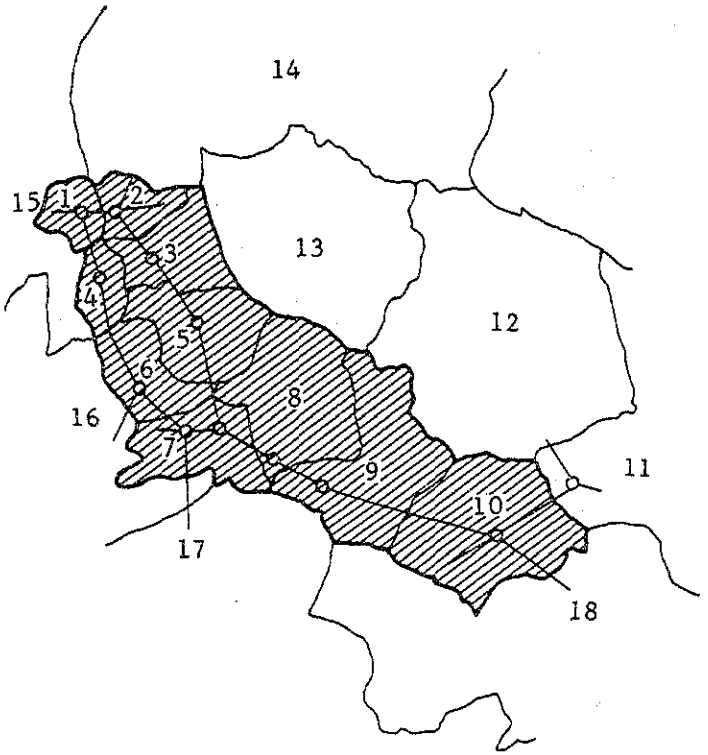
The area between Delhi and Kanpur is divided into 10 zones for passenger transportation and into 6 zones for freight transportation according to the administrative unit. The other area is divided into 8 zones.

The traffic among zones within the Study area and the traffic coming to and going from the other area are forecasted. The zoning map, and states, districts and cities included in each zone are shown in Fig. 3.2.3-1 and Table 3.2.3-1 respectively.

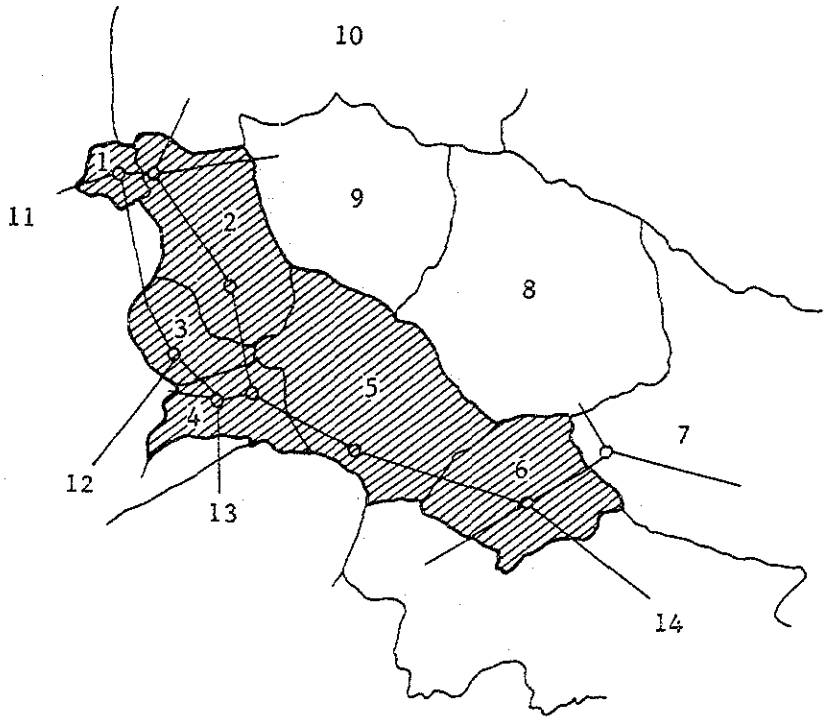
(2) Forecasting procedures

The procedures of traffic demand forecast are shown in Figs. 3.2.3-2 and 3.2.3-3.

Zoning map for passenger traffic



Zoning map for freight traffic



Legend: Hatched area shows the inner zone

Fig. 3.2.3-1 Zoning Map

Table 3.2.3-1 Zoning for Traffic Demand Forecast

Zone number for Passenger	Zone number for Freight	State	District	Main city
1	1	Delhi		
2	2	Utter Pradesh	Ghaziabad	
3	2	Utter Pradesh	Bulandshar	
4	11	Haryana	Faridabad	
5	2	Utter Pradesh	Aligarh	
6	3		Mathura	Mathura
7	4		Agra	Agra, Tundla
8	5		Etah, Mainpuri	
9	5		Etawah, Farukkhabad	
10	6		Kanpur, Unnao	
11	7		Lucknow & beyond Lucknow	
12	8		Hadori, Sitapur Kheri, Shajahanpur Pilibit	
13	9		Budaun, Bareilly Moradabad, Ranpur	
14	10		Manital, Pithoragarh Almora, Chamori, Garhwal Northern parts of UP	
15	11	Rajasthan, Haryana Punjab, Gujarat, etc. beyond Delhi		Ahmadabad
16	12	Beyond Mathura		
17	13	Utter Pradesh Madhya Pradesh Maharashtra, Andhra P., etc. beyond Agra	Jhansi, Lalitpur	Bombay
18	14	Utter Pradesh Orissa, West Bengal Bihar, Sikim, etc. beyond Kanpur to east	Jalaun, Hamipur, Fatehpur Banda, Baebareli, etc.	Calcutta

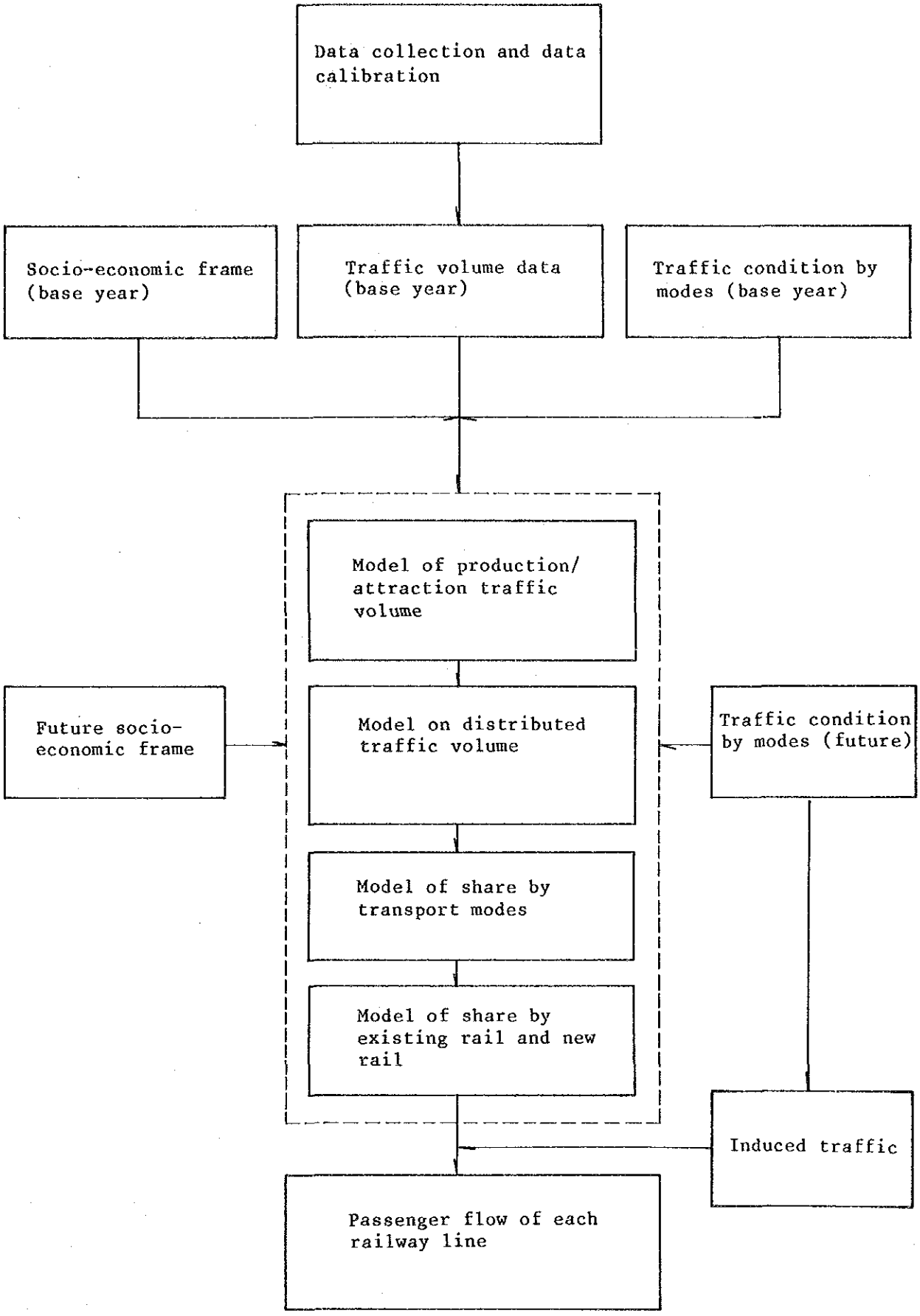


Fig. 3.2.3-2 Flow of Passenger Traffic Demand Forecast

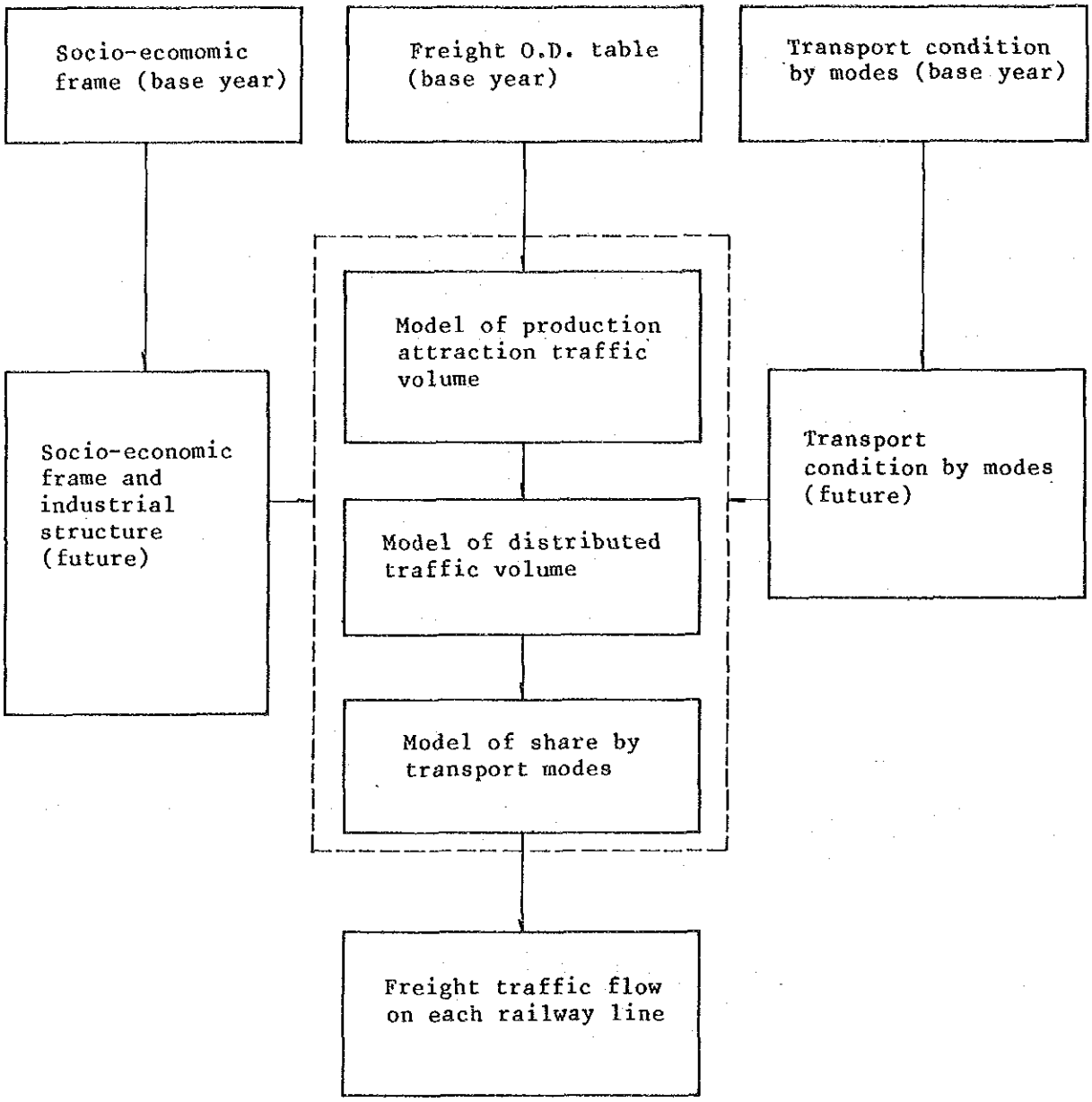


Fig. 3.2.3-3 Flow of Freight Traffic Demand Forecast

1) Production/attraction traffic volume

As the generalized unit, the rate of production/attraction traffic volume to the zonal population and that to the zonal GDP are used for passenger and freight traffic respectively.

$Pi = Poi \times Fi$

$Aj = Aoj \times Fj$

Pi, Aj: future production/attraction traffic volume

Poj, Aoj: current production/attraction traffic volume

Fi, Fj: population (passenger) and GDP (freight) growth ratio in zone i and zone j

2) Correlation between traffic and economic growth

a) Passenger traffic

The analysis on correlation between the number of road and railway passengers and the GNP shows the elasticity of 1.493. (See appendix. 1-1) So far, the increase in the number of passengers has been larger than that of the GNP. In the future, however, like in other countries with well developed transport system, it will approach 1.0. Thus, in this study, it is assumed that the elasticity of the number of passengers against the GDP will decline to 1.0 by the year 2000, and settled to 1.0 in and after 2000.

The GDP per capita in 2000 is forecasted to be 1.5 times greater than that in 1985, remaining at a lower level compared with the growth of the GDP. So, GDP elasticity value of the passenger volume after 2000 may be bigger than 1.0. However, since this is a long term forecast with various uncertain factors, a lower value of 1.0 on the safer side has been taken.

Table 3.2.3-2 shows the future trend of the number of passengers estimated based on these assumptions.

Table 3.2.3-2 Assumed Future Trend of Passenger Traffic

Year	GDP	Elasticity	Growth rate (five-year)	Growth rate-/1985
1985	3,367			1.000
		1.370		
1990	4,299		1.397	1.397
		1.246		
1995	5,485		1.355	1.893
		1.123		
2000	7,001		1.315	2.490
		1.000		
2015	12,611		1.801 (15 years)	4.485
	crores(RS) 1971 price			

GDP: Volume in Study area

b) Freight transportation

Like the case of passenger transportation, the regressional analysis of the trend of the total freight traffic volume of road and railway transportation against the GNP shows the elasticity of 1.31, which is smaller than that of passengers, but has presented larger growth than the GNP. (See appendix 1-1) In this study, it is assumed that the present elasticity will continue until 2000, and fall to 1.0 in 2000 by reason that the present industrial structure will not immediately change.

Table 3.2.3-3 shows the future trend of the total freight transportation estimated based on these assumptions.

Table 3.2.3-3 Assumed of Future Trend of Freight Traffic

Year	GDP	Elasticity	Growth rate (five-year)	Growth rate-/1985
1985	3,367			1.000
		1.309		
1990	4,299		1.377	1.377
		1.309		
1995	5,485		1.376	1.894
		1.309		
2000	7,001		1.376	2.607
		1.000		
2015	12,611		1.801 (15 years)	4.695
	crores(RS) 1971 price			

GDP: Volume in the Study area

Table 3.2.3-4 shows the freight volume growth rate in the period 1984/85 - 1999/2000 calculated from the category-wise production plan of the 7th 5-year plan. According to this, a 275% freight volume is expected in 2000 compared with that in 1985. This figure is nearly the same as the forecast result made based on the GDP and its elasticity value. Since the forecast covers a long term with various uncertain factors, a comparatively lower value based on GDP is adopted.

Table 3.2.3-4 Assumed Future Trend of Freight Traffic of Main Commodities (Based on Seventh five-year plan)

Item	Volume	Share (Weight)	projected out put			Growth rate	Future demand (Weight)
			1984/85	1999/2000	unit/year		
Coal	1,213,641	86.6%	147.4	417	mill.tonnes	2.829	245
Iron ore & etc	123,420	8.8%	42.2	85	mill.tonnes	2.014	18
Cement	24,192	1.7%	30.1	87	mill.tonnes	2.890	5
Fertilizers	24,310	1.7%	5,181.0	15,580	thousand tonnes	3.007	5
Food grains	15,911	1.1%	150.0	238	mill.tonnes	1.587	2
Total	1,401,474	100.0%					275
	ton/month						
notes	①	②	③	④		⑤ = ④ / ③	⑥ = ② x ⑤

① Freight traffic volume handled by Allahabad Division of Northern Railway (Table 3.2.1-6)

③ & ④ Seventh five-year plan (Table 3.1.3-5)

Trend of Future freight traffic = 275% (2000/1985)

3) Distributed traffic volume

a) Passenger transportation

The gravity model is estimated based on the present traffic distribution pattern using the formula below, and the primary value of distributed traffic volume is calculated incorporating the future production/attraction traffic volume into this formula.

$$Tij = k \frac{(Pi \times Aj)^{\alpha}}{(dij)^{\gamma}}$$

Tij: Traffic volume between zones i and j

Pi : Production traffic volume in zone i

Aj : Attraction traffic volume in zone j

Dij: Average road and railway distance between zones i and j

k, α, γ: Parameter

b) Freight traffic

The future distributed freight traffic volume is calculated using the Fratar model based on the present (1986) distribution pattern.

$$Tij = tij.Fi.Fj \left(\frac{Li + Lj}{2}\right)$$

$$Fi = \frac{Pi}{Poi} \qquad Fj = \frac{Aj}{Aoj}$$

$$Li = \frac{Pi}{\sum_{j} (tij.Fj)}$$

where,

Tij: Future traffic volume between zones i and j
tij: Present traffic volume between zones i and j
Pi : Future production traffic in zone i
Poi: Present production traffic in zone i
Aj : Future attraction traffic volume in zone j
Aoj: Present attraction traffic volume in zone j

4) Share model for traffic mode

a) Passenger transportation

The following share model for passenger transportation mode is set.

$$S_a = \frac{EXP(fa)}{EXP(fa) + EXP(fb) + EXP(fc)}$$

where,

Sa : Share of traffic mode a
fa = α x (Taij + Caij/$\bar{W}$ + Kaij)
Taij: Time required for mode a to travel between zones i and j
Caij: Fare required for mode a to travel between zones i and j
$\bar{W}$: Time value
Kaij: Special condition due to other factors between zones i and j
α : Parameter

The optimum parameters are calculated according to trial and error method, and then Kaij is established for each zone pair.

For the share estimation between railway and other traffic modes, the larger value of EXP(f(x)) of the New Corridor and conventional lines is set as the representative value for the railway, and the share of the New Corridor and of the conventional lines within the railway traffic is calculated using the formula above, based on the difference in the transport time and fare required for the each railway lines.

b) Freight traffic

The large reduction in transport time can hardly be expected in spite of the implementation of the project, since the proportion of on-rail time to the total transport time is small. On the other hand, most of the commodities transported is bulk freight which is the most suited for railway transportation, and this tendency is to continue in the future. So the railway shear ratio between zones are assumed as unchanged in the future.

5) Induced traffic

In addition to the traffic increase caused by the economic frame expansion, some traffic is expected to be induced through a reduced traffic resistance between zones where a new traffic facility (New Corridor) is to be constructed. Since the induced traffic is considered to be directly proportional to the resistance reduction between zones, calculation can be made in the following formula.

$$RI_{ij} = \frac{\sum_{k} \text{Exp}\,(f'k)}{\sum_{k} \text{Exp}\,(fk)}$$

where

RI_{ij}: Rate on induced traffic between zones i and j

fk, f'k: Value of the share model in 4) (= inverse of the traffic resistance between zones i and j)

fk: Value of mode k without project

f'k: Value of mode k' with project

i,j: Zone

3-2-4 Premises of Demand Forecast

(1) Railway

In each case, the transport capacity is regarded as limitless, and the transport time is calculated adopting the average maximum train speed.

The train speeds and fares used in the above calculation are as follows.

a) The section between Delhi and Kanpur

. Train speed: max. 130 km/h, commercial speed 70 km/h

. Passenger fare: 2nd class Express/Mail (0.11 Rs/Pass-km) and Long distance train (0.36 Rs/Pass-km)

b) The New Corridor

i) Long distance train

. Train speed: max. 160 km/h, commercial speed 120 km/h

. Passenger fare: The equivalent fare of the "Rajdhani Express" (0.36 Rs/Pass-km)

ii) Super express train

. Train speed: max. 250 km, commercial speed 170 km/h

. Passenger fare: higher fare level by 0.25, 50, 75 and 100% than that of 2nd class Exp/Mail train

The time and cost for access/degress as well as waiting are also taken into account. (See Appendix 1-2)

(2) Road

It is assumed that traffic capacity of the existing road will be increased according to the increase in road traffic volume but expressways will not be newly constructed. The required time and fare are calculated according to the speed and fare of a long distance bus. As in the case of the railway, the time and cost for access/egress and waiting are taken into account.

(3) Airline

The capacity is not limited and the required time is calculated according to the timetable. The time and cost for access, egress and check-in are added to the required time and fare.

(4) Time value

The time value is assumed to be proportional to the growth of the GDP per capita. The current time value is calculated in the "Road User Cost Study" (Source: Surface Transport), and the time value for a passenger of a long distance bus is adopted. (See Appendix. 1-2. (3))

(5) Forecast year

The forecast year is set at the year of 2000 and every five year from 1990 up-to 2015 is calculated based on the traffic at the year of 1985, 2000 as well as related economic frame works.

3-2-5 Result of the Demand Forecast

(1) Traffic demand

Table 3.2.5-1 shows the future traffic demand by modes. Table 3.2.5-2 shows the rate of induced traffic volume. The induced traffic volume, which is expected mainly from the construction of the New Corridor, is added to the traffic volume of the New Corridor.

With upgrading the existing railway section, the increased transport capacity will absorb the future traffic demand for some time, but the share of railway transportation will not increase much because reduction in travelling time is small.

If the New Corridor should be introduced, the reduction in travelling time increase the share of railway transportation, although increase of the fare level will cause reduction in its share and traffic volume.

- The forecast is premised on 5 percent growth rate of the GDP upto the year 2000 and 4 percent from 2001 to 2015. The lower growth rate will lead to traffic demand decline.

Table 3.2.5-1 Traffic Demand Forecast

(Passenger/day)

Passenger Traffic Demand (Inter-zonal Traffic)

Year	Case \ Mode	Railway				Bus	Air Line	Total
		Mail & Exp	L. Exp.	New Corridor	Rail Total			
1985	Current Traffic	33.9% 191,611	0.6% 3,649		34.5% 195,260	62.4% 352,865	3.1% 17,600	100.0% 565,725
	Without project	35.9% 507,254	1.4% 19,154		37.2% 526,408	57.9% 819,074	4.8% 68,500	100.0% 1,413,982
	With Upgrading	37.1% 524,575	1.4% 19,414		38.5% 543,989	56.8% 803,558	4.7% 66,493	100.0% 1,414,040
	With Upgrading and New Corridor							
2000	*fare level 0%	26.8% 379,353	0.8% 11,674	17.3% 244,401	44.9% 635,428	52.8% 746,191	2.3% 32,421	100.0% 1,414,040
	fare level 25%	28.4% 400,883	1.1% 14,933	13.2% 186,333	42.6% 602,149	54.2% 766,450	3.2% 45,441	100.0% 1,414,040
	fare level 50%	29.9% 422,178	1.3% 18,821	9.2% 130,099	40.4% 571,098	55.4% 783,439	4.2% 59,503	100.0% 1,414,040
	fare level 75%	31.2% 441,797	1.5% 20,852	6.3% 89,263	39.0% 551,912	56.3% 796,116	4.7% 66,012	100.0% 1,414,040
	fare level 100%	32.7% 462,697	1.5% 20,852	4.5% 63,413	38.7% 546,962	56.7% 801,066	4.7% 66,012	100.0% 1,414,040

Freight Traffic Demand (Inter-zonal Traffic) (ton/day)

Year	Case \ Mode	Railway	Truck	Total
1985		70.4%	29.6%	100.0%
	Current traffic	175,988	74,003	249,991
2000	With/without the project	62.2%	37.8%	100.0%
		404,213	245,764	649,977

Upper figures show shares.

* Fare level means that fare level of Super Exp. train will be set at higher level by 0.25, 50, 75 and 100% than that of 2nd class Exp./Mail trains of the Section.

Table 3.2.5-2 Induced TRAFFIC Ratio in year 2000

Case	$\sum_i \sum_j \sum_k$ EXP (fk)	$\sum_i \sum_j RI_{ij}$
Without project	2.97	1.00
With Upgrading	2.99	1.00
With Upgrading and the New Corridor construction		
fare level 0%	3.15	1.06
fare level 25%	3.08	1.04
fare level 50%	3.05	1.03
fare level 75%	3.02	1.02
fare level 100%	3.01	1.01

Legend: $\sum_i \sum_j \sum_k$ Exp (fk): Inversed total transport resistance

$\sum_i \sum_j RI_{ij}$: Induced traffic ratio

(2) Traffic assignment to alternative network

The traffic demand in each case is assigned to each case of railway network, regardless of the transport capacity. The link traffic volume in each case is shown in the Figs. 3.2.5-1 ∿ 3.2.5-11

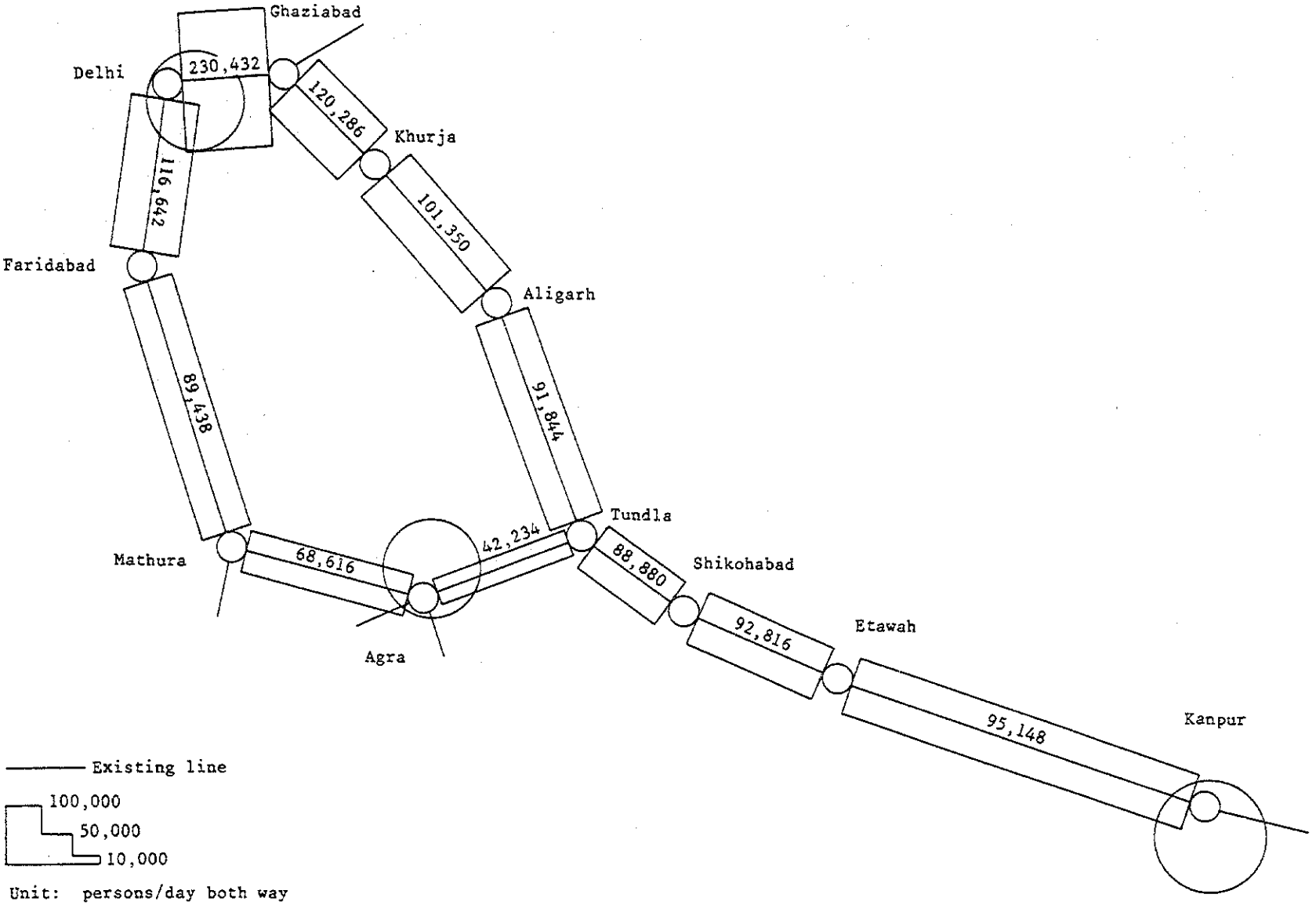


Fig. 3.2.5-1 Passenger Link Traffic Demand in 2000 (Without Project)

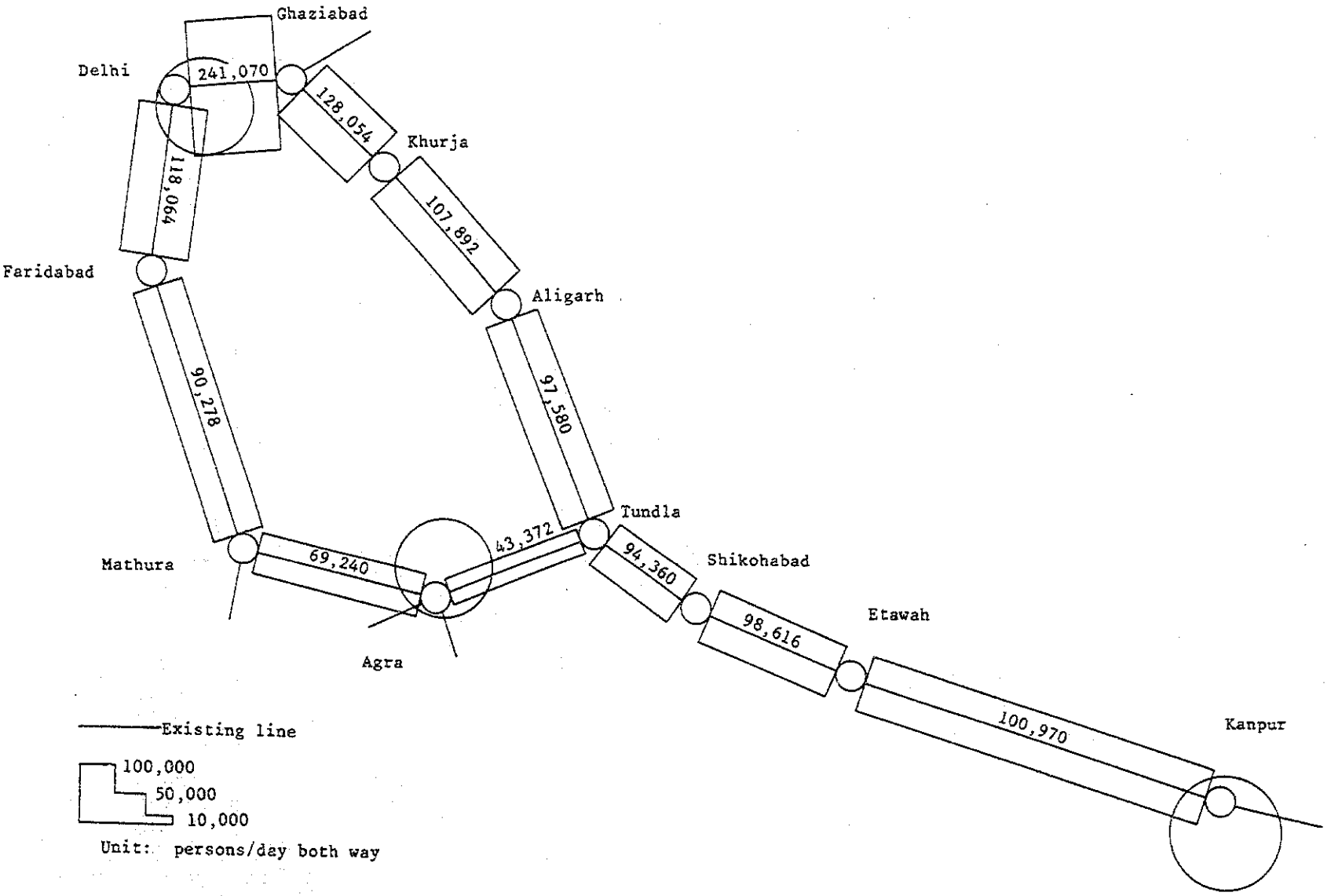


Fig. 3.2.5-2 Passenger Link Traffic Demand in 2000 (With upgrading the Section)

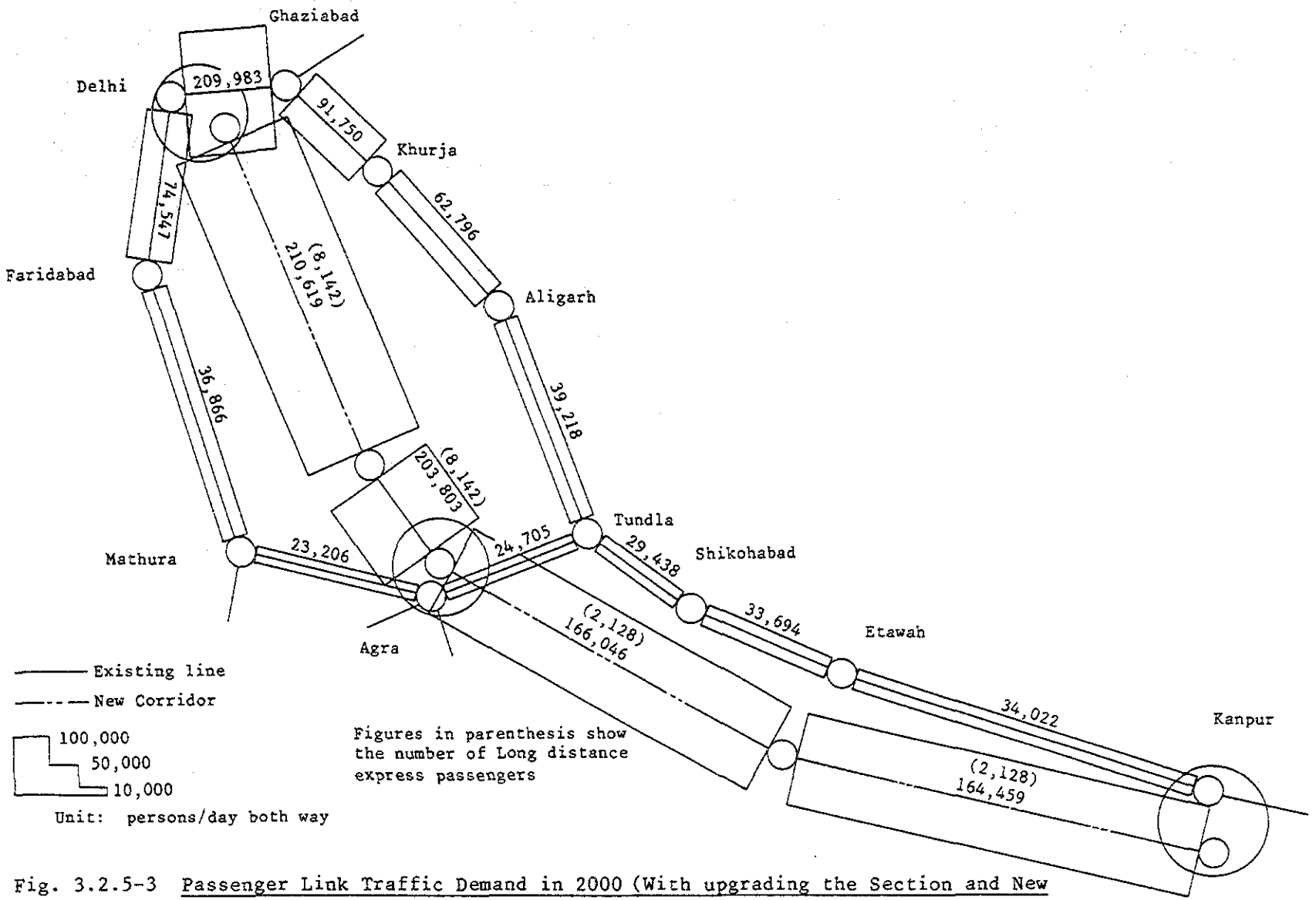


Fig. 3.2.5-3 Passenger Link Traffic Demand in 2000 (With upgrading the Section and New Corridor Construction with 0% fare level)

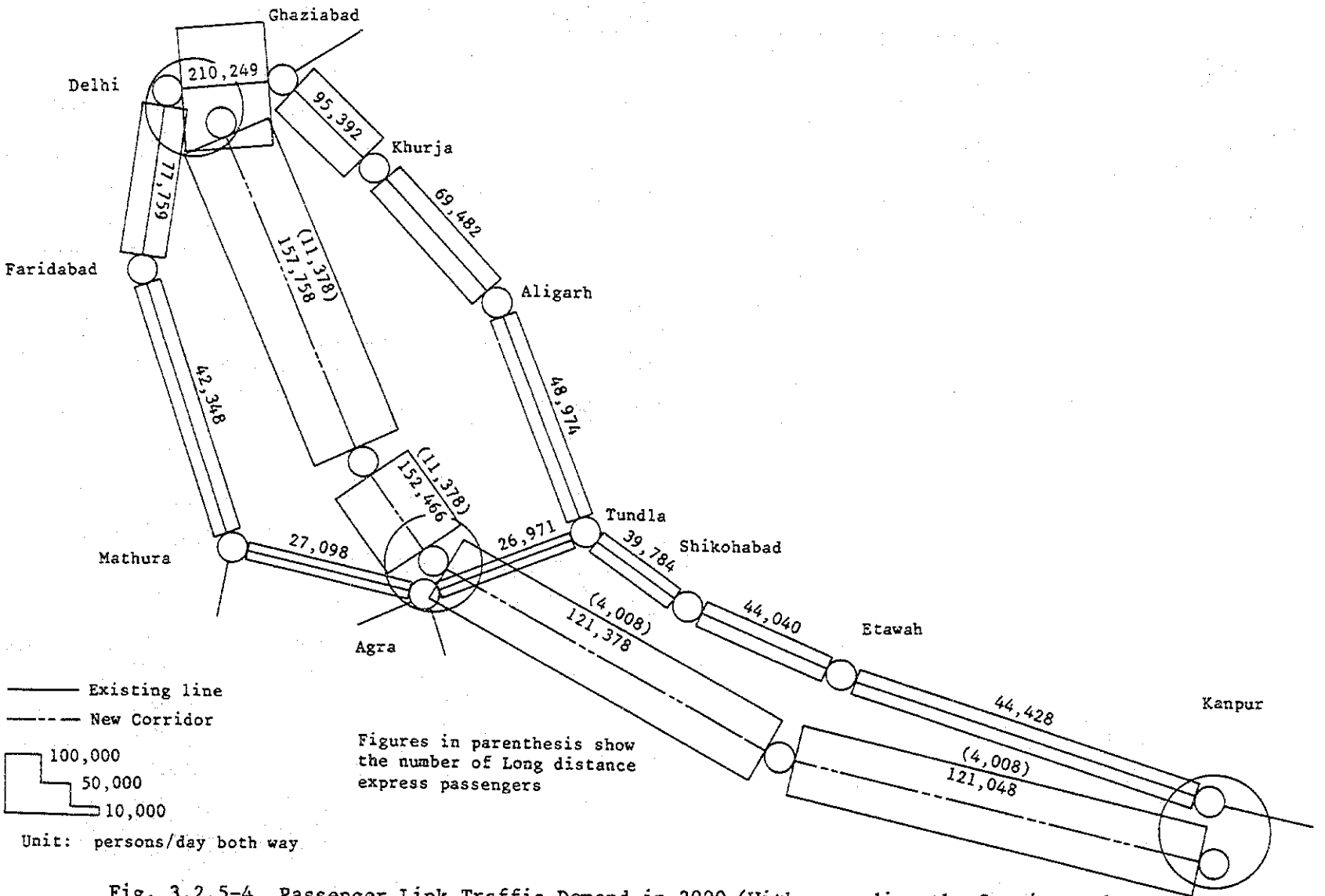


Fig. 3.2.5-4 Passenger Link Traffic Demand in 2000 (With upgrading the Section and New Corridor Construction with 25% fare level)

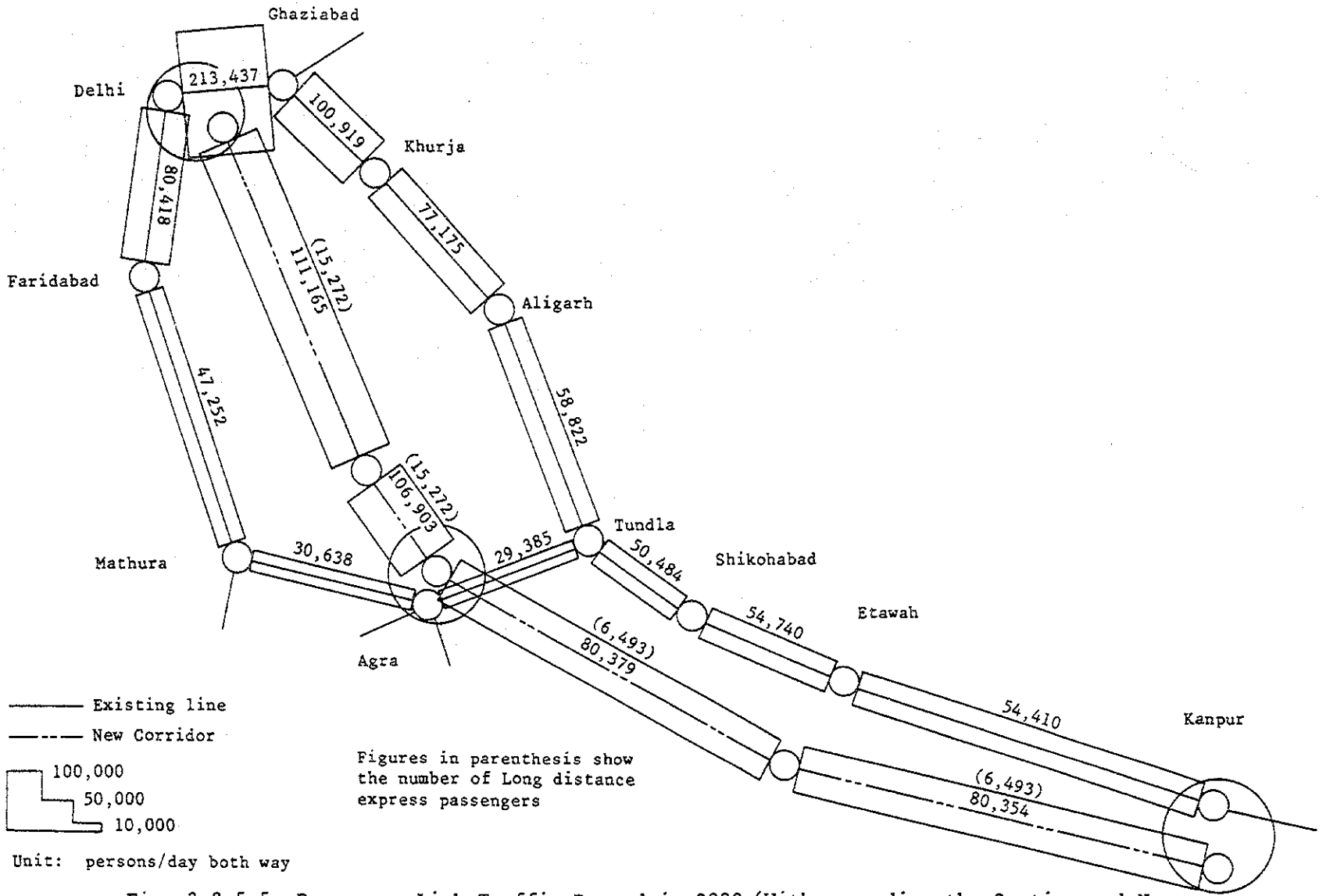


Fig. 3.2.5-5 Passenger Link Traffic Demand in 2000 (With upgrading the Section and New Corridor Construction with 50% fare level)

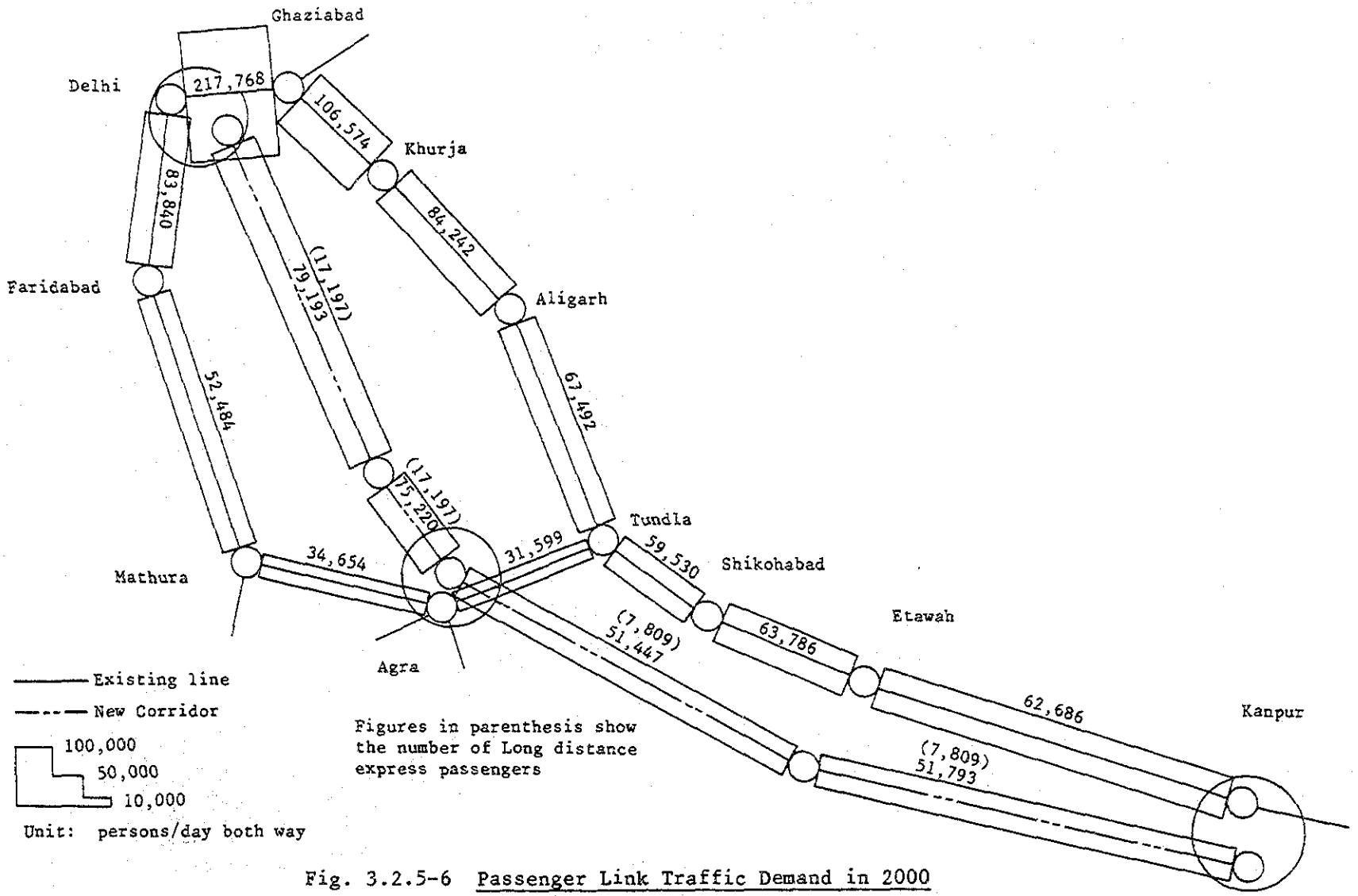


Fig. 3.2.5-6 Passenger Link Traffic Demand in 2000
(With upgrading the Section and New Corridor Construction with 75% fare level)

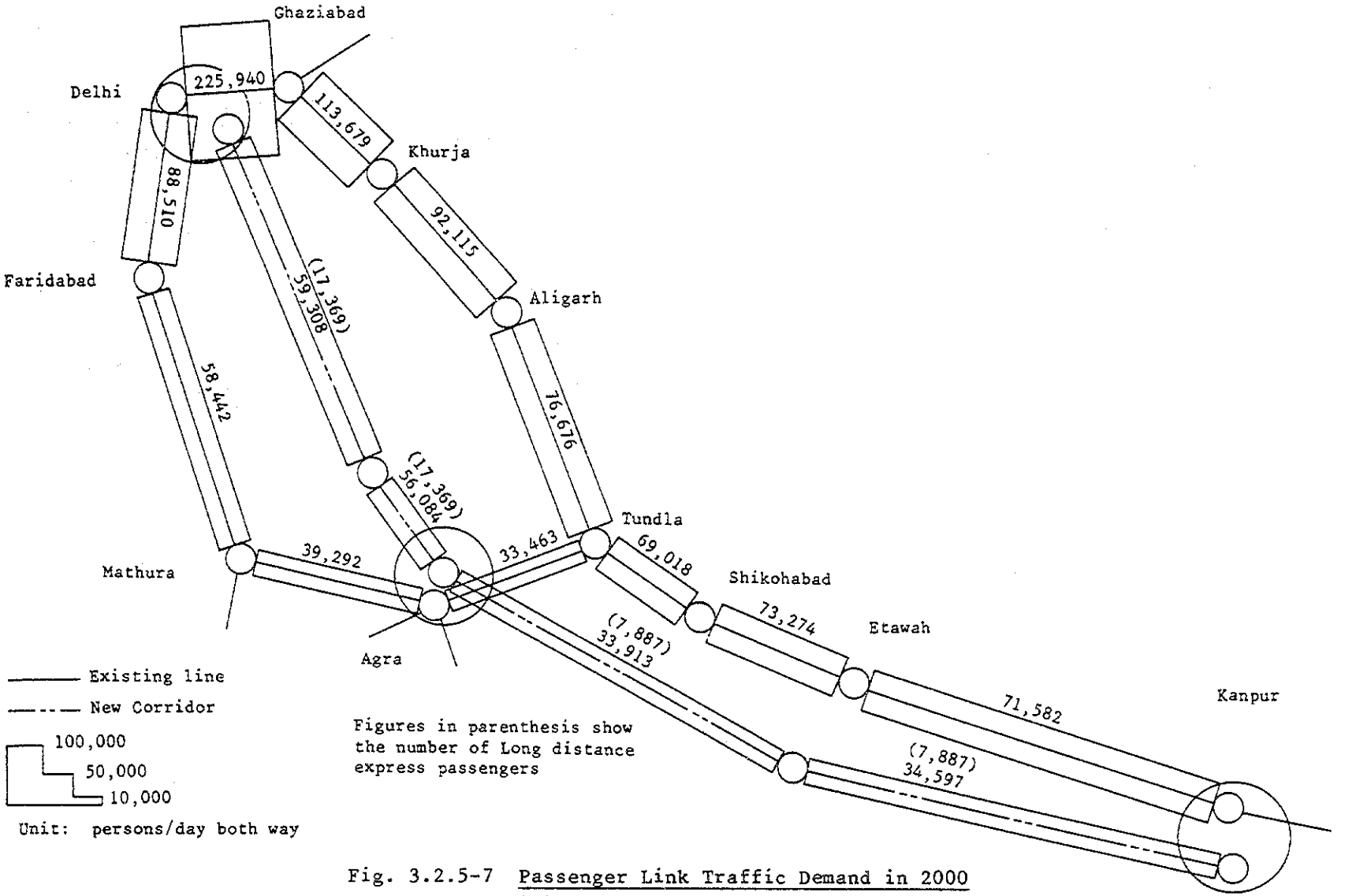


Fig. 3.2.5-7 Passenger Link Traffic Demand in 2000
(With upgrading the Section and New Corridor Construction with 100% fare level)

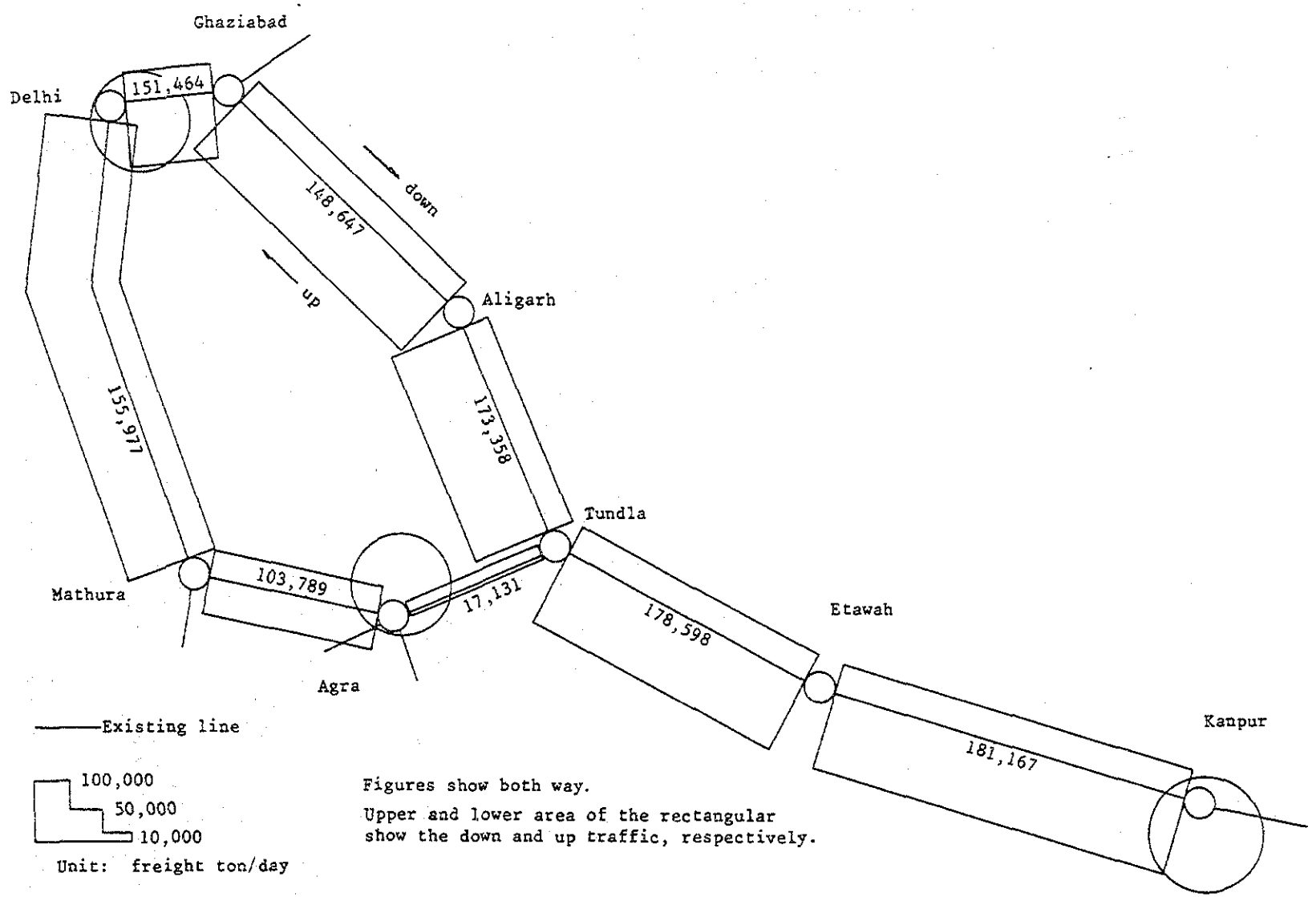


Fig. 3.2.5-8 Freight Link Traffic Demand in 2000

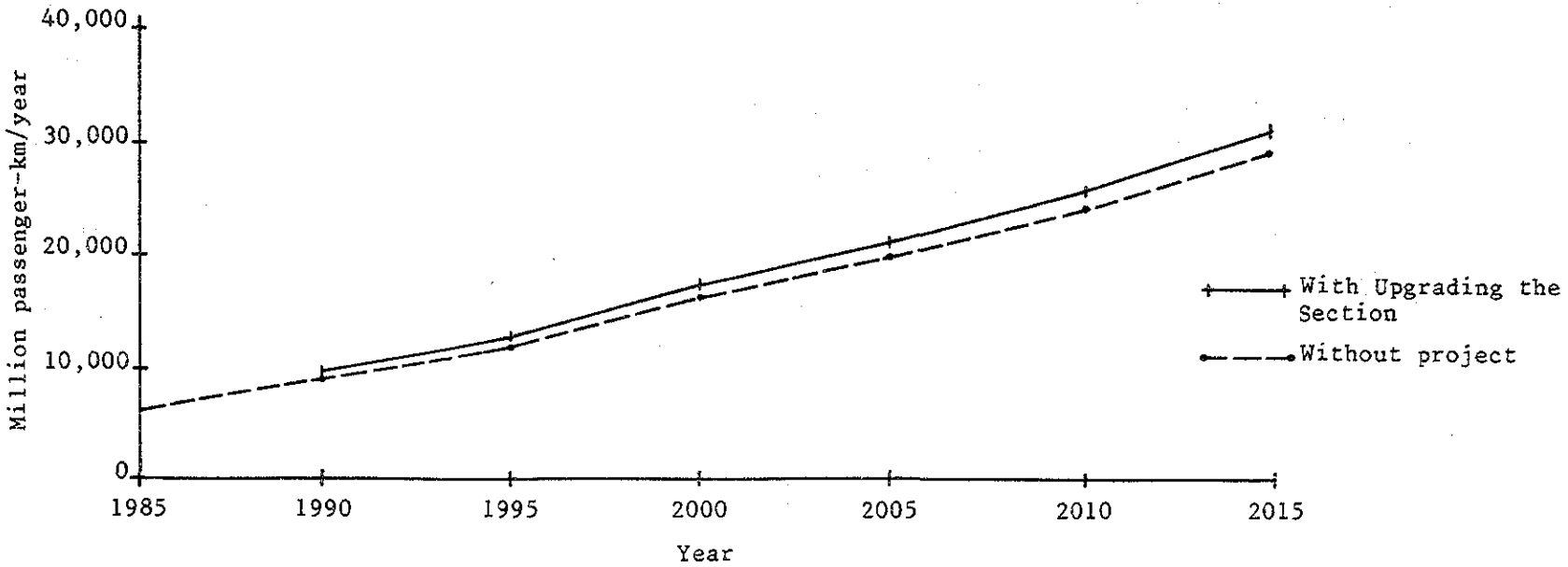


Fig. 3.2.5-9 Future Trend of Passenger Traffic Demand on the Section

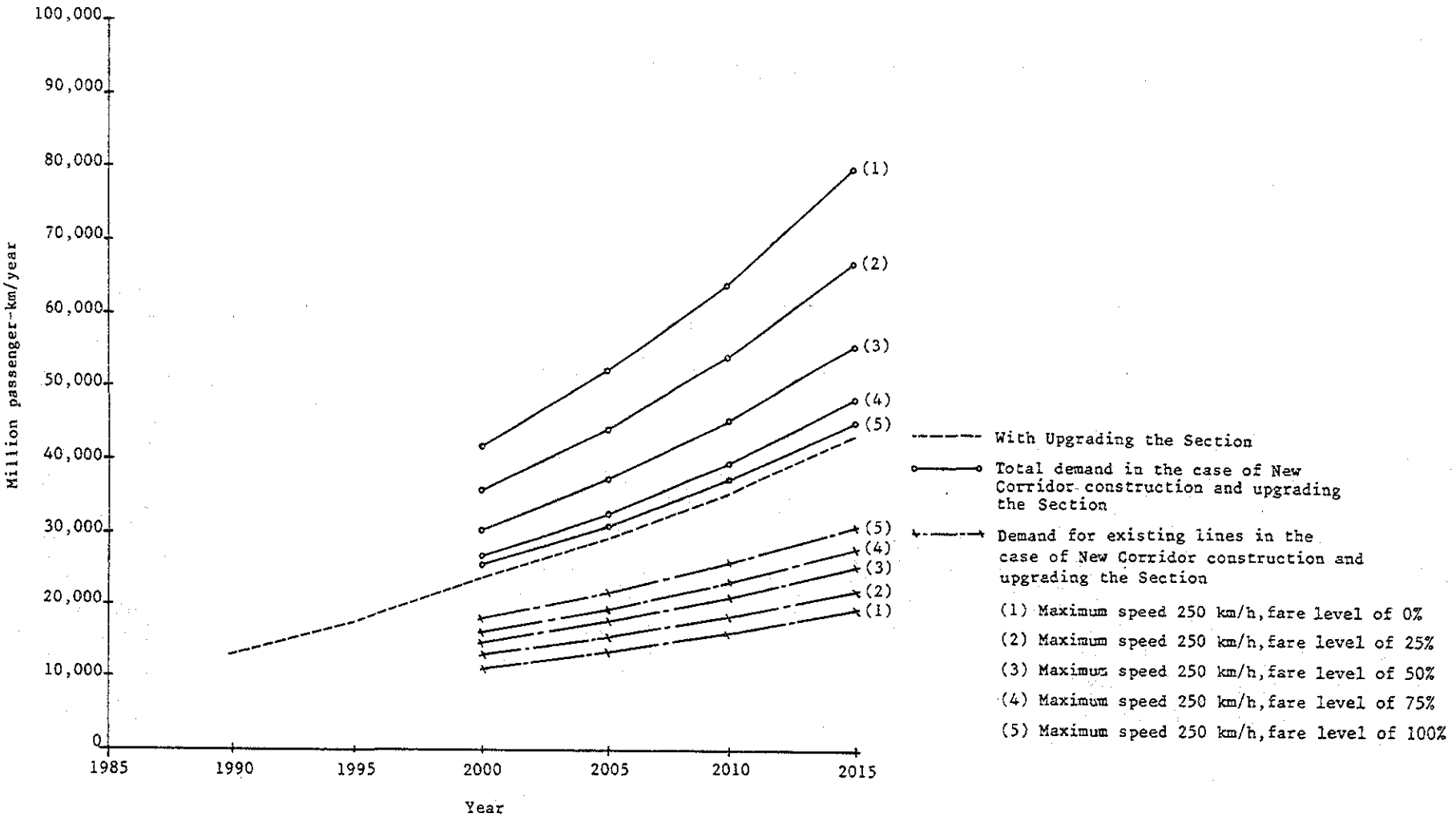


Fig. 3.2.5-10 Future Trend of Passenger Traffic Demand between Delhi and Kanpur, and Delhi and Agra