A PROGRAMMING MODEL FOR INTER-STATE FLOW PATTERN OF FERTILISERS IN INDIA

Dissertation submitted to the Jawaharlal Nehru University
in partial fulfilment of the requirements for
the award of the Degree of

MASTER OF PHILOSOPHY

computer printout

AVINASH CHANDRA JHA

CENTRE FOR THE STUDY OF REGIONAL DEVELOPMENT
SCHOOL OF SOCIAL SCIENCES
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI—110067, INDIA

1988

253

जवाहरलाल नेहरु विश्वविद्यालय
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI-110067

CENTRE FOR THE STUDY OF REGIONAL DEVELOPMENT
SCHOOL OF SOCIAL SCIENCES

CERTIFICATE

This is to certify that the dissertation entitled "A Programming Model for Inter-State Flow Pattern of Fertilisers in India" submitted by Mr. Avinash Chandra Jha, in partial fulfilment of six credits out of the total requirements of twenty-four credits for the degree of MASTER OF PHILOSOPHY of the University, is, to the best of our knowledge, a bonafide work and may be placed before the examiners for evaluation.

[DR. DEEPA SARAN]
Co-Supervisor

[PROF. A.K. MATHUR]
Supervisor

[PROF. A.K. MATHUR]
Chairman

21st July, 1988

Gram : JAYENU Tel. : 667676, 667557 Telex : 031-4967 JNU IN

ACKNOWLEDGMENTS

I take this opportunity to express my deep sense of gratitude to my supervisor Professor A.K. Mathur and Co-Supervisor, Dr. Deepa Saran, from whom I received unstinted encouragement and valuable guidance. My thanks are also due to Professor A. Kundu, for his valuable suggestions from time to time.

I express sincere thanks to librarian and other staff members of Fertiliser Association of India for helping me a lot in this work. I also express my deep sense of gratitude to Mr. V. Muralidhar, who did the computer work with maximum care and to Mr. Gajanan Hegde who gave this dissertation the present form with great care and patience.

I think, I shall be failing in my duty, if I do not express my thanks to all my family members who endured my long absence during this work.

Finally, I bow to the hoary weight of tradition and accept the blame myself for any errors that remains in this dissertation.

Avinash Chandra Jha

AVINASH CHANDRA JHA

CONTENTS

LIST OF TABLES

LIST OF APPENDICES

CHAPTER-I

INTRODUCTION

The increasing importance of inter-regional flows brougtht into prominence several lacunae of traditional trade theory, which was criticised for its virtual neglect of space aspects of economic activity. In order to fill up this gap, theories in location have been formulated from time to time.[1] The synthesis of these two theories, assumes a set of regions about which resources, technologies and tastes about a commodity are given and location of industry is effectively achieved by introducing programming techniques. In this formulation space is treated explicitly and the linear programming technique is applied as a tool of analysis to achieve the results. This formulation can further be specified as minimum transportation effort problem.

The most important factors influencing the choice of location are the cost of transportation (both that of raw material from the source to the point of production and of finished products from the point of production to point of

----

1. See --

a. Losch, A., The Economics of Location (W.H. Woglom and W.F. Stolper, trans), New Haven Yale University Press, 1954.

b. Weber A., Theory of location of Industries. (C.J. Friedrich, trans). The Univerity of Chicago Press, Chicago, 1962.

c. Isard, W., Location and space economy, John Wiley, New York, 1956.

d. Hoover, E.M. The location of economic activity, McGraw Hill, New York, 1948.

consumption) and the availability and cost of labour. There may be many other factors, economic and non-economic, influencing the choice of location for the entrepreneur, but most of them are the result of an established pattern of industrialisation which itself may further lead to imbalanced regional growth as well as growth at a higher cost in terms of national resources. Thus in case of developing economy, where almost every sector has to be established and expanded it becomes very important to have a picture in view as to how the shape of things should turn out and there from to know the gaps to be filled and corrective measures to be taken.

From the point of view of nation as a whole, it must be kept in mind that the cost of labour is not so much a problem as the heavy investment of scarce steel in laying a new railway track, and availability of labour in any region in country like India is also not much of a problem. Thus transportation problem may be singled out as the most important factor causing a heavy drain on the scarce material resources.

This problem of transportation cost can be studied broadly from two aspects static and the dynamic. These can also be termed as long run and short run approaches. The static approach assumes regional requirements and capacities as constant. In short run no change can be brought in these and the optimality therefore can be achieved as a system of distribution which minimises the total cost of commodity, the cost being inclusive of transport. Hence the emphasis is laid on regionalisation and increased efficiency of movement. This can be achieved by finding out the ideal flow pattern that minimises total costs backed by direct control of distribution to achieve it. Alternately, we may ask for a pricing system which will force the producers and distributors to adopt the ideal pattern in order to avoid loss.[1]

The dynamic approach leads us to go a little deeper into the problem of regional economic growth overtime. Here the aim is to find out the optimum localtional pattern in future such that the cost is minimised to the consumer of the product. The location of supply points at the geographically suitable places saves much of cross hauls and traffic movements.

1.1 Objective of the study

The present study is based on static approach of problem of transportation cost. It is an attempt to find the optimal pattern of flow with regional capacities and requirements as given. The aim of supply system for any product should be to match supply with demand both at the

---

1. Ghosh, Ambika, Efficiency in location and inter-regional flows. Cement Industry During athe Five-Year plans 1950-1959, North-Holland Publishing Company, Amsterdam, 1965. p.2.

macro and micro levels in the country. This could be done by ensuring availability of the required quantities of the product at the places where it is required at the correct time and price. Theoretically stated, thus, it can appear as a simple exercise of supplying sufficient quantities of the product all over the country with the back up of production and import of needed quantities. However, this apparently simple exercise often results in highly complex and irrational situation in practice. The complexity and irrationality in the situation is directly proportional to the extent of the area of distribution, the quantity to be distributed, the pattern of demand, the availability of production, imports and above all infrastructural facilities.

The immensity of the problem of transportation in fertilizer industry can be gauged from the fact that it has to be made available to six lakh villages grouped into over five thousand blocks, covering a geograhical area of 1.27 million square miles, from about 103 production points and 28 points of imports. Since by the end of seventh Plan i.e. 1989-90 the consumption of fertiliser is expected to increase up to 32 million tonnes, the problem of its distribution will become more acute.[1]

----

1. Chauhan, K.K.S., "Challenges of Logistics in Seventh Plan: Need for integrated Transport system", Fertiliser News - August 1986. p.12.

A side issue of the problem of transportation in fertiliser industry is that fertiliser demand is highly seasonal with the consumption period being limited to a little over four months in the year. On the other hand the production of fertiliser is carried out for the whole year. Thus it requires an almost impossible dovetailing of production and imports of the 12 months of the year with the limited consumption period.

Location of fertiliser plants give another dimension of the problem of distribution of fertiliser. Location of production facilities for fertiliser could not be decided on the basis of high and low demand pockets in the country as in the case of some other products. Historically, most of the fertiliser factories were located on the coast line while the largest markets are in the up country mainly in the Indo-Gangetic plains. The nitrogenous factories based on naptha were located nearer the oil refineries and the oil refineries themselves were located on the coast due to their dependence on the imported crude.

This scenario is fast changing now. The fuel oil based nitrogenous units like Nangal, Panipat and Bhatinda were located in consuming areas. With the discovery of offshore oil and gas and the decision to construct the HBJ pipeline, six of the new nitrogenous units based on associated gas from Bombay High are also coming up in inland locations right in the midst of the consuming areas. Thus the average lead is expected to come down once all the units based on HBJ pipeline are commissioned. But this will take time and will solve the problem only partially.

Faulty product planning in some of the major production units in the country leads to an anomalous situation of a at least some of the units producing certain types of fertilisers which are not agronomically, required for the zones in which such units are located. This either leads to such products being irrationally made use of by the farmers or being irrationally carted away to far off destination where they are required thereby adding uncalled for burden to the already weak transport system in the economy.

All the above-mentioned factors and shortage of infrastructural facilities contribute in spiralling cost of distribution of fertilisers. Distribution and maketing cost of fertiliser in the country could normally average around 20 per cent of selling prices. The cost of transport from producing centres to consuming centres is the single largest component in the marketing cost accounting under normal condition for 40 per cent of the total cost. This is on the basis of 90 per cent of the product being transported by rail beyond a distance of 300 km. The average lead in the total transport of fertilisers is around 1000 kms. A sample analysis of major fertiliser manufacture in the country indicates that the cost of transportation which accounted for 34.5 per cent of total cost of distribution and marketing during 1976-77 had gone up to around 45.6 percent in 1979-80. Even after fully providing for transport cost inflation during this period the transport element in the distribution and marketing cost of fertilisers cannot justifiably be more than 40 per cent.[1]

As a result of this the amount of subsidy paid on transportation of fertilisers has also gone up steeply. In 1979-80 the subsidy paid on transportation of fertilisers was 28.93 crores which was around 9.02 percent of total subsidy paid on fertilisers. In 1984-85, the subsidy paid on fertilisers increased to Rs.175 crores which was around 19 per cent of total subsidy paid on fertilisers.[2]

Apart from these with the present agriculture development strategy of Government and fertilisers playing the pivotal role in this strategy, it is necessary to pay urgent consideration to the development of ideal least cost fertiliser supply system. This will encourage fertiliser use by minimising the sale price of fertilisers chargeable to consumers and will also reduce the burden of subsidy on

----

1. Pushpraj, K., A Rational supply planning system for fertilisers. Proceedings of FAI Annual Seminar - FAI Publication, New Delhi. 1980.

2. Mittal, V. Strategies of cost Reduction in logistics of fertilisers Distribution. proceedings of FAI Annual Seminar 1984 - FAI Publication, New Delhi, p.49.

the public exchequre. Keeping the above-mentioned unique features of fertiliser industry in mind, this industry has been selected for the present study.

1.2 Period of study:

This study has been done for two points of time i.e. 1979-80 and 1985-86. These two points of time have been taken keeping in mind that during this 5-6 years period a number of new plants have come up in inland areas. Therefore, it is interesting to see the change in flow pattern of fertilisers due to this change in the pattern of location of fertiliser plants.

1.3 Data base

All the data used in this study have been obtained from secondary sources. Most of the data for this study have been obtained from the Fertiliser Association of India publications like Fertiliser Statistics, Fertiliser Marketing News and Fertiliser News. The data for portwise arrival of fertilisers have been obtained from the Ministry of Agriculture, Government of India.

1.4 Framework of the study

The framework of the study is as follows:

In Chapter II an in-depth study of changes in production and consumption patterns of fertilisers over time in India has been undertaken.

In Chapter III, the programming technique for application in our model has been developed. This chapter also deals with certain assumptions which have been made for this study.

In Chapter IV an ideal flow pattern for different types of fertilisers has been obtained by using the technique of linear programming and then it has been compared with the actual flow pattern of fertilisers.

In Chapter V, certain conclusions have been drawn about the flow pattern and location of units in the fertiliser indutry on the basis of the present study.

1.5 Literature Survey

As the data which are required for this type of study are not readily available, therefore, there is paucity of work of this type. Most of the studies of this type were undertaken in late sixties and early seventies.

L. King, E. Casetti J. Odland and K. Semple in their paper "Optimal Transportation Patterns of coal in the Great Lakes Region" tried to find out an optimal transportation pattern of bitumenous coal in Great lakes region of the United States and Canada.[1] This study has investigated

----

1. King L., Casetti E., Oldland J., Semple K., "Optional Transportation Patterns of coal in the Greak Lakes Region", Economic Geography, Vol.47, No.3, 1971. pp.401-413.

least cost flows of bitumenous coal from 15 mining districts to 19 receiving centres surrounding the Great Lakes area. Since at the time, when this study was undertaken, operational form of linear programming model for a problem of the size involved in the study were not readily available with the authors thus they have done their study on the basis of Fulkerson's "Out of Kilter Algorithm".

F.E. Hopkins in the paper "Taransportation cost and industrial location : An analysis of the Household Furniture Industry", had done a similar type of study for household furniture industry of New York[1]

In India the most pioneering work in this field has been done by Ambika Ghosh in his study "Efficiency in Location and Inter-regional flows".[2] This study has been done for the Indian Cement industry for the period of 1950-59. Dr Ghosh has tried to obtain an optimal flow pattern of cement industry by using linear programming technique and has then compared it with the actual flow pattern. He has discussed about the use of programming technique to develop

----

1. Hopkins, F.E., "Transportation cost and Industrial Location: An Analysis of the Household Furniture Industry", Journal of Regional Science, Vol.12, No.2, 1972.

2. Ghosh, Ambika, Efficiency in Location and Inter-regional Flows, North Holland Publishing Company, Amsterdam, 1965. pp.261-277.

locational criterion for new installation. In this study the author has tried to develop a model on a multi-sectoral, multi-regional basis for a more comprehensive treatment of the interdependent aspects of regional allocations and general industrial development.

L.C. Mahajan and Mrs Meena in their paper "Transport Cost Minimisation of Fertiliser Distribution in Punjab" has tried to find out a least cost transportation system of fertilisers in Punjab for 1970-71.[1] They have tried to obtain this optimal flow model on the basis of projections of demand and supply of fertilisers. Researchers in their study have taken seven points of production which are in or around Punjab and apart from that, Kandla has been taken as a point of import. Taking these eight points of origin Mr Mahajan has tried to find out a least cost system of supply for all the districts of Punjab.

Narain Das and D.B. Sardesai in their paper "Location of Industries in India: Transport cost minimisation", have tested a methodology based on input output analysis and linear programming for determining the optimal location of industries in various regions from the point of view of transport cost![2] Five commodities have been selected for

----

1. Mahajan, L.C. and Mrs. Meena, "Transport cost Minimisation of Fetilizer Distribution in Punjab", Fertiliser News - May 1967, FAI Publication. pp.35-42.

2. Das, Narain and Sardesai, D.B., "Location of Industries in India - Transport cost minimisation", Arth Vijnana, Vol.9 (Special Issue), 1967. pp.177-183.

this study whose industrial location has been tested in four regions. They have assumed uniform production relations in all the regions and have also assumed that no cost is involved for intra-regional movements and all movements of commodities are catered by railway. But as the authors have themselves mentioned this study is only illustrative of the procedure used and have no substantive significance.

Last study which we would like to discuss here has been done by P.N. Mathur and S.R. Hashim in their paper "A model for location of industries and inter-regional commodity flows".[1] The model which has been developed on 1959 data, gives a static picture as to what the situation should be, given the location of natural resources, the region- wise demand of various commodities and a technique of production. The authors have taken 23 sectors and 4 regions in the perview of their study.

After surveying this literature, we can conclude that not much work has been done in this field and a lot has yet to be done in this direction.

1.6 Limitations of the study

Due to the paucity of data required for this study and time constraint, there are certain limitations in this study.

---

1. Mathur P.N., and Hashim, S.R. "A model for Location of Industries and Inter-Regional commodity Flows," Indian Journal of Regional science, vol.1, No.1, 1968, pp.24-36.

The actual movement of fertiliser takes place in material terms. However, since the data of consumption are not available in terms of materials, therefore, this whole study is based on the data of nutrient terms of fertiliser.

The study could have been more appropriate and reliable if all the 103 points of production and 381 districts of consumption would have been under taken in this study. But since the capacity ofthe computer available with researcher was not capable of handling matrix of such a huge dimension, the scope of this study is limited to state level.

Due to the same reason, some ofthe states which do not produce fertiliser and whose consumption of it is also very low, like, Tripura, Meghalaya, Manipur and Himachal Pradesh, have not been included in this study. The import of fertilisers is done from 28 ports of the country. But again for the same reason only four major ports namely, Calcutta, Bombay, Madras and Kandla are assumed to handle all the imports. These four ports have been selected on the basis of their geographical location and amount of fertiliser which arrives on these ports.

Since the data of movement by roads and its rates are not readily available, in the present study it has been assumed that total movement of fertilisers is done by railways only.

Another limitation of this study due to time constraint is that no attempt has been made in this study to obtain an ideal flow pattern on the basis of future projections of demand and supply.

In spite of these limitations, this study is an attempt to give an insight into the flow pattern of fertilisers in India.

CHAPTER-II

FERTILISER INDUSTRY: A BACKGROUND

In order to gauge the problem of transportation of a commodity it is very necessary to have an indepth idea about the production and consumption pattern of that cmmodity. It is also important to have an idea about comparative production and consumption pattern of that commodity in different regions. Thus the present chapter is an attempt to study the production and consumption pattern of fertilisers over the years. A comparative survey of production and consumption pattern of fertilisers in different states has also been done in this chapter.

2.1 Growth of Fertiliser Industry

The fertiliser industry in India has come a long way since the first super phosphate factory with a capacity of 6400 tonne P_2O_5 per annum was established in 1906, and the first synthetic ammonia production was set up in Belagula, Mysore in 1941. This was followed in 1946 by the state government of Travancore under the name of Fertilisers and Chemicals Travancore Ltd. at Undyogmandal (near Cochin) where wood was used as feedstock for ammonia production. In the wake of great famine of Bengal in 1943, the government decided an all out effort to step up food production. It was recognised that chemical fertilisers could play a crucial part towards the attainment of this objective. The plans to set up the first large ammonium sulphate plant at Sindri were thus conceived. While Sindri was being planned, it became apparent that more such units would have to be set to keep pace with expanding requirements of nitrogenous fertilisers. Two committees set up by the Government of India went into the details of new locations and capacities for expanding production, came out with recommendations for putting up fresh nitrogenous capacities at Nangal, Trombay, Namrup, Rourkela, Gorakhpur, and Neyveli based on different available feedstocks.

Fertiliser industry got a further impetus in sixties due to the advent of sreen revolution in Indian agriculture, which was based on HYV seeds and fertiliser. Due to green revolution a pressure was built on consumption of fertilisers. In order to meet this growing demand of fertilisers new technologies were developed in this industry which were cheaper and suitable for the existing conditions in the country. Until sixties, small phosphatic units were set up principally by private sector entrepreneurs like Parrys, JK Chemicals and Dharamdasi Morarji, but the more costly nitrogenous plants has been essentially set up in public sector. When the newer processes based on the use of light petroleum feedstock like naptha began to gain decisive advantages and offer possibilities of cheaper fertiliser production, private sector also initiated action in setting up fertiliser plants namely, EID - Parry in Madras in 1963 followed by GSFC Baroda (1967) India Explosives Kanpur (1969). The first co-operative sector plant was set up in

1975 at Kalol by Indian Farmers and Fertilisers Co-operative Ltd.

The Indian Fertilisers scene has been continually expanding and embracing a whole range of fertiliser technology using a wide spectrum of feedstock and producing a vast array of products. Today the Fertiliser Industry occupies a pivotal position in the country and in nitrogenous and phosphatic fertilisers India ranks as the fourth and fifth largest producer respectively in the world.

The built-up in terms of nutrient capacity as well as the number of units may be seen from Table 2.1.

Table: 2.1

Total capacity and number of operating Fertiliser factories N and P_2O_5 (1951-52 to 1986-87)

Year	Cumulative capacity (.000 tonnes N)	Number of plants 'N'	Cumulative capacity '000 tonnes P_2O_5	Number of plants P_2O_5
1951-52	89	4	28	11
1961 62	246	8	107	17
1971-72	1,487	20	534	33
1980-81	4,586	36	1,330	51
1981-82	4,732	37	1,469	52
1982-83	5,174	39	1,492	58
1983-84	5,200	40	1,614	63
1984-85	5,592	41	1,768	66
1985-86	6,695	47	1,953	75
1986-87	6,880	47	2,214	84

Source: Fertliser Scene in India, July 1987, FAI.

As is clear from the above table, there has been around 78-fold increase in the installed capacity of fertiliser nutrients in our country.

The sector-wise break-up of nitrogenous and phosphatic fertilisers in 1986-87 has been shown in Table 2.2.

Table: 2.2

Sectorwise capacity of Fertiliser Industry
(1986-87)
(April-March)

Sector	Capacity ('000 tonnes)			
	N		P_2O_5	
Public	3,846	(55.8)	777	(35.1)
Private	1,836	(26.7)	1,128	(50.9)
Co-operative	1,198	(17.4)	309	(14.0)
Total (All India)	6,880	(100.0)	2,214	(100.0)

Figures in brackets represent percentage share to total capacity.

Source: Fertiliser Scene in India - July 1987. FAI

It is clear from Table 2.2 that of the total capacity of 6.9 million tonnes, 56 per cent is in public sector followed by 27 per cent in private sector and nearly 17 percent in the co-operative sector. In phosphate, however, as much as 51 per cent of the total capacity is in private sector followed by 15 percent in public sector and 14 per cent in co-operative sector respectively.

2.2 Technology Profiles

An interesting feature in the development of fertiliser production in India is the optimisation and use of indigenously available feedstock and raw materials. India has the unique experience of having used a large variety of feedstocks for ammonia production which includes coke, lignite electrolytic hydrogen, coke oven gas, naptha natural gas, fuel oil and coal. Choice of feedstock at different points of time was dictated by various factors, like availablility of raw materials, processes, technology, etc. which determined commercial viability and social purpose. The preference of light hydrocarbon feedstocks like naptha or natural gas was to a great extent influenced by several sophistications which were introduced in the technology for production of ammonia starting from such feedstocks. This included use of several new types of catalysts which made the processing more efficient in feedstock and fuel utilisation. One major distinctive feature of the new technologies was that whereas the older processes at Sindri used nearly 2000 kwh of power per tonne of ammonia and 1400-1500 kwh at Trombay, Gorakhpur etc. the new process using centrifugal compressors reduced this requirement to 40-50 kwh. and in the newer plants down to 10-20 kwh tonns of ammonia. The developmentof large single stream units of 600, 900 and 1350 tonne/day of ammonia capacity enabled the investment and operating costs to be reduced significantly.

Durgapur was first of such plants during this new era in planning. This was quickly followed by plants at Cochin, Madras, Namrup, Expansions and Barauni, Goa, Haldia, Trombay Expansion and Kalol which were also based on new technology. An overall review during 1968 showed that a point was fast approaching when naptha allocations for fertiliser production might shrink domestic availability and with increasing demand on crude it was apprehended that petroleium and its products might ultimately be priced out of reach of countries like ours and therefore steps were taken to revive schemes for coal based ammonia plants. Coal based plants were sanctioned at Ramagundam, Talcher and Korba in 1970. While the first two projects were taken up for implementation the third one at Korba has been kept in abeyance pending, stabilisation of the actual performance of the other two projects. At the same time, in view of the uncertainities of success of the coal based projects and felt need for additional production of nitrogenous fertiliser, it was examined as to which petroleum based feedback would involve the least amount of foreign exchange outgo; in case imports of feedstock became inevitable. The best choice was found for high sulphur heavy stock and five units were sanctioned to be set up at Panipat, Bhatinda, Nangal, Sindri and Bharuch. The lignite based plant at Neyveli was also switched over to fuel oil. After the large finds for associated and natural gas inter alia in Bombay High and south Basin regions in the later part of the seventies Government took a decision to base the new capacity predominantly on natural gas as preferred feedstock.

In case of phosphatic fertiliser the case is slighly different. Considering that both the principal inputs for phosphatic production, namely, rock phosphate and sulphur had to be essentially imported and taking into account the compulsion to maximise foreign exchange savings during the early sixties, production of nitrophosphate was considered for minimising sulphur requirements. During 1978, extensions were made and in Trombay-IV, Calcium nitrate freeze out method for furnishing nitrophosphate with 60 per cent water solubility was adopted. Another nitrophosphate plant is under commission at Haldia. Another approach to minimise the import of sulphur was endeavoured in utilising the indigenous sources of sulphur bearing material i.e. iron pyrites and smelter gas from metallurgical operations to produce sulphuric acid for rock solubilisation. Pyrites based sulphuric acid plant was set up at Sindri and 5 units based on zinc/cooper smelter gas were set up at Khetri, Udaipur, Ghatsila, Vizag and Udyogmandal. At Sindri and Khetri it was decided to produce triple super phosphate with high nutrient content of 46 percent P_2O_5. The options for raw materials for phosphatic fertiliser are limited. The available reserve for rock phosphate in India is of the order of 100 million tonnes. About 0.5 million tonnes rock phosphate is used from indigenous sources, which in terms of nutrient amounts to barely 18 to 20 per cent of our P_2O_5 production. For the rest the country is dependent upon imports be it in the form of rock phosphoric acid or finished fertilisers several plants in India are based on imported phosphoric acid. It was considered preferable to locate complex fertiliser plants which involve importation of raw materials, on coastal locations and consequently suitable locations like Kandla, Goa, Cochin, Madras, Tuticorin etc. were chosen.

2.3 Capacity Utilisation

As we have seen in the earlier part of this chapter there has been a subtantial increase in the installed capacity of fertilisers in our country. But apart from that the overall rates of capacity utilisation have also improved substantially thereby augmenting country's production capability even further. In nitrogenous fertilisers, for instance, as against capacity utilisation rate of just 62 per cent a decade ago, the overall performance rate increased to 79 per cent in 1986-87 (Appendix-I). In phosphatic fertilisers too the increase in the operating rate was phenomenal from 45 per cent to 81 percent in 1986-87. A significant feature of increasing production performance has been a substantial jump in the capacity utilisation rate for the public sector from below 56.3

percent in 1981-82 to 65 percent in 1986-87 in respect of nitrogenous fertilisers (Appendix-2). In phosphatic fertilisers too the capacity utilisation rate in the public sector increased from 45 per cent in 1981-82 to about 72 percent in 1986-87.

The last one decade has also seen improved performance of the industry touching a much wider cross-section of the plants. In nitrogenous for instance, the number of plants operating at above 80 percent capacity utilisation rate increased from just 5 in 1976-77 to 20 in 1986-87 (Appendix-3). Those operating above 90 percent capacity utilisation also increased significantly from 4 to 9 during the same period.

But an intriguing fact about capacity utilisation in fertilisers is that if we see the zone-wise capacity utilisation we find that capacity utilisation level for both the fertilisers are very low in East zone. In case of nitrogenous fertiliser the capacity utilisation in East zone was as low as 37 percent in 1983-84 and has plummeted down further to 35 percent in 1985-86 (Appendix-4). However, in case of phosphatic fertiliser there has been considerable improvement from 12 percent in 1983-84 to 59 percent in 1985-86. In case of western zone the capacity utilisation level for both types of fertilisers was as high as 90 per cent in 1985-86.

If we look into the reasons for the loss of production, we find that production at various plants was affected mainly due to equipment and power problems. Equipment breakdown continued to be predominant factor accounting 47.4 per cent of nitrogenous and 26.8 per cent of phosphatic loss during 1985-86 (Appendix-5). Problems relating to failure of equipment were mainly due to ageing of plants. Inadequate and poor quality of power supply adversely affected performance of several plants. The major equipment problems were experienced with compressors turbines, heat exchangers, reformers and catalysts etc. other problems like process/operation problems and extended turn around jobs also affected production at some units.

2.4 Consumption of Fertiilisers

Even though growth of fertiliser consumption in India may have been somewhat erratic on a year to year basis, it shows a consistent and substantial increase on a long term basis.

Fertiiliser nutrient consumption increased by over 65 thousand tonnes per annum during the decade ending 1965-66. The rate of increase escalated to over 210 thousand tonnes per annum during the next decade. The increase in absolute terms since 1975-76 has been about 538 thousand tonnes per annum. Fertiliser nutrient consumption increased from nearly 130,000 tonnes in 1955-56 to nearly 8,737,000 tonnes in three decades ending 1985-86.

A glance at the Table - 2.3 gives details of consumption of all types of fertiliser nutrients during this period.

TABLE-2.3

All India Consumption of N, P_2O_5 and K_2O (1951-52 to1986-87)
(unit: Thousand tonnes)

Year	N	P_2O_5	K_2O	Total $N+P_2O_5+K_2O$
1951-52	58.7	6.9	-	65.6
1955-56	107.5	13.0	10.3	130.8
1960-61	211.7	53.1	29.0	293.8
1965-66	574.8	132.5	77.3	784.6
1968-69	1208.6	382.1	170.0	1760.7
1972-73	1839.0	581.3	347.6	2767.9
1973-74	1829.0	649.7	359.8	2838.6
1978-79	3419.5	1106.0	591.5	5116.9
1979-80	3498.1	1150.9	606.4	5255.4
1980-81	3678.1	1213.6	623.9	5515.6
1981-82	4068.7	1322.3	676.2	6067.2
1982-83	4224.2	1435.2	726.5	6386.6
1984-85	5486.1	1886.4	838.5	8211.4
1986-87	5860.5	2089.9	869.7	8815.8

Source: Ministry of Agriculture, New Delhi.

The year 1983-84 marked a watershed year in the history of fertiliser consumption in India with an unprecedent increase of over one million tonnes (nutrients). Quite apart from being an excellent year from the point of view of weather, this order of increase also brought into the sharper focus the role of appropriate Government policies and the industry in giving a boost to fertiliser consumption.

While the tempo of the growth was more or less maintained in kharif 1984, the period thereafter has unfortunately not been quite promising from the point of view of fertiliser consumption. It is indeed logical to expect that the rate of growth of consumption in percentage terms would decline with the base increasing during each succeeding period. That would in fact explain the rate of growth of 50-, 27 and 21 percent during the period ending 1965-66,1975-76 and eight year period ending 1983-84 (Table: 2.4)

However, the fact remains that the Indian agriculture has acquired the necessary resilience as has been amply demonstrated by recent experience when despite drought for three consecutive years, fertiliser consupmtion and consequently food grain production could be sustained at reasonably high levels.

Table - 2.4

Consumption of Fertiliser nutrients ($N + P_2O_5 + K_2O$) 1955-56, 1965-66, 1975-76, 1983-84 and 1986-87

Year	Consumption ($N+P_2O_5+K_2O$) ('000 tonnes)	Average change per annum over previous quoted year	
		In absolute terms ('000 tonnes)	Average rate of growth
1955-56	130.8	-	-
1965-66	784.6	65.4	50.0
1975-76	2,893.6	210.9	27.0
1983-84	7,710.1	602.1	20.8
1986.87	8,815.8	368.3	4.8

Source: Fertiliser Scene - July 1987, FAI.

2.5 Pattern of Fertiliser Consumption

A survey of cropwise and regionwise consumption pattern of fertilisers in our country reveals the fact that it is highly skewed. Table 2.5 shows the results of survey done by NCAER in 1975-76.

This survey clearly brings out the fact that more than 80 percent of fertiliser consumption is on cash and irrigated crops like wheat, rice and sugarcane etc. While the latest trends are not easily availale but it is more likely that the pattern of consumption continues to be skwed towards irrigated crops.

Table: 2.5

All India Cropwise consumption of Fertiliszer nutrients

Crop	Share of total fertiliser consumption
Paddy	40.5
Wheat	24.2
Sugarcane	8.7
Groundnut	2.2-
Cotton	6.7
Other crops	17.7
Total	100.0

Source: Fertiliser Scene - July 1987 - FAI

A close survey of area-wise consumption pattern of fertilizers reveals that the consumption pattern is highly skwed area wise also. A glance at Table 2.6 makes this fact clear.

In the past the fertiliser consumption has grown in selected regions notably in Punjab, Haryana, Western U.P. as also in parts of Andhra Pradesh, Maharastra and Tamil Nadu. In 1983-84 only 24 out of over 400 districts in the country accounted for as much as 25 per cent of total fertiliser consumption. Of these 24 districts as many as 9 were from Punjab, 5 from A.P., 3 from Maharashtra, 2 each from Haryana, Tamil Nadu and one each from Gujarat, Karnataka and

Table: 2.6

Zone	Share in		Growth rate of Fertiliser consumption (Annual consumption)	
	Area	Fertiliser	1976-77 to 1978-79	1982-83 to 1983-84
Central	36.58	27.7	19.7	19.1
Eastern	16.49	9.7	17.9	32.8
Northern	6.39	23.0	25.1	14.3
Southern	21.56	27.2	23.0	22.9
Western	18.96	14.4	20.0	36.6
All India	100.00	100.0	22.5	21.7

Source: Fertilizer Statistics - 1984-85 . FAI

U.P. The disparities in fertiliser consumption are so large that the northern region which accounts for 6.4 per cent of net sown area accounted for 23 per cent of fertiliser consumption during 1980-83 while Eastern region which accounts for 16.5 per cent of net sown area accounted for only 9.7 per cent of fertiliser consumption during the same period. The rate of fertilizer consumption in northern region was around 68.3 kg/hectare which was around 4.5 times of Eastern region in 1979-80 (Appendix 6). By 1985-86 this difference has declined but still the difference is around 2.5 times. In 1984-85 only 5 states accounted for nearly 60 per cent of total fertiliser consumption, the percentage share of each state being U.P. 9.8 percent, Punjab 12.7 percent, Andhra Pradesh 11.6 per cent, Tamil Nadu 8.1 percent and Maharashtra 7.1 percent. However, in recent years there has been a considerable improvement in consumption level of fertilisers in Eastern India but still it is far behind the north western region. The reason is obviously the skwed pattern of spread of Green Revolution.

2.6 Comparative Study of Production and Consumption Pattern of Different States

As stated earlier, the location of fertiliser plants is raw material based. As a consequence the major fertiliser plants of our country are generally located in coastal areas. In the preceding part of this chapter we have observed that consumption pattern of fertilisers in our country is highly skwed and the major consuming areas are in northern parts of the country. As a consequence of these two factors there is major imbalance in the production and consumption pattern of fertilisers in different states. A survey of the data of production and consumption of fertilisers of different states for two points of time 1979-80 and 1985-86 reveals this fact clearly (Appendices 7 and 8). In states likes U.P., Bihar, Andhra Pradesh, Punjab, Haryana, and West Bengal there was huge deficit of fertilisers in 1979-80. This deficit continues to exist in 1985-86 also even though a large capacity has been created in these areas during this six years period. It has happened so because the consumption of fertilisers in these states has gone up more rapidly than the production.

Kerala, Tamil Nadu, Gujarat and Goa are the four states where we find huge amount of surplus of both the fertilisers at both the points of time. In Assam, we find surplus of nitrogenous fertiliser at both the points of time. In Maharashtra there was surplus production of P_2O_5 in 1979-80 but in 1985-86, this trend is reversed and there is surplus in nitrogenous fertiliser but deficit in P^2O^5, Orissa and Rajasthan has also surplus production of nitrogenous fertiliser at both the points of time, but this surplus is of very little amount.

Continuing the old raw material based location pattern, the new capacities have mostly been created in coastal states like Gujarat, Tamil Nadu and Kerala and as we have seen earlier the consumption in these states has not gone up rapidly as production, thus the surplus continues to exist in 1985-86 also and rather it has gone up during this period. Hence from a comparative analysis of consumption and production pattern of different states we reach to conclusion that there is major imbalance in production and consumption pattern of different states and this imbalance continues even after creation of capacity of major amount in northern region of the country during this six years period.

This imbalance in the production and consumption necessitates huge amount of cross haulage of fertilisers, thus putting a heavy pressaure on the transport system of the country.

2.7 Imports

Although the production of fertilisers has gone up considerably in last thirty years but still around thirty per cent of the total consumption of fertilisers is met through imports. Since the raw materials required for the production of potassic fertiliser is not available in our country thus the total consumption of this fertiliser is met through imports only.

A glance at the Table 2.7 reveals the fact that a large amount of foreign exchange is being spent on imports of fertiliser.

It is clear from the table that there has been a sharp increase in the imports of fertiliser after 1966-67. There has been big hike in value of imports in 1985-86. This hike has taken place due to sharp increase in the prices of pertroleum products in the world market. The share of fertilisers and fertiliser materials in total imports of the country in 1985-86 was around 7.3 per cent.

Table: 2.7

Imports of N, P_2O_5 and K_2O (in '000 tonnes)

Year	N	P	K	Total N,P,K	Total value of imports (Rs.million)
1955-56	53.0	-	10.0	63.0	73.3
1960-61	399.0	-	20.0	419.0	121.8
1965-66	326.0	14.0	77.7	413.0	411.9
1966-67	632.0	148.0	118.0	898.3	1288.2
1967-68	867.0	349.0	270.0	1486.0	1933.0
1968-69	844.0	138.0	213.0	1195.0	1629.0
1973-74	659.0	213.0	370.0	1242.0	1767.5
1978-79	1233.1	243.5	517.4	1994.0	4600.0
1979-80	1295.3	763.1	473.2	2005.6	5545.0
1985-86	1615.8	804.8	893.8	3314.4	14050.0

Source: Fertiliser Stastics, 1986-87 . FAI

2.8 Future Programme of Development of Fertiliser Industry

Notwithstanding rapid growth of fertiliser industry during the past and recent decelaration in fertiliser consumption, India will continue to be deficit in fertiliser availability and the consequent need for imports to meet the gap. Consequently, there is need for further increase in capacity and improvement in capacity utilisation rates to meet the challenge of growing fertiliser demand. While all out efforts are being made by the fertiliser units to further improve their operating rates including debottle-necking, modernisation, rehabilitation packages in several old vintage plants and above all installation of captive power generation units to tide over the difficulties created by erratic and undependable power supply from grid the government has also formulated massive plans to make new additions to capacity consistent with the projected requirement for fertilisers.

Quite apart from the four gas based units at Thal and Hazira, each complex of 1.5 million tonnes urea capacity, which have already been commissioned and are in operation, six more gas based fertiliser plants proposed along the HBJ pipeline route are in various stages of commissioning. While the fertiliser plant at Guna being executed by NFL has already been commissioned, Aonla and Sultanapur two other gas based projects, the former in the co-operative and later in the private sector have already made substantial progress and are likely to be commissioned by the end of this year. The remaining three gas based projects besides Nagarjuna now under implementation are also likely to be completed in next 3 years.

In the field of phosphatic fertilisers also substantial addition to capacity has been envisaged involving setting up of 3 coastal plants based on imported phosphoric acid, four expansions and four plants based mainly on indigenous raw materials pyrites and rock phosphate. Of the new DAP plants, the GSFC plant are Sikka and Hindustan lever plant at Haldia have already been commissioned while the Godavari Fertilisers plant at Kakinada has made significant headway towards commissioning. On the expectation that these projects will concretise by the end of the seventh plan period, the nitrogen capacity in the country would have reached to a level of 9.3 million tonnes and that of phosphatic fertilisers to a level of 2.9 million atonnes.

2.9 Problems of Fertiliser Industry

As we have seen in the earlier parts of this chapter fertiliser industry has made commendable progress in last few decades and government has also made a very ambitious plan for future progress of this industry. But this industry is also beset with certain chronic problems like rising subsidies and resource constraints.

Resource Constraints : The production of fertiliser is highly capital intensive. The present investment in fertiliser industry is around Rs.6,950 crore (at current cost). Assuming that about 85 percent of the new ammonia capacity will be based on gas and end product will be urea, the additional investment for nitrogenous fertilisers alone will be about Rs.5,200 crore up to 1991 on current price basis. Similarly assuming that new phosphatic fertiliser plants will be based on ammonium phosphate of which about half produced from our own phos acid and balance on imported phos acid, the investment on phosphatic fertiliser plants will be about Rs.1,200 crores by 1991.[1]

This by no means appears to be a small task. As would be clear from Table 2.8, the investment per annual tonne has increased more than four fold during the past two decades.

Table: 2.8

Investment per Annual Tonne Nitrogen

Year	Average investment per annum tonne 'N' (in Rs.)
1965	3,400
1969	3,867
1974	5,855
1976	6,052
1979	9,787
1981	10,920
1982	11,360
1985-86	13,420
1986-87	14,340

Source: Fertiliser Scene July 1987 - FAI

----

1. Fertiliser Scene in India, July 1987, FAI.

This has been the result of mounting inflation all over and in particular increase in the cost of plant and machinery. The existence of various duties including custom on imported equipment and excise duty on indigenous equipment as well as high interest rates have also contributed significantly to higher investment cost.

Financing of the foreign exchange component of the cost of fertiliser projects, which is any where in the range of 30-40 percent for projects currently under implementation, is another area where difficult choices will have to be made in view of deteriorating balance of payment position, drying up of concessional sources of finance and rampant insistence by international financial institutioins, such as world bank, IFC, ADB, etc., on certain 'Conditionalities' which no developing country would like to risk. Already the government has expressed reservations about meeting 50 per cent of the free foreign exchange cost of new gas based plants in view of the difficult balance of payments situation and incipient repayment obligation of IMF loan.

Subsidy: The rising fertiliser subsidy burden and pressures mounting from various quarters, including the international agencies, to eliminate the subsidies pose another serious challenge to the realisation of ambitious targets laid down in the seventh plan in terms of capacity creation and fertiliser consumption. Table 2.9 gives clearcut idea about the sharp increase in fertiliser subsidy in last six years.

Table: 2.9

Fertiliser Subsidies (in Rs. crores)

Year	Subsidies on imported Fertiliser	Subsidies on domestic production	Total
1979-80	282	321	603
1980-81	335	170	505
1981-82	100	275	375
1982-83	55	550	605
1983-84	142	900	1042
1984-85	727	1200	1927
1985-86	324	1600	1924

Source: Fertiliser Statistics 1986-87

As is clear from this table, after 1983-84, there has been a very sharp increase in amount of fertiliser subsidy.

The conscious policy to keep fertiliser prices low without at the same time affecting the viability of existing capacity and generation of new capacity has led to this significant increase in fertiliser subsidy from government exchequer. This situation has arisen because of the consumer price which determines net realisation of the fertiliser unit (consumer price - distribution margin) in a majority of the cases has been lower than the ex-factory individual retention prices. The subsidy on indigenous fertilisers which reached a level of Rs.1700 crores in 1986-87 is expected to increase further in view of projected increase in production and likely continuation of government policy of providing low cost fertiliser to the farmer and increasing trend in cost of various inputs and services supplied to fertiliser industry has generated a lot of concern in various quarters particularly in view of its budgetary implications at a time when the country is facing a serious resource crunch.

In spite of these problems with which fertiliser industry is beset, the future prospect of this industry is very bright since a considerable amount of development of agriculture depends upon the growth of this industry. Keeping this factor in mind Government is paying its serious attention towards the growth of this industry.

CHAPTER-III

THE MODEL

This chapter deals with transportation cost model of linear programming which has been used in the present study to get optimal flow pattern of fertilisers. The problem of planning the location and regional flow pattern is very old in economics. The mathematical tool available for long for finding an optimal flow was the maxima and minima approach of calculus. While the method of maxima and minima was often used for the purpose of solving a problem formally as a theoretical exercise, the requirement of continuous function with a known form and having derivatives was for practical purposes much more difficult to achieve.[1] In order to point out the difficulties associated with this method, it is better to set down the above in the framework of minimum or maximum problem of calculus.

If X_{ij} are the deliveries from ith to the jth region and C_{ij}, the associated costs of production and transportation, then the condition that the requirements or demands, of a region must be met; may be written as:

$$F_j(X_{ij}, X_{2j}, ---- X_{nj}) \geq r_j$$

----

1. Ghosh A (1965). "Efficiency in location and interegional flows", North-Holland Publishing, Amsterdam, 1958, p.23 .

Another condition that regional capacities must not be exceeded may be written as:

$$F_j\ (X_{i1},\ X_{i2},\ \text{--------}\ X_{in})\ \leq\ K_i$$

The cost function to be minimised becomes

$$F\ (C_{11}\ X_{11},\ C_{12}\ X_{12}\ \text{------},\ C_{nn}\ \ X_{nn})$$

If the above two conditions are taken as defining equalities rather than inequalities, that is, if

$$F_j = r_j,\ F_i = K_i$$

then the solution can be easily obtained by forming the Langrangian expression:

$$G = F - \sum_j \lambda_j\ (F_j - r_j) - \sum_i \mu_i\ (F_i - K_i)$$

and obtaining the partial differential equations.

$$\frac{\partial G}{\partial X_{ij}} = 0,\quad \frac{\partial G}{\partial \lambda_j} = 0,\quad \frac{\partial G}{\partial \mu_i} = 0$$

$$i = 1,2,\text{------},n,\qquad j = 1,2,\text{------},n$$

Although this framework of analysis is quite familiar in economics as a theoretical tool but the difficulties associated with defining continuous, differentiable, functions of the type envisaged here prevents the actual application of this approach in most cases. Another difficulty is that in many cases, the stated bounds are not reached or are not likely to be reached so that the inequality becomes an effective condition.

The recent development of linear programming technique has, however, provided a computational tool for tackling such maxima and minima problems where the maximising and minimising functions and the constraints are linear, the variables considered attain only non-negative values and restraining equations can be formed as a set of equalities and inequalities.

The general framework of the problems in linear programming can be stated as follows:

Maximise (minimise) $\sum_i \sum_j C_{ij} X_{ij}$

Subject to $\sum_j a_{ij} X_{ij} \leq K_i$

$$\sum_i a_{ij} X_{ij} \geq r_i$$

$$X_{ij} \geq 0$$

However, a special case of linear programming known as the transportation problem is used for formulating and solving the problem of the optimum regional flow. This special case of linear programming was formulated and solved several years before the general solution of linear programming was obtained through what is known as the Simplex technique.

This special case of linear programming was in fact solved in connection with obtaining an optimum spatial delivery system for a product which originated in several centres and has to be distributed in several localities. The problem can formally be stated as follows:

Let the jth regional demand or requirement, be denoted by r_j and the capacity of the ith centre of production by K_i, if X_{ij} denote as before the delivery from the ith to jth region and C_{ij} is its associated cost then:

$$\text{Maximise (minimise)} \quad \sum_i \sum_j C_{ij} X_{ij}$$

$$\text{Subject to} \quad \sum_j X_{ij} \leq K_i$$

$$\sum_i X_{ij} \geq r_j$$

This problem can very easily be explained by a formal example. Suppose there are four demand unit and three supply units. We can identify the supply units as O_1, O_2 and O_3 and demand units as D_1, D_2, D_3 and D_4. The relevant data on plant capacities, destination requirements and shipping costs for individual shipping routes are recorded.

	DESTINATIONS				Origin capacity per time period
	D_1	D_2	D_3	D_4	
O_1	C_{11} X_{11}	C_{12} X_{12}	C_{13} X_{13}	C_{14} X_{14}	b_1
O_2	C_{21} X_{21}	C_{22} X_{22}	C_{23} X_{23}	C_{24} X_{24}	b_2
O_3	C_3 X_{31}	C_{32} X_{32}	C_{33} X_{33}	C_{34} X_{34}	b_3
Destination requirement per time period	d_1	d_2	d_3	d_4	

The transportation model like the general linear programming model consists of three components. First we have to formulate a linear objective function which is to be minimised. This function represents the total shipping costs of all the goods to be sent from origins to the destinations. Second, out of the seven linear structural constraints of the above problem, three (one for each row) will give the relationship between the origin capacities and goods to be received by different destinations. These are called capacity constraints.

Requirement constraints are the four constraints in each column which satisfy the relationship between the destination requirement and the goods to be shipped from different origins.

Thirdly, we can specify a set of non-negativity constraints for the structural variables X_{ij}. They state that no negative shipment is permitted. The general correspondence between a typical linear programming problem is thus complete.

The three component parts of a transportation problem can be written in the following way -

Minimise

$$
\begin{aligned}
F(X) = \; & C_{11}X_{11} + C_{12}X_{12} + C_{13}X_{13} + C_{13}X_{14} \\
& + C_{21}X_{21} + C_{22}X_{22} + C_{23}X_{23} + C_{24}X_{24} \\
& + C_{31}X_{31} + C_{32}X_{32} + C_{33}X_{33} + C_{34}X_{34}
\end{aligned}
$$

Subject to

$$X_{11} + X_{12} + X_{13} + X_{14} = b_1$$

$$X_{21} + X_{22} + X_{23} + X_{24} = b_2$$

$$X_{31} + X_{32} + X_{33} + X_{34} = b_3$$

$$X_{11} + X_{21} + X_{31} = d_1$$

$$X_{12} + X_{22} + X_{32} = d_2$$

$$X_{13} + X_{23} + X_{33} = d_3$$

$$X_{14} + X_{24} + X_{34} = d_4$$

where $X_{ij} \geq 0$; $i = 1,2,3$; $j = 1,2,3,4$

This transportation problem can be solved by three steps. The first involves the initial shipping assignment in such a manner that a basic feasible solution is obtained. This means that $m + n - 1$ cells of the transportation are used for shipping purposes. In second step we determine the implied costs associated with the empty cells. The third step involves determining a new and better basic feasible solution.

The initial basic feasible solution is obtained with the number of filled up cells equal to $m + n - 1$. The initial optimum solution can be obtained by north - west corner rule or by the minimum cost cell method. The second and third steps can be carried out by stepping stone or by the modified distribution method. The difference between the two is that the former principle is carried out by taking small loops and in the latter one large loop is made after finding the implied cost of empty cells.

3.1 Assumptions

In order to carry out the present study certain assumptions have been made. These assumptions are:

1) The first assumption for this study is that production and demand factors are given and they are taken as constant. The supply is determined on the basis of production of the different states and demand is determined on the basis of consumption of the various states. No importance is attached to the cost of production. When the cost of production is assumed to be given it is the transportation costs that have to be minimised.

2) The intra regional movement may be distributed into rail, road and animal transport and it is extremely difficult to form an idea of this internal movement as

no official statistics exists for last two, while official statistics for rail transport is limited to inter-regional movement only. Thus in the absence of any reasonable reliable information on this the problem has been confined only to the consideration of inter-regional movement.

3) It has been further assumed that inter-regional movement of fertilisers is done by railways only. This assumption is based on certain concrete facts.

As is clear from Table 3.1 that till 1979-80, the percentage share of railways in movement of fertilisers was around 68 percent.

Although it is clear from this table that the share of railways in movement of fertilisers is declining every year but this has not happened because the railways are uneconomic in transportation of fertilisers as compared to other modes of transport. This has happened because of non-availability of railway wagons at proper time. Table 3.2 makes this fact clear that for the distance of 300 Km and more the railway is economic than roads.

Table 3.1

Movement of Fertiliser

Year	Quantity of Fertiliser distributed	Quantity cleared by rail	Percentage share of Rail
1976-77	8.4	7.8	92.85
1977-78	9.8	8.2	83.67
1978-79	11.1	8.2	73.87
1979-80	-	-	-
1980-81	15.3	8.8	58
1981-82	17.1	9.4	55
1982-83	18.9	10.1	53
1983-84	20.9	10.8	52
1984-85	23.0	11.6	50
1985-86	25.1	12.4	49

Source: Fertiliser News, August 1986.

Table 3.2

Costs of Transportation of Fertiliser by Rail and Road

DISTANCE	COST PER TONNE (IN RS.)	
	RAIL	ROAD
300 Kms	40.05	90.00
500 Kms	57.35	145.00
1000 Kms	100.67	285.00

Source: Fertiliser News, July 1979

Since the present study has been carried out for interstate flow pattern, thus the distances are generally more than 300 Kms. Hence this assumption is totally logical.

4) As we have seen in the model discussed earlier in this chapter, that for the present type of study, the cost of transportation between the point of origin and point to destination must be known and for knowing the cost of transportation idea of distance between the two points should be clear. In the present study in order to measure the distances between two states two nodal points have been assumed in each state. These two nodal points are the dominant consumption and dominant production points. These dominant production and consumption points have been delineated after surveying the production of different plants of the state and consumption of different districts of state. Now the distance between the dominant production point of one state and dominant consumption point of another state has been obtained through railway broadshaw and its cost has been calculated by railway freight charges of fertiliser movement.

5) Import of fertilisers takes place through 28 ports or so in our country. In order to limit the size of the

matrix it has been assumed that all the fertilisers in our country is imported on four ports only, namely, Calcutta, Madras, Bombay and Kandla. These four ports have been selected on the basis of their geographical location and the amount of fertilisers which arrives on different ports.

6) In the present study two optimal flow patterns are obtained for both the types of fertiliser; one on the basis of production and another on the basis of capacity. As it would have been unrealistic to assume hundred percent capacity utilisation; therefore, after looking into the causes of loss of production in different states, the capacity utilisation level has been increased by certain percentage in different states according to the causes due to which the production is lost.

CHAPTER IV

ANALYSIS OF FLOW PATTERNS - ACTUAL AND OPTIMAL

After discussing the transportation cost model of linear programming technique in the preceding Chapter, in the preesent chapter optimal flow patterns of different types of fertiliser have been obtained by using this technique. Then after an attempt has been made to compare the optimal and actual flow patterns for two points of time, i.e. 1979-80 and 1985-86.[1]

4.1 Comparison Between Actual and Optimal Flow Patterns of Nitrogenous Fertiliser

Tables 4.1 and 4.2 show the actual flow pattern of nitrogenous fertiliser. Table 4.3(a) to Table 4.4(b) represent the optimal flow pattern of nitrogenous fertiliser.

Eastern Region

We find that in 1979-80, in the actual movement of nitrogenous fertiliser, Assam apart from consuming a part of its production, also supplied to Bihar and West Bengal.

----

1 (a) The data of actual flow pattern of fertiliser are not available.

(b) But the fertiliser industry comes under Essential Commodity Act. Thus, the allocation plan of fertiliser is decided twice in a year (i.e. before Kharif and Rabi season) by Government. In the present study in the absence of actual flow pattern of fertiliser, this allocation pattern has been taken as a proxy of actual flow pattern.

Table 4.1

Actual Inter-State Flow Pattern of Nitrogenous Fertiliser in 1979-80
[in '000 tonnes]

Origin States	Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Estimated Production of origin States
	Destination States															
Assam	10.34	35.67		26.38												72.39
Bihar		46.01					25.45						18.00			89.46
Orissa		10.70	23.82	11.40			17.1	16.8	0.37		0.12		1.22			81.55
West Bengal		5.8	10.03	66.97									7.9			90.70
Haryana					23.75	9.0	10.81									43.56
Punjab					32.28	112.33	14.5								15.3	174.41
Uttar Pradesh		7.75			19.65	23.63	232.46						1.9			285.39
Andhra Pradesh			7.09	5.01				53.22	0.86				5.57			71.75
Karnataka						4.6	4.6	25.94	105.8	3.68	9.2		4.60	6.9		165.32
Kerala				0.84		1.35	3.56	52.77	15.93	31.52	31.91		2.04	14.13		154.05
Tamil Nadu			6.98	1.39	3.25	5.04	8.44	93.5	48.25	14.54	196.18	1.58	7.54	39.15		425.80
Gujarat		1.48	0.52	4.5	27.84	71.4	76.88	5.0	5.86	1.73	6.30	127.78	21.1	21.25	22.65	394.26
Madhya Pradesh								3.7					1.0	3.0		7.7
Maharashtra		11.75		11.45			19.1	9.57	12.3		4.8	2.5	11.05	67.75	2.3	152.55
Rajasthan					11.79	16.83	18.36						15.86		44.15	106.99
Goa								64.19	38.43			4.60		63.24		170.46
Delhi																0.0
Deficit Registered with the Pool	1.84	54.72	5.7	83.46	110.84	291.92	572.8	127.89	40.09	3.56	91.54	94.19	46.05	95.51	67.05	1687.16 (4173.5)*
Estimated Requirements of Destination States	12.18	174.22	54.19	212.54	229.84	536.31	1004.65	452.98	267.93	55.04	331.39	230.67	144.5	311.1	152.3	(4169.84)@

Deficit Registered with the pool is met through imports. *Total Production; @Total Requirements

Table 4.2

Actual Inter-State Flow Pattern of Nitrogenous Fertiliser in 1985-86
[in '000 tonnes]

Origin States	Destination States: Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Estimated Production of origin States
Assam	7.67	29.57		26.35			10.6									74.19
Bihar		194.1		4.40			7.1									205.6
Orissa		17.0	67.85	35.35				30.7	3.70	0.60	1.40		4.8	0.40		161.8
West Bengal	0.90	4.95	3.2	89.35			4.1						3.20			105.7
Haryana					139.15	10.6	37.6						2.0			189.35
Punjab		1.50			23.45	324.35	10.0	8.0	6.50						15.0	388.8
Uttar Pradesh	2.30	75.2	1.45	12.0	16.5	18.8	434.45						15.5			576.2
Andhra Pradesh			7.4	5.81				130.05					8.13	7.10		158.49
Karnataka								27.80	124.55	3.50	13.15			2.30		171.3
Kerala								58.29	36.15	42.76	54.3			7.15		198.61
Tamil Nadu							2.70	178.03	72.81	16.84	281.68		8.80	19.95		580.84
Gujarat	0.50	12.06	1.3	8.5	49.8	110.10	131.84	8.91	12.14	1.7	5.1	232.8	79.3	42.80	52.45	749.30
Madhya Pradesh								2.15	0.2				1.40	2.55		6.3
Maharashtra		6.20		8.10			150.35	83.80	21.4		3.35	8.20	95.7	258.50		635.6
Rajasthan					16.2	20.20	25.30						14.30		63.0	139.0
Goa							2.9	58.20	39.15				5.45	52.75		158.4
Delhi																
Deficit Registered with the Pool		88.54	7.65	127.47	76.48	345.45	562.88	191.43	56.92	0.52	203.79	152.6	65.24	151.69	56.73	2087.39 (6586.93)*
Estimated Requirements of Destination States	11.37	429.12	88.85	318.23	321.58	829.5	1377.42	778.6	373.52	65.92	563.77	393.25	303.82	540.99	187.18	(6583.12)@

Deficit Registered with the pool is met through imports. *Total Production; @Total Requirements

Table 4.3(a)

Optimal Inter-State Flow Pattern of Nitrogenous Fertiliser (1979-80)
(Production)
[in '000 tonnes]

Origin States	Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Production of origin States
								Destination States								
Assam	5.60	26.10	46.40													78.10
Bihar						77.30										77.30
Orissa		56.60														56.60
West Bengal		56.50														56.50
Haryana						64.50										64.50
Punjab						183.70										183.70
Uttar Pradesh							205.30									205.30
Andhra Pradesh													60.60			60.60
Karnataka									53.00							53.00 (106.40)
Kerala								40.40		46.40						86.80 (68.50)
Tamil Nadu								91.80			324.60					416.40
Gujarat						79.82						156.08			115.40	351.30
Madhya Pradesh													6.70			6.70
Maharashtra														126.10		126.10
Rajasthan							116.00									116.00
Goa									151.00							151.00
Delhi						0.00										0.00
Calcutta		5.80		144.90			4.73									155.43
Kandla					174.50	68.78	430.27									673.55
Madras								237.50				68.02	29.60	131.20		466.32
																(3520.3)*
Requirements of Destination States	5.60	145.00	46.40	144.90	174.50	474.10	756.30	369.70	204.00	46.40	324.60	224.10	96.90	257.30	115.40	(3385.2)@

Figures in the brackets represent actual production. *Total production; @Total requirement.
Slack variable of 135.1 has been used here. Optimal value of the original objective function is Rs.259606.79

Table 4.3(b)

Optimal Inter-State Flow Pattern of Nitrogenous Fertiliser (1979-80)
(Capacity)
[in '000 tonnes]

Origin States	Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Production of origin States
								Destination States								
Assam	5.60	66.20	46.40													118.20
Bihar						64.65	126.85									191.50
Orissa		78.80											9.40			88.20
West Bengal				68.15			28.45									96.60
Haryana						129.25										129.25
Punjab						280.20										280.20
Uttar Pradesh							278.40									278.40
Andhra Pradesh													71.40			71.40
Karnataka									50.10							50.10 (124.80)
Kerala								113.10		46.40						159.50 (219.20)
Tamil Nadu								121.65			324.60					446.25
Gujarat							35.27					224.10		31.13	115.40	405.90
Madhya Pradesh													6.70			6.70
Maharashtra														140.25		140.25
Rajasthan							129.20									129.20
Goa									153.90							153.90
Delhi						0.00										0.00
Calcutta				76.75												76.75
Kandla					174.50			158.13								332.63
Madras								134.95					9.40	85.92		230.27
																(3520.0)*
Requirements of Destination States	5.60	145.00	46.40	144.90	174.50	474.10	756.30	369.70	204.00	46.40	324.60	224.10	96.90	257.30	115.40	(3385.20)@

Figures in the brackets represent actual production of states. Slack variable of 135.1 has been used here. Optimal value of the original objective function is Rs.231388.80. *Total Production; @Total Requirements.

Table 4.4(a)

Optimal Inter-State Flow Pattern of Nitrogenous Fertiliser (1985-86)
(Production)
[in '000 tonnes]

Origin States	Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Production of origin States
								Destination States								
Assam	9.30		66.40													75.7
Bihar		174.80														174.80
Orissa		77.39		12.81												90.20
West Bengal				50.20												50.20
Hary'na						142.10										142.10
Punjab						373.90										373.90
Uttar Pradesh		99.21					443.19									542.40
Andhra Pradesh			20.70										116.30			137.00
Karnataka																0.0 (110.8)
Kerala										59.80						59.80 (179.4)
Tamil Nadu								114.90			378.90					493.80 (516.6)
Gujarat						271.20	492.10								160.80	924.1
Madhya Pradesh													6.0			6.0
Maharashtra							163.86		104.40				3.22	373.92		645.4
Rajasthan							163.00									163.0
Goa									191.30							191.30
Delhi							0.00									0.00
Calcutta				193.89												193.89
Kandla					296.40		220.65									517.05
Bombay												286.50		36.68		323.18
Madras								454.00					127.68			581.68
																(5938.7)*
Requirements of Destination States	9.30	351.4	87.1	256.9	296.40	787.2	1482.5	568.9	295.7	59.8	378.9	286.5	253.2	410.6	160.80	(5703.3)@

Figures in the brackets represent actual production. *Total production; @Total requirement.
Slack variable of 235.4 has been used here. Optimal value of the original objective function is Rs.1045697.21.

Table 4.4(b)

Optimal Inter-State Flow Pattern of Nitrogenous Fertiliser in 1985-86
(Capacity)
[in '000 tonnes]

Origin States	Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Production of origin States
	Destination States															
Assam	9.30		87.10													96.40(124.1)
Bihar		268.10														268.10
Orissa		83.30		71.17									55.03			209.50
West Bengal				103.95												103.95
Haryana					78.30	97.95										176.25
Punjab						410.55										410.55
Uttar Pradesh							611.11									611.11
Andhra Pradesh								169.44					33.36			202.80
Karnataka													140.40			140.40
Kerala										59.80						59.80(243.0)
Tamil Nadu								154.11			378.90					533.01(576.0)
Gujarat						278.70	484.60								160.80	924.10
Madhya Pradesh													7.00			7.00
Maharashtra							224.09		97.70			150.20	17.41	410.60		900.00
Rajasthan							163.00									163.00
Goa									198.00							198.00
Delhi							0.00									0.00
Calcutta				81.78												81.78
Kandla					218.10											218.10
Bombay												136.30				136.30
Madras								245.35								245.35
																(5956.7)*
Requirements of Destination States	9.30	351.4	87.1	256.9	296.4	787.2	1482.8	568.9	295.7	59.80	378.9	286.5	253.2	410.6	160.8	(5703)@

Values in brackets represent actual capacity of the states.
Slack variable of 253.9 has been used Optimal value of original objective function is Rs.957546.13. *Total Production; @Total Requirements.

However, in 1985-86, besides supplying to Bihar and West Bengal, it also supplied to Uttar Pradesh.

But in the optimal flow, the linkage pattern established gives us a different type of movement. According to the optimal flow pattern of 1979-80, Assam, after consuming a part of its nitrogenous production, should have supplied to Bihar and Orissa. The capacity based optimal flow pattern of 1979-80 also gives the same picture. The optimal flow pattern of 1985-86 shows that Assam should have supplied to Orissa only, apart from consuming a part of its production. In this way we find that according to the actual flow pattern of 1979-80 and 1985-86, the linkage of Assam increased from two outside states (in 1979-80) to three outside states (in 1985-86); but the optimal plan suggests that this linkage should have been reduced from two states to one outside state only.

According to the actual flow pattern of 1979-80, in case of Bihar we find that apart from consuming a sizable part of its producltion in its own state, it supplied a small quantity of nitgrogenous fertiliser to Uttar Pradesh and Madhya Pradesh. Referring to the actual flow pattern of 1985-86, Bihar after keeping a sizable proportion of its production of nitrogenous fertiliser for self-consumption catered to Uttar Pradesh and West Bengal instead of Madhya Pradesh.

The optimal flow pattern of nitrogenous fertiliser gives quite a different plan. According to the optimal flow pattern of 1979-80, Bihar should have supplied all of its production to Punjab. The capacity based optimal flow pattern of the same year shows that Bihar should have sent its total product to Punjab and Uttar Pradesh. By way of the optimal flow pattern of 1985-86 Bihar should have consumed all its production in the state itself and should not have served outside its boundaries.

The actual flow pattern of 1979-80 shows that Orissa had linkage with seven states. It sent small quantity of 370 tonnes and 120 tonnes to far off states like Karnataka and Tamil Nadu. In 1985-86 also Orissa served the need of as many as eight states, apart from itself. Among them distant states like Kerala, Tamil Nadu, Karnataka and Maharashtra were served with smaller quantity of nitrogenous fertiliser.

But the optimal plan of 1979-80 shows that Orissa should have consumed its total production within the state. According to the optimal plan of 1985-86, Orissa should have been linked with West Bengal only. The capacity based optimal plan of 1985-86, shows the linkage of Orissa with West Bengal and Madhya Pradesh only.

The actual flow pattern shows that West Bengal served three states in 1979-80, but in 1985-86, it served five states, though with smaller quantities.

According to the optimal flow model, West Bengal should not have served any outside state and should have consumed all of its production internally at both the points of time. The optimal plan of 1979-80 based on capacity shows that West Bengal should have served only one outside state, viz. Uttar Pradesh.

Northern Region

In case of Haryana, where the production of nitrogenous fertiliser has gone up considerably in these six years, the actual flow pattern showed links with two states in 1979-80 and three in 1985-86. But the optimal flow pattern of both the years showed that Haryana, instead of consuming internally should have sent whole of its production to Punjab. The optimal plan of 1985-86 based on capacity showed that Haryana should have consumed a part of its production internally.

According to actual flow pattern of 1979-80, Punjab apart from serving its own state, also supplied nitrogenous fertiliser to two other states (West Bengal and Uttar Pradesh). But in 1985-86, when the production of nitrogenous fertiliser almost doubled, it served six other states. Far off states like Karnataka, Andhra Pradesh and Bihar were also served by Punjab in 1985-86.

The optimal plan of both the years give a quite different picture from actual flow pattern. According to these optimal flow patterns, Punjab should have consumed all its production internally, instead of sending it to any outside state.

Uttar Pradesh, where the production of nitrogenous fertiliser has increased considerably during the six years, served four outside states apart from meeting considerable part of its internal demand, according to the actual flow pattern of 1979-80. In 1985-86, it served seven outside states, apart from meeting almost fifty per cent of its internal demand.

But according to optimal flow pattern of 1979-80, Uttar Pradesh should not have served any outside state. It should have consumed all of its production internally. However, according to optimal flow pattern of 1985-86, Uttar Pradesh should have served Bihar only; apart from meeting considerable amount of its own internal demand. Thus we find quite a different linkage pattern of Uttar Pradesh in optimal flow model of both the years.

Southern Region

In case of Andhra Pradesh, where again production of nitrogenous fertiliser has almost doubled in six years period, the actual flow pattern gives almost similar picture at both the points of time. Andhra Pradesh thus had linkage with four outside states. The only difference is that whereas in 1979-80, Andhra Pradesh served Karnataka, in 1985-86 it served Maharashtra instead of Karnataka.

A glance at the optimal flow pattern of 1979-80 reveals that Andhra Pradesh should have sent all its nitrogenous production to Madhya Pradesh. The picture about optimal flow pattern of1985-86 is quite different. According to optimal flow pattern of 1985-86, based on production Andhra Pradesh should have sent all its production to two states (Orissa and Madhya Pradesh). But the capacity based optimal flow pattern for the same year shows that Andhra Pradesh should have met a considerable part of its internal demand and then should have served Madhya Pradesh.

In the actual flow pattern of 1979-80, Karnataka, had linkage with seven outside states. In that particular year Karnataka, apart from meeting its internal demand also met demands of far flung states like Punjab and Uttar Pradesh, where the consumption of nitrogenous fertiliser was very high. But in actual flow pattern of 1985-86, we find that linkage of Karnataka came down to four states. In 1985-86, it stopped supplying nitrogenous fertiliser to Punjab and Haryana. This has happened because of the coming up of many newnitrogenous fertiliser plants in the Gangetic Plain area which started meeting demands of these states.

The case of Karnataka is interesting, as far as optimal flow pattern is concerned. According to optimal flow pattern of 1979-80 out of the total production of 1.06 lakh tonnes only 53 thousand tonnes should have been utilised. Optimal flow pattern of 1979-80, based on capacity also gives a similar picture. The result of optimal flow model of 1985-86, show that out of the total production of 1.10 lakh tonnes not a single tonne should have been utilised.

Thus we find that location of fertiliser plant in Karnataka are not viable from the view of transportation cost. Since during these six years new fertiliser plants came up in plain regions of the country, the utility of the fertiliser plants located in Karnataka dwindled more from the point of view of transportation cost.

As per the actual flow pattern of 1979-80 of nitrogenous fertiliser, we find that Kerala after meeting a sizable part of its consumption catered to the demand of eight more states. Among these eight states, there were distant states like West Bengal, Haryana, and Punjab, although the supply to these states were considerably low.

In the actual flow pattern of 1985-86, we see that the number of states served came down from eight to four. The supply to states like Punjab, Haryana and West Bengal was snapped from Kerala. The possible explanatioon for this change can again be, the coming up of new nitrogenous fertiliser plants in Gangetic plain region of the country during these six years.

In the optimal flow pattern we find a similar repetition in case of Kerala, noticed in case of Karnataka. Here again, we find that out of total production of 1.68 lakh tonnes, only 86 thousand tonnes should have been utilised and apart from meeting its internal demand, Kerala should have served Andhra Pradesh. In optimal flow pattern of 1985-86, the amount of nitrogenous fertiliser which should have been utilised came down to 59 thousand tonnes and as per this plan it should have met its internal demand only. Thus, according to this optimal flow model about 1.20 lakh tonnes production of nitrogenous fertiliser in Kerala should not have been utilised.

After meeting its internal demand to a large extent, Tamil Nadu, according to the actual flow pattern of 1979-80 served about eleven states, although the supply to farther states like West Bengal and Haryana was as low 1039 and 3250 tonnes respectively. The number of states served by Tamil Nadu in 1985-86 came down to six in actual flow pattern of that year.

In the optimal linkage pattern of 1979-80, we find that Tamil Nadu should have established links with only one outside state i.e. Andhra Pradesh, apart from meeting its internal consumption of nitrogenous fertiliser. But contrary to this in the optimal flow pattern of 1985-86 we find that instead of utilising the total production of 5.16 lakh tonnes of Tamil Nadu, only 4.93 lakh tonnes should have been utilised, thus leaving unutilised production of around 23 thousand tonnes. But here again apart from serving its internal demand Tamil Nadu should have met the need of Andhra Pradesh.

Western Region

The case of Gujarat where the capacity of nitrogenous production is very high, is very interesting. According to the actual flow pattern of 1979-80, Gujarat served all the states except Assam, after consuming a large amount of its production internally. In the actual flow pattern of 1985-86, Gujarat served Assam also. Thus, since the production of this state was very high as compared to its consumption it was able to serve a large number of states.

On the contrary, the optimal flow pattern gives a very different linkage pattern for Gujarat in both the years. As per the optimal flow model of 1979-80, Gujarat, apart from serving its internal requirement, should have served the demand of Punjab and Rajasthan. The optimal flow pattern of 1985-86 gives a different linkage pattern. According to this, Gujarat, should not have consumed a single tonne of its production internally, but should have sent it to Punjab, Uttar Pradesh and Rajstahn.

The actual flow pattern of 1979-80 shows that Madhya Pradesh where the production of nitrogenous fertiliser is very low, served two other states after meeting a part of its internal demand. In 1985-86, however, the number of states served by Madhya Pradesh rose to three.

On the contrary, for both points of time, according to optimal flow pattern Madhya Pradesh should have consumed all its production internally.

The actual flow pattern for Maharashtra suggests the fact that it had linkage with nine states, apart from meeting internal consumption in 1979-80. For 1985-86, the actual flow pattern showed that Mahrashtra continued to maintain its supply to those states with which it had dealt within the earlier year of 1979-80, with the exception of Rajasthan.

Optimal flow pattern for 1979-80, suggests that on the contrary Maharashtra should have consumed its total production of nitrogenous fertiliser internally. But the optimal flow pattern of 1985-86, indicates that when the production of Maharashtra actually increased by four times, it should have catered to the demand of Uttar Pradesh and Karnataka and at the same time should have also supplied a little quantity to Madhya Pradesh, apart from meeting a large part of internal consumption.

According to the actual flow pattern of 1979-80 and 1985-86, Rajasthan supplied nitrogenous fertiliser to four states i.e. Haryana, Punjab, Uttar Pradesh and Madhya Pradesh; apart from consuming a large part of the production internally. On the other hand the optimal flow pattern of both the years suggests that Rajasthan should have supplied its total production of nitrogenous fertiliser to one state, viz. Uttar Pradesh. Thus, the optimal patterns suggest that it should not have even used its production internally.

A glance at the actual flow pattern of nitrogenous fertiliser reveals the fact that Goa, established link with four states in 1979-80, which increased to five states in 1985-86. It supplied nitrogenous fertiliser to Andhra Pradesh, Karnataka, Gujarat and Mashrastra in 1979-80 and Uttar Pradesh, Andhra Pradesh, Madhya Pradesh, Karnataka and Maharashtra in 1985-86.

However, according to the optimal plan of both the years Goa should have supplied its total production of nitrogenous fertiliser to Karnataka.

Imports

Having finished the comparison of domestic production, we should now look at the flow pattern of imported nitrogenous fertiliser. Since the data for actual flow pattern of imported fertiliser is not readily available, therefore we may attempt to study the optimal pattern only.

On the basis of the port-based statistics, the optimal flow pattern of 1979-80 shows that imported nitrogenous fertiliser which came to Calcutta port should have been supplied to Bihar, West Bengal and Uttar Pradesh. But in the year 1985-86, supply should have been to West Bengal only.

The nitrogenous fertiliser which came at Kandla port should have served the demands of Haryana, Punjab and Uttar Pradesh. But the optimal plan of 1985-86 suggests thatit should have served only Haryana and Uttar Pradesh.

The nitrogenous fertiliser which arrived at Madras port in 1979-80 should have served the demand of Andhra Pradesh, Gujarat, Madhya Pradesh and Maharashtra. On contrary to this the optimal plan of 1985-86 suggests that Madras should have catered the needs of Andhra Pradesh and Madhya Pradesh.

According to optimal flow model of 1985-86, the nitrogenous fertiliser which arrived at Bombay port should have served the demand of Maharashtra and Gujarat.[1]

----

1 As the capacity of the computer available with the researcher was limited to the extent 21x15 matrix and fictitious origin had to be used in case of 1979-80. Therefore, Bombay port had been dropped in case of 1979-80.

4.2 Comparison Between Actual and Optimal Flow Pattern of Phosphatic Fertiliser

After comparing the actual and optimal flow pattern of nitrogenous fertiliser in preceding part of this chapter, here a comparison has been attempted between actual and optimal flow pattern of phosphatic fertiliser. Before starting the comparison at the very outset, it is worthwhile to mention that, in case of phosphatic fertiliser while the production is generally concentrated in Western and Southern India, the major phosphatic fertiliser consuming states are in Eastern and Northern region of the country. Therefore, it is very pertinent to make survey of flow pattern of this type of fertiliser.

Tables 4.5 and 4.6 show the actual flow pattern of phosphatic fertiliser for 1979-80 and 1985-86. Tables 4.7(a) to 4.8(b) show the optimal flow patterns for 1979-80 and 1985-86.

Eastern Region

The actual flow pattern of phosphatic fertiliser for 1979-80 and 1985-86 reveals the fact that whatever small amount of phosphatic fertiliser was produced in Assam was consumed within state itself and was not supplied to any other state. The optimal flow pattern of Assam, for both the points of time, conform to this actual flow pattern for both the period.

Table 4.5

Actual Inter-State Flow Pattern of Phosphatic Fertiliser in 1979-80
[in '000 tonnes]

Origin States	Destination States: Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Estimated Production of origin States
Assam	0.55															0.55
Bihar		0.92					0.92									1.84
Orissa			0.10													0.10
West Bengal	0.62	3.56		8.27			3.00									15.45
Haryana																-
Punjab																-
Uttar Pradesh						1.27	6.6									7.87
Andhra Pradesh			7.52	5.30				67.05	2.11				6.32			88.30
Karnataka									6.66							6.66
Kerala				0.84	1.15	3.45	7.06	20.8	8.66	17.25	12.01		2.60	8.95	3.13	85.92
Tamil Nadu			3.46	1.46	1.28	2.57	3.03	37.6	51.65	5.17	69.54	4.04	6.3	12.9		199.0
Gujarat		3.94	1.37	11.7	11.84	52.61	54.57	3.52	4.52	0.91	4.42	77.99	7.12	7.05	14.43	255.99
Madhya Pradesh			0.72				0.88						14.33			15.93
Maharashtra		11.75		11.45			17.1	9.55	11.8		4.8	7.3	8.39	56.6	2.69	141.43
Rajasthan					4.16	16.54	8.5						4.59	0.94	8.21	42.94
Goa								18.76	7.26					8.73		34.75
Delhi																
Deficit Registered with the Pool	3.54	8.41	0.08	42.99	27.95	115.05	144.18	28.67	15.49	4.99	2.63	12.86	20.92	9.36	5.44	442.55 (1339.16)*
Estimated Requirements of Destination States	4.82	28.86	13.58	82.09	46.62	191.52	244.76	185.76	108.15	29.45	93.28	102.02	70.6	105.22	32.86	(1339.16)@

Deficit Registered with the pool is met through imports. *Total Production; @Total Requirements.

Table 4.6

Actual Inter-State Flow Pattern of Phosphatic Fertiliser (1985-86)
[in '000 tonnes]

Origin States	Destination States: Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Estimated Production of origin States
Assam	1.15															1.15
Bihar		1.6														1.6
Orissa			1.0													1.0
West Bengal	5.05	17.3	3.05	34.75			6.90			0.60						67.65
Haryana					7.75	13.7	4.25								0.85	26.55
Punjab					4.7	19.65	1.40								0.50	26.25
Uttar Pradesh		7.95			1.0	1.25	30.2									40.40
Andhra Pradesh			9.7	6.22				73.54	0.65				4.78			94.89
Karnataka								7.05	28.1	0.65	3.2					39.0
Kerala								24.72	16.98	23.85	17.81			8.9		92.26
Tamil Nadu				2.30			6.90	82.92	58.76	13.68	142.35		9.20	14.7		330.81
Gujarat	1.30	32.36	3.30	22.1	22.3	83.05	78.6	5.30	12.64	2.0	7.0	110.2	35.95	36.3	25.3	477.7
Madhya Pradesh		1.85	2.65				0.70						29.1	2.0		36.3
Maharashtra		6.2		8.1			3.20	13.3	9.45		1.10	17.75	12.3	82.35	0.80	154.55
Rajasthan					2.19	8.75	11.55					0.20	11.71		18.5	52.9
Goa							7.55	16.55	14.1				11.9	18.55		68.65
Delhi					2.70	8.0	3.9						2.9		2.45	19.95
Deficit registered with the Pool	1.92	50.87	9.16	41.19	26.16	167.25	208.99	84.54	50.49	1.03	13.38	63.2	34.28	20.84	8.54	775.94
																(2306.55)*
Estimated Requirements of Destination States	5.58	118.53	28.76	114.75	66.8	301.65	363.49	307.92	192.97	39.75	183.81	191.4	152.66	183.59	54.94	(2306.55)@

Deficit registered with the central pool is met through imports. *Total Estimated Production; @Total Estimated Requirements.

Table 4.7(a)

Optimal Inter-State Flow Pattern of Phosphatic Fertiliser in 1979-80
(Production)
[in '000 tonnes]

Origin States	Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Production of origin States
	Destination States															
Assam	0.40															0.4
Bihar		9.90														9.90
Orissa				0.00												0.00
West Bengal				13.20												13.20
Haryana						0.00										-
Punjab						0.00										-
Uttar Pradesh							8.50									8.50
Andhra Pradesh		16.20	13.30	19.50									35.90			84.90
Karnataka									6.10							6.10
Kerala								43.80		25.40						69.20
Tamil Nadu								16.60	52.90		99.50					169.00
Gujarat						48.20	69.10					70.00			26.10	213.40
Madhya Pradesh													14.10			14.10
Maharashtra												26.40		90.60		117.00
Rajasthan							10.60									10.60
Goa									27.50							27.50
Delhi						19.30										19.30
Calcutta				28.45												28.45
Kandla					30.20		93.10									123.30
Madras				1.75				65.60				18.00				85.35 (1000.2)*
Requirements of Destination States	0.40 (0.70)	26.10	13.30	62.90	30.20	67.5 (178.0)	181.40	126.00	86.50	25.40	99.50	114.40	50.00	90.60	26.10	(1111.00)@

Figures in the bracket represent actual requirements. A fictitious origin of 110.8 has been used here. Optimal value of the current objective function is Rs.71529. *Total Production; @Total Requirements.

Table 4.7(b)

Optimal Inter-State Flow Pattern of Phosphatic Fertiliser in 1979-80
(Capacity)
[in '000 tonnes]

Origin States	Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Production of origin States
								Destination States								
Assam	0.70			1.30												2.00
Bihar		26.10				27.80										53.90
Orissa				1.60												1.60
West Bengal				15.20												15.20
Haryana																-
Punjab																-
Uttar Pradesh							9.35									9.35
Andhra Pradesh			13.30	38.68				10.22					50.00			112.20
Karnataka									8.40							8.40
Kerala								71.37		25.40		5.30				102.05
Tamil Nadu								44.43	46.60		99.50					190.53
Gujarat						20.10	124.03					43.17			26.10	213.40
Madhya Pradesh							15.00									15.00
Maharashtra												47.56		90.60		138.16
Rajasthan					3.68		32.92									36.60
Goa									31.50							31.50
Delhi						19.30										19.30
Calcutta				6.12												6.12
Kandla					26.52											26.52
Madras												18.37				18.37
																(1000.20)*
Requirements of Destination States	0.70	26.10	13.30	62.90	30.20	67.2 (178.0)	181.30	126.00	86.50	25.40	99.50	114.40	50.00	90.60	26.10	(1111)@

Values in brackets represent actual requirement of state. A fictious origin of 110.8 has been used here Optimal value of the original objecti function is Rs. 71478.63. *Total Production; @Total Requirements.

Table 4.8(a)

Optimal Inter-State Flow Pattern of Phosphatic Fertiliser in 1985-88
(Production)
[in '000 tonnes]

Origin States	Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Production of origin States
	Destination States															
Assam	1.20															1.20
Bihar		1.30														1.30
Orissa		1.00														1.00
West Bengal		34.80														34.80
Haryana						22.80										22.80
Punjab						31.80										31.80
Uttar Pradesh		38.30														38.30
Andhra Pradesh			33.40										71.60			105.00
Karnataka													6.40			6.40
Kerala										34.80						34.80(102.6)
Tamil Nadu									4.66		145.40					150.06(296.1)
Gujarat						232.60	142.60								55.50	430.70
Madhya Pradesh													35.90			35.90
Maharashtra		18.48							27.22					99.70		145.40
Rajasthan							37.90									37.90
Goa									124.50							124.50
Delhi							15.10									15.10
Calcutta	2.40	1.87		92.30												96.57
Kandla		9.15			69.70		178.70									257.55
Bombay												109.30		51.66		160.96
Madras								242.80	8.02				38.90			289.72
																(2235.8)*
Requirements of Destination States	3.6	104.9	33.4	92.3	69.7	287.2	374.3	242.8	164.4	34.8	145.4	109.3	152.8	151.3	55.5	(2025.0)@

Values in brackets represent actual production of states. A slack variable of 213.84 has been used here. Optimal value of the original objective function is Rs.379587.62. *Total Production; @Total Requirements.

Table 4.8(b)

Optimal Inter-State Flow Pattern of Phosphatic Fertiliser in 1985-88
(Capacity)
[in '000 tonnes]

Origin States	Destination States: Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Production of origin States
Assam	2.70															2.70
Bihar	0.90	63.50														64.4
Orissa		33.28	32.72													66.0
West Bengal		8.12		34.40												42.52
Haryana						22.80										22.8
Punjab						46.24										46.24
Uttar Pradesh							53.01									53.01
Andhra Pradesh			0.68					28.95					94.12			123.75
Karnataka													7.48			7.48
Kerala										34.80						34.80(128.35)
Tamil Nadu								40.14	1.07		145.40					186.61(307.7)
Gujarat						218.16	145.66					11.38			55.50	430.70
Madhya Pradesh													51.20			51.20
Maharashtra									38.83			1.42		151.36		191.61
Rajasthan							70.15									70.15
Goa									124.50							124.50
Delhi							20.76									20.76
Calcutta				57.90												57.90
Kandla					69.70		84.72									154.42
Bombay												96.50				96.50
Madras								173.71								173.71
																(2234.90)*
Requirements of Destination States	3.6	104.9	33.4	92.3	69.7	287.2	374.3	242.8	164.4	34.80	145.4	109.3	152.8	151.3	55.5	(2025.01)@

Values in bracket represent actual capacity. A slack variable of 214.64 has been used. Optimal value of original objective function is Rs.346864.43.
*Total Production; @Total Requirement.

According to the actual flow pattern of 1979-80, Bihar which produced very little amount of phosphatic fertiliser, after consuming a part of its production internally, supplied to Uttar Pradesh. But in 1985-86, whatever was produced, was consumed within the state only.

The optimal pattern of both the years of phosphatic fertiliser conforms to this actual flow pattern.

Orissa, did not produce phosphatic fertiliser in 1979-80. In 1985-86, this state produced only 100 tonnes of phosphatic fertiliser, which according to the actual flow pattern of that year, was consumed inside the state itself. But according to optimal plan of that year, Orissa should have supplied it to Bihar.

As per the actual flow pattern of 1979-80, West Bengal has established linkage with three outside states apart from consuming a considerable part of its production internally. In 1985-86, however, the linkage of this state increased to five states. It supplied phosphatic fertiliser to far flung state of Kerala though this supply was of only 600 tonnes.

However, the optimal plan of 1979-80, suggests that West Bengal should not have supplied phosphatic fertiliser to any outside state, and should have consumed its total production of phosphatic fertiliser interanlly only. On the contrary, the flow pattern of 1985-86, suggests that whatever phosphatic fertiliser was produced in West Bengal that year, should have been supplied to Bihar. The capacity based optimal flow pattern of 1985-86, suggests that West Bengal should have supplied to Bihar and should also have consumed large part of its production internally.

Northern region

Since there was no production of phosphatic fertiliser in Punjab and Haryana in the year 1979-80, thus there is no question of comparison. But in 1985-86, when the capacity was created in these two states, according to the actual flow pattern, they supplied their production to three states, apart from meeting a part oftheir internal demand.

However, the optimal flow pattern of 1985-86, suggests that whatever phosphatic fertiliser was produced in Haryana should have been supplied to Punjab. Similarly in case of Punjab, whatever was produced should have been consumed within the State only.

Uttar Pradesh, supplied to Punjab apart from consuming internally, as per the actual flow pattern of 1979-80. But according to the actual flow pattern of 1985-86, it also established linkage with Haryana and Bihar.

The optimal flow pattern of both the year do not conform to this actual flow pattern. According to the optimal flow pattern of 1979-80, Uttar Pradesh should have consumed all of its production of phosphatic fertiliser internally. On contrary to this, the optimal flow pattern of 1985-86, suggests that whatever phsophatic fertiliser was produced in Uttar Pradesh, should have been supplied to Bihar directly.

The actual flow pattern of 1985-86, shows that Delhi established linkage with five states. But the optimal plan reduced this linkage to one and as per this plan Delhi should have supplied its total production to Uttar Pradesh only.

<u>Southern Region</u>

Andhra Pradesh served four states apart from meeting its own demand as per the actual flow pattern of 1979-80 and 1985-86. Contrary to this pattern, in 1979-80 Andhra Pradesh should have served Bihar, Orissa, West Bengal and Madhya Pradesh and should not have consumed its product internally. On the other hand, the optimal flow pattern of 1985-86 shows that Andhra Pradesh should have served the demand of Orissa and Madhya Pradesh only.

In case of Karnataka we find conformity in actual and optimal flow pattern of phosphatic fertiliser in 1979-80. But according to actual flow pattern of 1985-86 Karnataka served three other states apart from meeting its internal demand. On the contrary, the optimal flow pattern of the same year, shows that Karnataka should have supplied its total production of phosphatic fertiliser to Madhya Pradesh and should not have consumed a single tonne internally.

According to the actual flow pattern of 1979-80, Kerala served about ten states, apart from itself. This linkage is reduced to four in 1985-86, according to the estimate of actual flow pattern of that year. However, the optimal plan of 1979-80 showsthat Kerala should have supplied to Andhra Pradesh, apart from its own internal distribution. On the contrary to this, the optimal plan of 1985-86 suggests that out of the total capacity of 1.2 lakh in Kerala only around 35 thousand tonnes should have been utilised, therefore leaving 68 thousand tonnes phosphatic fertiliser produced in Kerala unitilised.

Just like the actual flow pattern of nitrogenous fertiliser of 1979-80, the actual flow pattern of phosphatic fertiliser in 1979-80 established linkages of Tamil Nadu with eleven states, besides meeting the internal demand. Again like nitrogenous fertiliser, the linkage pattern of Tamil Nadu in case of Phosphatic fertiliser was reduced to six states according to the actual flow pattern of phosphatic fertiliser in 1985-86.

However, we get a very different picture of linkage pattern of Tamil Nadu according to the optimal plan of 1979-80. As per the optimal plan of 1979-80, apart from meeting the internal demand, it should have established linkages only with Andhra Pradesh and Karnataka. On the contrary, the optimal plan of 1985-86, suggests that out of the total production of around 2.96 lakh tonnes of this state only 1.50 lakh tonnes should be utilised and that it should cater to the demand of Karnataka only. Therefore, jut like Kerala in case of Tamil Nadu also we find underutilisation of the production of optimal plan of 1985-86.

Western Region

Again, like the actual flow plan of nitrogenous fertiliser of 1979-80, for phosphatic fertiliser too, Gujarat established linkages with all the states undertaken in this study except Assam. As per the actual flow pattern of 1985-86, this linkage continued. Rather Gujarat established link with Assam, through it supplied only 1300 tonnes of phosphatic fertiliser to this state. But the optimal plan of 1979-80, shows that Gujarat, apart from meeting its own demand should have served three other states only. The optimal plan of 1985-86 also gives same linkage pattern for Gujarat.

Maharashtra served nine states apart from itself according to the actual flow pattern of both the points of time. On the contrary, the optimal plan of 1979-80, shows that Maharashtra should have served Gujarat apart from itself. But the optimal plan of 1985-86 shows that

Maharashtra should have served Bihar and Karnataka apart from itself.

Rajasthan supplied phosphatic fertiliser to five states apart from itself according to the actual flow pattern of 1979-80 and 1985-86. The only difference in actual plan of these two years is that instead of supplying to Maharashtrea, Rajasthan supplied to Gujarat in 1985-86. However, the optimal plan of both the years shows that Rajasthan should have supplied its total production of phosphatic fertiliser to Uttar Pradesh.

As per the actual flow pattern of 1979-80, Goa supplied its produce to Andhra Pradesh, Karnataka and Rajasthan. But in 1985-86, it supplied to Andhra Pradesh, Karnakata, Madhya Pradesh, Maharashtra and Uttar Pradesh. On the contrary, the optimal plan of both the years show that Goa should have suipplied to Karnataka only.

Imports

According to optimal plan of 1979-80, the phosphatic fertiliser which arrived at Calcutta should have gone to West Bengal. But as per the optimal plan of 1985-86, Calcutta port should have served Assam, Bihar and West Bengal only.

The optimal plan for Kandla port suggests that it should have served phosphatic fertiliser to two states. But in 1985-86, this port should have served three states as per the optimal plan of 1985-86.

Madras should have served three states according to the optimal plan of 1979-80 and 1985-86. In 1979-80, it shoauld have served to West Bengal, Andhra Pradesh, and Gujarat, whereas in 1985-86 it should have served to Andhra Pradesh, Karnataka and Madhya Pradesh. As per optimal plan of 1985-86, Bombay port should have served to Gujarat and Maharashtra.

4.3 Optimal Flow pattern of Potassic Fertiliser

The case of potassic fertiliser is quite different from the other two types of fertiliser. This fertiliser is not produced in the country and whatever is consumed is met through imports. Again, since the actual flow pattern of imported fertiliser is not readily available, we have, therefore, attempted to obtain the optimal flow pattern only.

Tables 4.9 and 4.10 represent the optimal flow pattern of potassic fertiliser. The optimal plan of 1979-80 reveals that the potassic fertiliser which arrived at Calcutta should have served the demand of Bihar, Orissa, West Bengal and Madhya Pradesh. Contrary to this, the optimal plan of 1985-86 suggests that Calcutta port should have served the demands of Assam, Bihar and West Bengal only.

Table 4.9

Optimal Inter-State Flow Pattern of Potassic Fertiliser (1979-80)
(Imports)
[in '000 tonnes]

Origin Ports	Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Imports of origin Ports
	Destination States															
Calcutta		13.20	7.20	32.90									3.48			56.78
Kandla					10.70		47.37		75.80			39.10		73.10		246.07
Madras								22.65		33.90	113.80					170.35
																(473.20)*
Requirements of Destination States	0.0 (0.50)	13.20	7.20	32.90	10.70	0.0 (30.00)	47.37 (71.40)	22.65 (39.10)	75.80	33.90	113.80	39.10	3.48 (12.80)	73.10	0.0 (5.60)	(559.1)

Values in brackets represent actual requirements of states. A fictitious origin of 85.4 has been used here. Optimal value of original objective function is Rs.36696.88. *Total Imports; @Total Requirement.

Table 4.10

Optimal Inter-State Flow Pattern of Potassic Fertiliser (1985-86)
(Imports)
[in '000 tonnes]

Origin Ports	Destination States: Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Imports of origin Ports
Calcutta	3.80	43.88		59.60												107.28
Kandla		1.22			6.20	23.70	114.80					25.60		16.18	4.60	192.3 (286.00)
Bombay									87.74					91.02		178.76
Madras			19.90					76.50	7.76	47.90	143.90		25.80			321.76
Requirements of Destination States	3.80	45.10	19.90	59.60	6.20	23.70	114.80	76.50	95.50	47.90	143.90	25.60	25.80	107.20	4.60	(893.80)* (800.10)@

Value in bracket represents actual import at that port. A slack variable of 93.7 has been used here. Optimal value of original objective function is Rs.150776.33. *Total Imports; @Total Requirement.

As per the optimal plan of 1979-80, Kandla port should have served Haryana, Uttar Pradesh, Karnataka, Gujarat and Maharashtra. Contrary to this the optimal plan of year 1985-86, suggests that Kandla should have served the need of potassic fertiliser of Haryana, Punjab, Uttar Pradesh, Gujarat and Maharashtra.

According to optimal plan of Madras, this port should have served three states, viz. Andhra Pradesh, Kerala and Tamil Nadu. But the optimal plan of another year suggests that apart from these three states this port should have catered to Orissa, Karnataka and Madhya Pradesh also. The optimal plan of 1985-86, suggests that Bombay port should have served potassic fertiliser to Karnataka and Maharashtra.

4.4 Optimal Flow Pattern of Total Fertiliser (N.P.K.)

The demand for different types of fertiliser varies in different states. Some states consume very large amount of nitrogenous fertiliser but the consumption of phosphatic fertiliser is very low, on the contrary some states consume both the fertilisers in large quantity keeping this fact in mind, an attempt has been made to obtain an optimal flow pattern of all fertilisers (NPK) for both the points of time, Tables 4.11(a) to 4.12(b) show the optimal flow pattern of total fertilisers for 1979-80 and 1985-86. The

Table 4.11(a)

Optimal Inter-State Flow Pattern of Total Fertiliser (N,P,K) (1979-80)
(Production)
[in '000 tonnes]

Origin States	Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Production of origin States
							Destination States									
Assam	6.80	10.80	60.90													78.50
Bihar		48.23				38.97										87.20
Orissa		55.60														55.80
West Bengal		69.67		0.03												69.70
Haryana						64.50										64.50
Punjab						183.70										183.70
Uttar Pradesh							213.80									213.80
Andhra Pradesh			6.50										138.90			145.40
Karnataka									112.50							112.50
Kerala								104.30	27.80	105.60						237.70
Tamil Nadu									47.50		537.90					585.40
Gujarat						153.62						263.98			147.10	564.70
Madhya Pradesh													20.80			20.80
Maharashtra														243.10		243.10
Rajasthan							126.60									126.60
Goa									178.50							178.50
Delhi						19.30										19.30
Calcutta				240.67												240.67
Kandla					215.50	158.71	668.70									1042.91
Madras								430.50				113.52		178.00		722.02
																(4992.6)*
Requirements of Destination States	6.80	184.30	67.40	240.70	215.50	618.80 (682.10)	1009.10	534.80	366.30	105.60	537.90	377.50	159.70	421.10	147.10	(5055.9)@

Figure in the bracket represents actual requirement. A fictitious origin of 63.3 has been used here. Optimal value of the current objectives function is Rs.376931.47. *Total Production; @Total Requirement.

Table 4.11(b)

Optimal Inter-State Flow Pattern of Total Fertiliser (1979-80)
(Capacity)
[in '000 tonnes]

Origin States	Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Production of origin States
								Destination States								
Assam	6.80	83.75	29.65													120.20
Bihar						189.65	55.75									245.40
Orissa		89.80														89.80
West Bengal		10.75		101.05												111.80
Haryana						129.25										129.25
Punjab						280.60										280.60
Uttar Pradesh							287.75									287.75
Andhra Pradesh			37.75										145.85			183.60
Karnataka									133.20							133.20
Kerala								214.85		105.60						321.25
Tamil Nadu								51.18	47.70		537.90					636.78
Gujarat							102.23					369.97			147.10	619.30
Madhya Pradesh							7.85						13.85			21.70
Maharashtra														278.41		278.41
Rajasthan							165.80									165.80
Goa									185.40							185.40
Delhi						19.30										19.30
Calcutta				139.65												139.65
Kandla					215.50		389.72									605.22
Madras								268.77				7.53		142.69		418.99
																(4993.40)*
Requirements of Destination States	6.8	184.30	67.40	240.70	215.50	618.8 (682.10)	1009.1	534.80	366.30	105.6	537.90	377.50	159.70	421.11	147.10	(5055.9)@

Value in bracket represents actual requirement of state. A fictitious origin of 63.3 has been used here. Optimal value of the original objective function is Rs.347030.30. *Total Production; @Total Requirement.

Table 4.12(a)

Optimal Inter-state Flow Pattern of Total Fertiliser (N,P,K) (1985-86)
(Production)
[in '000 tonnes]

Origin States	Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Production of origin States
								Destination States								
Assam	16.70		60.20													76.90
Bihar		176.10														176.10
Orissa		91.20														91.20
West Bengal		74.04		10.96												85.00
Haryana						164.90										164.90
Punjab						405.70										405.70
Uttar Pradesh		160.16					420.54									580.70
Andhra Pradesh			80.30										161.70			242.00
Karnataka													117.20			117.20
Kerala										142.60						142.60(281.40)
Tamil Nadu											391.60					391.60(812.70)
Gujarat						527.60	606.30								220.90	1354.80
Madhya Pradesh													41.90			41.90
Maharashtra							40.76		239.80				82.72	427.52		790.80
Rajasthan							200.90									200.90
Goa									315.80							315.80
Delhi							15.10									15.10
Calcutta				397.74												397.74
Kandla					372.30		688.30									1060.60
Bombay												421.30		241.58		662.88
Madras								888.10			276.70		28.38			1193.18
																(9067.5)*
Requirements of Destination States	16.70	501.50	140.50	408.70	372.30	1098.20	1971.90	888.10	555.60	142.60	668.30	421.30	431.90	669.10	220.90	(8507.6)@

Values in brackets represent actual production of states. A Slack variable of 559.9 has been used here. Optimal value of the original objective function is Rs. 1505029.43. *Total Production; @Total Requirement.

Table 4.12(b)

Optimal Inter-State Flow Pattern of Fertiliser (N,P,K) 1985-86
(Capacity)
[in '000 tonnes]

Origin States	Destination States: Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan	Production of origin States
Assam	16.70															16.70(126.81)
Bihar		332.50														332.50
Orissa		169.00	91.21	15.29												275.50
West Bengal				146.47												146.47
Haryana						199.05										199.05
Punjab						456.79										456.79
Uttar Pradesh							664.12									664.12
Andhra Pradesh			49.20					147.28					129.98			326.55
Karnataka													147.88			147.88
Kerala										142.60						142.60(371.35)
Tamil Nadu											668.60					668.60(883.70)
Gujarat						442.36	689.84								220.90	1353.10
Madhya Pradesh													58.20			58.20
Maharashtra							77.80		233.60			9.73	95.84	669.10		1086.07(1091.61
Rajasthan							233.15									233.15
Goa									322.0							322.0
Delhi							20.76									20.76
Calcutta				246.94												246.94
Kandla					372.30		286.23									658.53
Bombay												411.57				411.57
Madras								740.82								740.82
																(9067.4)*
Requirements of Destination States	16.70	501.50	140.50	408.70	372.30	1098.20	1971.90	888.10	555.60	142.60	668.30	421.30	431.90	669.10	220.90	(8507.6)@

Values in brackets represent actual capacity of states. A slack variable of 559.90 has been used here Optimal value of original objective function is Rs.1404480.69. *Total Production; @Total Requirement.

optimal flow pattern of total fertiliser, almost conforms to the optimal flow patterns of nitrogenous fertiliser.

Eastern Region

The optimal flow plan of total fertiliser indicates that Assam should have served to Bihar and Orissa in 1979-80 apart from itself. Contrary to this as per the optimal plan of 1985-86, Assam should have served only Orissa outside its boundary.

The optimal plan of Bihar suggests that it should have catered to the demand of Punjab apart from itself in 1979-80. However, in 1985-86, it should have consumed all its fertiliser production within its boundary only.

As per the optimal plan of Orissa, the total fertiliser production of this state should have been consumed in the state itself. But optimal plan of 1985-86 suggests that total fertiliser production of this state should have been transferred to Bihar.

The optimal plans of West Bengal shows that it should have consumed very little part of its production within State itself and apart from that should have served major part of its production to Bihar.

Northern Region

The optimal plan of Haryana is similar for both the points of time. According to the optimal plan Haryana should have supplied its total fertiliser production to Punjab.

Again we find similarity in optimal plans of Punjab. According to these plans Punjab should have consumed its total fertiliser production within the state itself.

The optimal plan of 1979-80, shows that Uttar Pradesh should have consumed its total fertiliser production within its state boundaries. Contrary to this optimal plan of another year shows that after meeting a considerable part of its internal demand Uttar Pradesh should have supplied to Bihar.

Delhi which produces only phosphatic fertiliser, should have supplied its produce to Punjab in 1979-80, as per the optimal plan of that year. Contrary to this, the optimal plan of 1985-86, shows that Delhi should have supplied its fertiliser production to Uttar Pradesh.

Southern Region

The optimal plans of both the period suggests that Andhra Pradesh should have supplied its total fertiliser production to Madhya Pradesh and Orissa., The case of Karnataka is again interesting the optimal plan of 1979-80, suggests that whatever fertiliser was produced in the state should have been consumed within the state itself. However, the optimal plan of 1985-86, shows that Karnataka should have supplied all its fertiliser production to Madhya Pradesh. This trend of optimal plans of total fertilser is quite different from the optimal plans of Nitrogenous fertiliser, which suggests that the production of Karnataka should not have been consumed.

The optimal plan of 1979-80 for total fertiliser, shows that Kerala should have catered to the demand of Andhra Pradesh and Karnataka after meeting its internal demand. However, the optimal plan of 1985-86, suggets that out of the total production of 2.81 lakh tonnes, only 1.42 lakh tonnes should have been utilised. Thus this plan almost conforms to the optimal plan of nitrogenous fertiliser for 1985-86.

The optimal plan of total fertiliser of 1979-80, suggests that Tamil Nadu after meeting its total internal demand should have supuplied fertiliser to Karnataka. Contrary to this the optimal plan of 1985-86, suggests that out of the total production of 8.12 lakhs tonnes of Tamil Nadu only 3.91 lakh tonnes should have been utilised, and that also within the state itself.

Western Region

As per the optimal plan of total fertiliser of 1979-80, Gujarat should have served, Punjab and Rajasthan apart from meeting a sizable proportion of its internal demand. But on the other hand the optimal plan of 1985-86 suggests that Gujarat, should have served to Uttar Pradesh also apart from Punjab and Haryana and should not have consumed a single tonne of its product internally.

Maharashtra should have consumed its total fertiliser production within state only, according to optimal plan of 1979-80. Contrary to this the optimal plan of 1985-86 suggests that Maharashtra should have served the demands of Uttar Pradesh, Karnataka and Madhya Pradesh, apart from meeting considerable part of its internal requirement.

Rajasthan should have supplied its total fertiliser production to Uttar Pradesh as per the optimal plan of both the points of time. This supply plan is quite similar to the optimal plan of nitrogenous fertiliser.

According to the optimal plan of 1979-80 and 1985-86, Goa should have served its total fertiliser production to Karnataka.

Imports

Now we come to the case of imported fertiliser which as assumed in this study comes on four ports. As per the optimal plan of 1979-80 and 1985-86 the fertiliser which came at Calcutta port in those years should have been supplied to West Bengal. The fertiliser which arrived at Kandla port should have served the needs of Haryana, Punjab and Uttar Pradesh, according to the optimal flow plan of 1979-80. But the optimal plan of 1985-86, shows that this port should have served only Haryana and Uttar Pradesh.

The optimal plan of 1979-80 shows that fertiliser which arrived at Madras should have catered to the need of Andhra Pradesh, Gujarat and Maharastra. Contrary to this the optimal plan of 1985, indicates that this port should have served Tamil Nadu and Madhya Pradesh besides Andhra Pradesh. The optimal plan of 1985-86 shows that Bombay should have served Gujarat and Maharashtra.

4.5 An Overall View

Thus we find that despite certain limitations the results of this study are revealing. After doing a thorough survey of the actual flow pattern for two points of time, we find certain important changes have occurred in the actual flow pattern of fertilisers.

As has been mentioned earlier, historically most of the fertiliser plants were located on the coast line, while the largest markets are in up country, mainly on the Indo-Gangetic plains. The location of fertiliser plants was itself based on raw material used. The nitrogenous factories based on naptha were l.ocated nearer the oil refineries and oil refineries themselves were located on coast due to their dependence on imported crude. The phosphatic units were also located on coastline as they depended on imported raw materials. But in recent past due to certain technological changes the location pattern of fertiliser industry has started changing and new capacities have started coming up in the plain region of the country.

The impact of this change on location pattern has also affected the flow pattern of fertilisers. This fact can very easily be discerned by making survey of the actual flow pattern of fertilisers for two points of time. Due to creation of new capacities in northern states like Punjab, Haryana and Uttar Pradesh, Southern States like Kerala, Tamil Nadu and Karnataka, which were supplying fertiliser to these states along with others in 1979-80, have stopped doing so in 1985-86. But still we find that Punjab and Haryana are getting supply of fertilisers from far flung western states like Maharashtra and Gujarat. Uttar Pradesh is still receiving fertilisers from Maharashtra, Gujarat and Assam.

After making a comparison of actual and optimal flow pattern we find that in actual flow patterns the producing states had established linkages with a large number of states, whereas the optimal flow pattern suggests that these linkages should have been very few.

In actual flow pattern of both the years we find that Gujarat had established linkages with almost all the fifteen states which have been undertaken for this study. But the optimal flow pattern suggests that this state should have established linkage with only three states. Similar is the case with Maharashtra. According to optimal flow pattern states should have met their total demand internally and then according to the situation exis ting at any moment of time should have supplied to the neighbouring states. But in case of actual flow pattern we find that states like Gujarat, Maharashtra, Tamil Nadu and Kerala (where there is large surplus production of fertilisers), instead of meeting their internal demand completely from their own production, gets supply from other states and supplies their own production to various other states. This type of discrepancy causes a heavy pressure on transport network of the country and also increases financial burden of transportation.

Another startling fact which comes out from a comparison of actual and optimal flow patterns of fertilisers is that Karnataka, Kerala and Tamil Nadu are not viable states for locating the new fertiliser plants from the point of view of transportation cost. We find that the optimal flow pattern of both the years suggests that production of these states should have either been underutilised or should have not been utilised at all. However, in actual flow pattern we find that the production capacity in these states is being utilised.

The non-viability of these states for location of new fertiliser plants has become more vulnerable due to the development of new technology in which for manufacturing one tonne of end product urea, the requirement of naptha would be about 0.468 tonnes. Since input coefficient for naptha based technology is only 0.468, other things remaining the same, the location of naptha feedstock based plant should preferably be market oriented.

One possible explanation for this discrepancy in the actual and optimal flow patterns can be that, in this study we have taken allocation pattern of fertiliser which is done on the basis of future projections of demand and supply, as a proxy of actual flow pattern but discrepancy of such a large extent cannot be explained by this reason only.

Another cause for this type of discrepancy can be the location pattern of fertiliser industry, which is raw material based as has been mentioned in earlier part of this chapter. Faulty product planning particularly in respect of phosphatics adds further confusions to the already difficult task of rationalising supply arrangements. Diammonium-phosphate required in the north and western zone is being produced in south and nitrogenous fertiliser required in south is being produced in the western zone. The earlier we do away with such a discrepancy which causes large criss cross movements, the better.

CHAPTER V

CONCLUSION

The present study was undertaken to analyse spatial variations in the production patterns, in the movement pattern of fertilisers and finally, to obtain a pattern of movement which would involve the minimisation aof distance covered and, therefore, of transport costs, to carry fertilisers. Availability of limited resources make it essential that a pattern of linkages, which minimises the distances, should be established. With the production and consumption patterns as given in short run, it is the linkage pattern which can be made efficient for utilising the resources to the maximum. The main findings of this study are now summarised below.

1 Previously the location of fertiliser plants was raw material based since the production of nitrogenous fertiliser was based on naptha and other such raw materials which were based on crude oil and crude oil refineries itself were based on imported crude, most of the nitrogenous plants were located in coastal states. Phosphatic fertilisers which was based on imported raw materials were also located in coastal regions of the country.

2 But in recent past due to the advent of new technologies we find that this location pattern has

started changing. The new pipe line technology has also helped in dispersing the location of fertiliser plants in plain region where the consumption of fertilisers is very high.

3 On the basis of the actual flow pattern of 1979-80 and 1985-86, we can conclude that there have been certain changes in the flow pattern of fertilisers during these six years due to coming up of new fertiliser plants in Indo-Gangetic region. The northern states of the country almost stopped taking fertilisers from far flung southern states during these six years. But still we find movement of fertilisers from the states of western region to northern region states, which puts tremendous pressure on transportation network of the country.

4 On the basis of this study, we can conclude that there is a wide variation in production and consumption pattern of fertiliser in our country. There is very high degree of regional variation in the consumption of fertilisers. As a consequence of the impact of the green revolution in certain regions only, the fertiliser consumption is also concentrated in those regions only. We find that the consumption of

fertiliser is concentrated in norethern region whereas the production is concentrated in western and southern region. Although, capacity exists in eastern region of the country for production of fertilisers but in this region the capacity utilisation is very low due to which production is very low. All these factors cause heavy pressure on transport network of the country and also raises the transportation cost of fertiliser.

5 On the basis of this study we can conclude that there is lot of discrepancy in the movement pattern of fertilisers in our country. There is large discrepancy between actual and optimal flow pattern. In the actual movement of the fertiliser we find that fertiliser is moving very long distances. All the major fertiliser producing states had established linkages with large number of states. But as per the optimal plan these linkages should have been reduced to a considerable extent.

6 As per this study, the location of new fertiliser plants in southern states like Kerala, Karnataka and Tamil Nadu is not viable from the point of view of transport cost. According to the optimal flow plan developed in this study, the fertiliser production of

these states should have either been under utilised or should not have been utilised at all.

After the advent of new naptha based technology according to which input coefficient for fertiliser production is only 0.468, other things remaining the same, the vulnerability of locating fertiliser plants in southern region increases more. The location of naptha feedstock based plants should preferably be market oriented and geographically well dispersed in the potential demand regions.

7 On the basis of this study we can conclude that faulty product planning specially in case of phosphatic fertiliser is causing a large amount of criss-cross movement of fertilisers. This can only be removed by streamlining the product planning and creating capacity of producing phosphatic fertilisers in major consuming region.

8 In the present study state has been taken as a unit of production and consumption. But further study of this type can be taken up by taking all the production plants of the country and districts as the consumption units. An optimal flow plan can also be suggested by taking future projections of consumption and production of fertilisers.

9 This study in the locational pattern of production, supply and inter-regional flow should be regard as a first step in assessing the extent of anomaly that is likely to be present in the inter-regional transactions. The principle is that in the long run economic regionalisation brings about a reduction in long haulage of goods. This study has approached the problem only from sectoral points of view. Similar studies of important commodities involving long haulage would be of value in further testing the results of this study. For example what is considered an optimal flow pattern or linkages between states may not be practicable in all the situations because of the possibilities of transport bottlenecks along the same routes are involved in the inter-regional flow of several commodities. The pattern of flows along different routes would be complementary for this purpose even though the distance calculation makes use of the routewise flow.

BIBLIOGRAPHY

Books

Barna, Tibor, (ed.) The Structural Interdependence of the Economy; John Wiley, New York, 1954.

Bonavia, M.R., The Economics of Transportation, Cambridge University Press, 1936.

Dantzig, B., Linear Programming and Extension, Princeton University Press, 1963.

Dorfman, R., Samuelson, P.A., Solow, R.M., Linear Programming and Economic Analysis, McGraw-Hill Book Co, New York, 1958.

Ferguson, R.O., and Sargent F. Lauren, Linear Programming: Fundamentals and Applications, McGraw-Hill Book Co., New York, 1958.

Gass, Saul, Linear Programming, McGraw- Hill Book Co.,New York, 1960.

Ghosh, Ambika, Efficiency in Location and Inter-regional Flows, North-Holland Publishing Co., Amsterdam, 1965.

Hansen, Janserck, Optimal Patterns of Location, North-Holland Publishing Co., Amsterdam, 1970.

Hoover, E.M.. The Location of Economic Activity, McGraw-Hill Book Co., New York, 1963.

Isard, W., Location and Space Economy, John Wiley, New York, 1956.

Isard, W., Methods of Regional Analysis: An Introduction to Regional Science, New York, 1960.

Johnston, J., Econometric Methods, McGraw-Hill Book Co., New York, 1960.

Lefeber, L., Allocation in Space: Production, Transportation and Industrial Location, North-Holland Publishing Co., Amsterdam, 1958.

Locklin, O.P., Economics of Transportation, Richard D. Irvin, Inc., Illinois, 1965.

Nourse, H.O., Regional Economics, McGraw-Hill Book Co., New York, 1968

Richardson, H.W., Regional Economics, Wei-denfield and Nicolson, London, 1969.

Weber, Alfred, Theory of Location of Industries, The University of Chicago Press, Chicago, 1962.

Dissertations

Kak, Shakti, Rationalisation of Commodity Flows Cement Industry - A Case Study. Unpublished M.Phil. Dissertation, submitted to the Centre for the Study of Regional Development, School of Social Sciences, JNU, New Delhi. 1972.

Murali Dhar, V., A Comparative Analysis of Fertiliser use in the Punjab and Bihar Agriculture. Unpublished M.Phil. Dissertation, submitted to the Centre for the Study of Regional Development, School of Social Sciences, JNU, New Delhi. 1981.

Articles

Cooper, L., "Solutions of Generalised Locational Equilibrium Models", Journal of Regional Science, 7, 1967.

Ghosh, Ambika, "An Inter-Industrial Programming Model for Production and Transportation of Commodities for Different Regions of India", Arth Vijnana, Vol.9, No.2, 1967.

Gupta, Uttam, "Prospects Bright", Indian Industries Problems and Prospects 1986-67, A Patriot Publication, 1987.

Heredia, F.J., "Evolution of a Fertiliser Marketing System in India - A Critical Review", Proceedings of FAI Annual Seminar 1980, FAI Publication 1980.

Hopkins. E. Frank, " Transportation cost and Industrial Location: An Analysis of the Household Furniture Industry", Journal of Regional Science, vol.12, No.2, 1972.

Chauhan, K.K.S., "Challenges of Logistics in Seventh Plan: Need for Integrated Transport System", Fertiliser News, August 1986.

Jain, S.N., "Need to Augment Production Capacity", Indian Industries Problems and Prospects 1986-87, A Patriot Publication.

King, L, Cassetti. E, Odland, J., Semple, K., "Optimal Transportation of Coal in The Great Lakes Region", Economic Geography, vol.47, No.3, 1971.

Kapoor, R., "Fertiliser Marketing: Some Constraints in the 80's" Proceedings of FAI Annual Seminar 1980, FAI Publication.

Kumar, Sharwan, and Ahluwalia, S.S., "An Optimising Model for the Distribution of Nitrogenous Fertiliser in 1970-71", Proceedings of FAI Annual Seminar 1967, FAI Publication.

Mathur, P.N., and Hashim, S.R., "A Model for Location of Industries and Inter-Regional Commodity Flows", Indian Journal of Regional Science, vol.1, No.1, 1968.

Mahajan, L.C., "Need for Developing Low Cost Fertiliser Supply System: Role of Transport Economist therein", Proceedings of FAI Annual Seminar 1967, FAI Publication.

Mahajan, L.C. and Mrs Meena, " Transport Cost Minimisation of Fertiliser Distribution in Punjab", Fertiliser News - May 1967.

Mittal, V., "Strategies for Cost Reduction in Logistics of Fertiliser Distribution",Proceedings of FAI Annual Seminar 1984. FAI Publication.

Mohan K., "Transport of Fertilisers", Proceedings of FAI Annual Seminar 1979, FAI Publication.

Narain, Das and Sardesai, D.B., "Location of Industries in India Transport Cost Minimisation", Arth Vijnana, vol.9 (Special Issue), 1967.

Pushpraj, K., "A Rational Supply Planning for Fertilisers", Proceedings of FAI Annual Seminar 1980. FAI publication.

Singh, Padam, "Dispersal in Usage can Raise Farm Output", Indian Industries: Problems and Prospects 1986-87. A Patriot Publication.

Sodhi, A.J.S., "Reaching Fertiliser to Farmers Doorstep", Proceedings of FAI Annual Seminar 1979, FAI Publication.

Vasudevan, V., "Maximum Utilisation of Transport Capability", Fertiliser News, July 1979.

Venkataramnan, S., "Integrated Transport System for Fertilisers", Proceedings of FAI Annual Seminar 1980. FAI Publication.

Verma, N.P., "Transportation of Fertiliser in India During the Eighties", Proceedings of FAI Annual Seminar 1979. FAI Publication.

Verma, N.P., "Transportation of Fertilisers in India - An Optimisation Study", Proceedings of FAI Annual Seminar 1980. FAI Publication.

Government Publications and Reports

Fertiliser Scene in India - July 1987, FAI Publication, New Delhi.

Fertiliser Marketing News - March 1979, Vol. 10, No.3.

Fertiliser Marketing News - August 1979, vol.10, No. 8

Fertiliser Marketing News - April 1985, ,Vol. 16, No.4

Fertiliser Marketing News - November 1985, Vol.16, No.11

Fertiliser Statistics - 1979-80, FAI Publication, New Delhi.

Fertiliser Statistics - 1985-86. FAI Publication, New Delhi.

Newman's Indian Bradshaw - June 1987, W. Newman and Co. Ltd., Calcutta.

APPENDICES

Appendix-I

Trends in All-India Capacity, Production and Capacity Utilisation of N and P_2O_5
('000 tonnes)
(1951-52 to 1986-87)

Year	N			P_2O_5		
	Capacity	Production	Capacity Utilisation (%)	Capacity	Production	Capacity Utilisation (%)
1951-52	88.7	28.9	37	27.7	9.8	38
1956.57	88.7	78.8	89	43.2	17.6	44
1961-62	246.3	154.3	63	107.2	65.4	61
1969-70	1349.3	730.6	54	443.5	223.7	52
1974-75	2625.1	1186.0	60	737.6	331.2	59
1979.80	3902.0	2224.0	61	1284.0	763.0	65
1980-81	4586.0	2163.9	53	1330.0	841.5	65
1983.84	5200.0	3491.5	67	1614.3	1064.1	70
1984.85	5592.0	3917.3	74	1767.6	1317.8	86
1985.86	6695.0	4322.9	72	1952.5	1430.1	85
1986-87	6880.0	5412.2	79	22141.0	1661.9	81

Source - Fertiliser Scene in India - July 1987 - FAI.

Appendix-II

All-India Capacity, Production and Capacity Utilisation of N and P_2O_5 Sectorwise
('000 tonnes)
(1981-82 to 1986-87)

Year	Sector	N Capacity	N Production	N Capacity Utilisation (%)	P_2O_5 Capacity	P_2O_5 Production	P_2O_5 Capacity Utilisation (%)
1981-82	Pub	2834.0	1625.9	56.3	658.0	296.5	45.1
	Pvt.	1397.0	1079.4	79.8	490.0	402	82.1
	Coop.	488.0	438.3	93.4	260.0	249.9	122.1
	Total	4719.0	3143.6	66.9	1408.0	945.4	67.4
1982-83	Pub	2986.0	1586.2	53.2	658.0	287.6	43.7
	Pvt.	1700.0	1390.8	85.5	574.0	424.7	84.9
	Coop.	488.0	447.0	91.6	260.0	267.7	103.0
	Total	717.40	3424.0	67.2	1492.0	980.0	69.1
1983-84	Pub	2986.0	1660.5	55.6	658.0	286.5	43.5
	Pvt.	1726.0	1397.0	81.3	696.3	508.5	70.4
	Coop.	488.0	434.0	88.9	260.0	269.1	103.5
	Total	5200.0	3491.5	67.0	1614.3	1064.1	70.0
1984-85	Pub	2986.0	1845.4	60.2	658.0	345.1	67.0
	Pvt.	2118.0	1549.9	90.0	849.6	624.4	90.6
	Coop.	488.0	522.0	107.0	260.0	348.3	134.0
	Total	5592.0	3917.3	74.0	1767.6	1317.8	86.0
1985-86	Pub	3669.0	2052.0	61.4	658.0	304.0	59.7
	Pvt.	1870.0	1680.4	89.9	1034.5	774.2	74.8
	Coop.	1156.0	590.5	95.1	260.0	351.9	135.3
	Total	6695.0	4322.9	72.0	1952.5	1430.1	85.0
1986-87	Pub	3846.0	2514.0	65.4	777.0	558.0	71.6
	Pvt.	1836.0	1780.2	99.1	1128.1	761.9	77.2
	Coop.	1198,0	1118.0	93.3	309.0	342.0	110.7
	Total	6880.0	5418.2	79.0	2214.1	1661.9	81.0

Source - Fertiliser Scene in India - July 1987 - FAI.

APPENDIX III

Number of Plants in Various Ranges of Capacity Utilisation - N

Capacity Utilization range (per cent)	1976-77	1984-85	1985-86	1986-87
Above 100	2	4	5	6
Between 91-100	2	2	3	3
" 81-90	1	11	8	11
" 71-80	8	4	8	5
" 61-70	2	4	3	8
" 51-60	4	4	4	1
" 41-50	3	5	1	2
Below 41	7	7	15	11
Total	29	41	47	47
All India Capacity Utilization (%)	64	74	72	79

Source - Fertiliser Scene in India - July 1987 - FAI.

APPENDIX IV

Zonewise capacity and production of nitrogenous and phosphatic fertilizers
1983-84 to 1985-86 (April-March)

Zone	1983-84				1984-85				1985-86			
		Production				Production				Production		
	Capacity	Quantity	Zone's share to total utilization	% capacity utilization	Capacity	Quantity	Zone's share to total utilization	% capacity utilization	Capacity	Quantity	Zone's share to total utilization	% capacity utilization
NITROGEN (N)												
East	1095	404.5	11.6	37	1095	425.5	10.9	39	1188	389.8	9.0	35
North	1381	1003.9	28.8	73	1397	1064.1	27.2	77	1397	1057.8	24.5	76
South	1306	823.3	23.6	63	1314	1066.3	27.2	81	1314	946.6	21.9	72
West	1418	1259.8	36.0	89	1786	1258.2	34.7	95	2796	1929.3	44.6	88
All India	5200	3491.5	100.0	67	5592	3917.3	100.0	74	6695	3422.9	100.0	72
PHOSPHATE (P_2O_5)												
East	186	22.1	2.1	12	200	30.4	2.3	67	438	36.3	2.6	59
North	69	58.3	5.5	89	144	73.9	5.6	59	173	107.8	7.5	67
South	609	409.0	38.4	69	602	538.9	40.9	90	605	514.1	35.9	85
West	751	574.7	54.0	81	822	674.6	51.2	83	874	771.9	54.0	90
All India	1614	1064.1	100.0	69	1768	1317.8	100.0	86	2090	1430.1	100.0	87

Source: Fertiliser News - October 1986.

Appendix V

Reasons for loss of production in N and P_2O_5
1983-84 to 1985-86
('000 tonnes)

Item	N						P_2O_5					
	1983-84	%age loss	1984-85	%age loss	1985-86	%age loss	1983-84	%age loss	1984-85	%age loss	1985-86	%age loss
1. Power Problems	245.9	28.5	84.9	16.1	88.3	12.5	37.4	23.2	2.9	6.5	2.6	2.6
2. Shortage of raw material	38.2	4.4	11.2	2.1	17.5	2.5	16.4	10.2	5.4	12.0	2.8	2.8
3. Equipment breakdown	421.6	48.8	317.2	60.2	333.9	47.4	50.6	31.4	15.2	33.0	26.6	26.8
4. Labour problems	3.2	0.4	12.7	2.4	15.0	2.1	4.0	2.4	2.0	4.4	10.5	10.6
5. Others	155.2	17.9	101.2	19.2	249.4	35.5	52.9	32.8	19.4	43.2	56.6	57.2
Total	864.1	100.0	527.2	100.0	704.1	100.0	161.3	100.0	44.9	100.0	99.1	100.0

Source: Fertilizer News - October 1986

Appendix VI

State-wise Consumption of Plant Nutrients per unit of Gross-cropped Area (Kg/ha)

1979-80 to 1985-86

	Year						
Zone/State	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86
Central	21.4	24.1	26.0	29.2	-	-	-
1. Madhya Pradesh	7.4	9.2	10.9	11.2	19.5	16.8	19.1
2. Rajasthan	8.6	8.0	7.9	9.7	11.3	11.3	11.6
3. U.P.	43.3	49.4	52.2	58.3	66.2	65.3	78.7
East	15.9	18.1	17.6	18.3	25.2	29.6	33.2
4. Assam	2.06	2.8	3.3	3.8	5.0	3.9	4.7
5. Bihar	15.9	17.8	18.0	18.4	27.4	39.6	48.8
6. Orissa	8.5	9.6	9.9	10.9	11.9	113.7	14.7
7. West Bengal	30.6	35.9	32.8	35.1	49.8	58.0	52.2
North	68.3	74.6	79.0	85.8	76.0	77.3	88.2
8. Haryana	39.7	42.5	45.5	48.0	56.0	63.5	65.5
9. Punjab	106.8	117.9	123.7	131.8	143.2	151.4	157.4
South	45.3	44.3	47.6	52.8	62.3	70.4	65.4
10.Andhra Pradesh	42.7	45.9	50.0	59.6	69.6	76.7	66.3
11.Karnataka	33.2	31.1	34.4	36.0	43.9	53.0	48.4
12.Kerala	36.2	33.4	32.9	36.4	44.5	44.7	49.8
13.Tamil Nadu	69.2	63.2	66.7	73.0	84.9	104.5	96.2
West	26.4	25.7	30.8	27.9	23.3	23.2	23.9
14.Gujarat	36.6	34.4	38.6	33.9	46.1	49.4	40.5
15.Maharashtra	21.3	21.2	26.6	24.8	31.5	29.2	31.7
All India	30.5	31.9	34.6	36.9	43.5	33.7	48.4

Source: Fertiliser Statistics - 1979-80 to 1985-86 -FAI.

STATEWISE PRODUCTION AND CONSUMPTION OF N, P_2O_5 & K_2O

1979-80 (April-March)

('000 tonnes)

Zone/State	N			P_2O_5			K_2O†	Total		
	Production	Consumption*	Surplus/ deficit (±)	Production	Consumption*	Surplus/ deficit (±)	Consumption*	Production	Consumption*	Surplus/ deficit (±)
Central	328.0	973.0	−645.0	52.5	258.3	−205.8	90.1	380.5	1,321.6	−941.1
Madhya Pradesh	6.7	96.9	−90.2	14.1	50.0	−35.9	12.8	20.8	159.7	−138.9
Rajasthan	116.0	115.4	+0.6	10.6	26.1	−15.5	5.6	126.6	147.1	−20.5
Uttar Pradesh	205.3	756.3	−551.0	8.5	181.3	−172.8	71.4	213.8	1,009.1	−795.3
Delhi	—	4.4	−4.4	19.3	0.95	+18.4	0.34	19.3	5.66	+13.6
East	267.5	347.6	−81.1	23.5	104.7	−81.2	54.6	291.0	507.0	−216.0
Arunachal Pradesh	—	0.06	−0.06	—	0.009	−0.009	0.017	—	0.086	−0.086
Assam	78.1	5.6	+72.5	0.4	0.7	−0.3	0.5	78.5	6.8	+71.7
Bihar	77.3	145.0	−68.7	9.9	26.1	−16.2	13.2	87.2	184.3	−97.1
Manipur	—	2.28	−2.28	—	0.56	−0.56	0.18	—	3.01	−3.01
Meghalaya	—	1.15	−1.15	—	0.5	−0.5	0.09	—	1.84	−1.84
Nagaland	—	0.06	−0.06	—	0.011	−0.011	0.021	—	0.09	−0.09
Orissa	56.6	46.4	+9.2	—	13.3	−13.3	7.2	55.6	67.4	−11.8
Sikkim	—	0.05	−0.05	—	0.18	−0.18	0.13	—	0.56	−0.56
Tripura	—	1.39	−1.39	—	0.35	−0.35	0.39	—	2.13	−2.13
West Bengal	56.5	144.9	−88.4	13.2	62.9	−49.7	32.9	69.7	240.7	−171.0
Mizoram	—	0.027	−0.027	—	0.025	−0.025	0.018	—	0.07	−0.07
North	248.2	677.5	−430.3	—	215.1	−215.1	44.1	248.2	936.7	−688.5
Haryana	64.5	174.5	−110.0	—	30.2	−30.2	10.7	64.5	215.5	−151.0
Himachal Pradesh	—	9.8	−9.8	—	2.3	−2.3	1.9	—	14.0	−14.0

(Continued)

STATEWISE PRODUCTION AND CONSUMPTION OF N, P_2O_5 & K_2O
1979-80 (April-March) (Concluded)

('000 tonnes)

Zone/State	N			P_2O_5			K_2O†	Total		
	Production	Consumption*	Surplus/deficit (±)	Production	Consumption*	Surplus/deficit (±)	Consumption*	Production	Consumption*	Surplus/deficit (±)
Jammu & Kashmir	—	16.5	−16.5	—	4.6	−4.6	1.5	—	22.5	−22.5
Punjab	183.7	474.1	−291.4	—	178.0	−178.0	30.0	183.7	682.1	−498.4
Chandigarh	—	2.61	−2.61	—	0.07	−0.07	0.010	—	2.62	−2.62
South	751.9	950.6	−198.7	329.2	338.7	−9.5	265.0	1,081.1	1,554.3	−473.2
Andhra Pradesh	60.6	369.7	−309.1	84.9	126.0	−41.1	39.1	145.4	534.8	−389.4
Karnataka	106.4	204.0	−97.6	6.1	86.5	−80.4	75.8	112.5	366.3	−253.8
Kerala	168.5	46.4	+122.1	69.2	25.4	+43.8	33.9	237.7	105.6	+132.1
Tamil Nadu	416.4	324.6	+91.8	169.0	99.5	+69.5	113.8	585.4	537.9	+47.5
Pondicherry	—	5.9	−5.9	—	1.3	−1.3	2.5	—	9.7	−9.7
West	628 4	483.8	+144.6	357.9	206.4	+151.5	113.2	986.3	803.4	+182.9
Gujarat	351.3	224.1	+130.2	213.4	114.4	+99.0	39.1	564.7	377.5	+187.2
Maharashtra	126.1	257.3	−131.2	117.0	90.6	+26.4	73.1	243.1	421.1	−178.0
Goa	151.0	2.3	+148.7	27.5	1.3	+26.2	1.0	178.5	4.6	+173.9
Dadra & Nagar Haveli	—	0.12	−0.12	—	0.08	−0.08	0.02	—	0.22	−0.22
Others	—	66.5	−66.5	—	27.1	−27.1	39.5	—	132.8	−132.8
All India	2,224.3	3,499.0	−1,274.7	763.1	1,150.3	−387.2	606.5 ✓	2,987.4	5,255.8	−2,268.4

*Consumption data are provisional and based on February/January period.

†There is no production of K_2O and entire requirement is met through imports.

Source: Ministry of Agriculture & Rural Reconstruction, New Delhi.

APPENDIX VIII

STATEWISE PRODUCTION AND CONSUMPTION OF N, P_2O_5 AND K_2O
1985-86 (April-March)

('000 tonnes)

Zone/State	N			P_2O_5			K_2O	Total ($N+P_2O_5+K_2O$)		
	Production	Consumption@	Surplus/ deficit@	Production	Consumption@	Surplus/ deficit@	Consumption@	Production	Consumption@	Surplus/ deficit@
East	**390.9**	**7!4.7**	**−323.8**	**38.3**	**238.0**	**−199.7**	**129.5**	**429 2**	**1082.3**	**−653.1**
Arunachal Pradesh	—	0.10	−0.10	—	0.05	−0.05	0.03	—	0.18	−0 18
Assam	75.7	9.3	66.4	1.2	3.6	−2.4	3.8	76.9	16 7	60.2
Bihar	174.8	351.4	−176.6	1.3	104.9	−103.6	45.1	176.1	501.5	−325.4
Manipur	—	3.9	−3.9	—	0.8	−0.8	0.13	—	4.84	−4.84
Meghalaya	—	1.6	−1.6	—	1.3	−1.3	0.17	—	3.0	−3.0
Mizoram	—	0.05	−0.05	—	0 03	−0.03	0.01	—	0.25	−0.25
Nagaland	—	0.18	−0.18	—	0.06	−0.06	0 01	—	0.22	−0.22
Orissa	90.2	87.1	3.1	1.0	33.4	−32 4	19.9	91.2	140.5	−49 3
Sikkim	--	0.62	−0.62	—	0.51	−0.51	0.04	—	1.20	−1.2
Tripura	—	3.5	−3.5	—	1.0	−1.0	0.72	—	5.15	−5.15
West Bengal	50 2	256.9	−206.7	34.8	92.3	−57.5	59.6	85.0	408 7	−323.7
A & N Islands	—	0 06	−0.06	—	0.04	−0.04	0.03	—	0.13	−0.13
North	**1058.4**	**2616.7**	**−1558.3**	**108.0**	**743.4**	**−635.4**	**150.3**	**1166.5**	**3510.4**	**−2344.0**
Haryana	142.1	296.4	−154.3	22.8	69.7	−46.9	6.2	164.9	372.3	−207.4
Himachal Pradesh	—	17.8	−17.8	—	3.4	−3 4	2.45	—	23.6	−23.6
Jammu & Kashmir	—	24.9	−24.9	—	7.5	−7.5	2.76	-	35.2	−35.2
Punjab	373.9	787.2	−413.3	31.8	287 2	−255.4	23.7	405.7	1098 2	−692.5
Uttar Pradesh	542.4	1482.8	−940.4	38.3	374.3	−336.0	114.8	580.7	1971.9	−1391 2
Chandigarh	—	0.8	−0.8	—	0.14	−0.14	0.2	—	1.1	−1.1
Delhi	—	6.75	−6.75	15.1	1.17	13.93	0.2	15.1	8.10	7.0

(Countinued)

STATEWISE PRODUCTION AND CONSUMPTION OF N, P_2O_5 AND K_2O

1985-86 (April-March) (Concluded)

('000 tonnes)

Zone/State	N Produc-tion	N Consump-tion@	N Surplus/deficit@	P_2O_5 Produc-tion	P_2O_5 Consump-tion@	P_2O_5 Surplus/deficit@	K_2O Consump-tion@	Total ($N+P_2O_5+K_2O$) Produc-tion	Total Consump-tion@	Total Surplus/deficit@
South	**943.8**	**1311.3**	**−367.5**	**509.5**	**590.2**	**−80.7**	**367.9**	**1453.3**	**2269.4**	**−816.1**
Andhra Pradesh	137.0	568.9	−431.9	105.0	242.8	−137.8	76.5	242.0	888.1	−646.1
Karnataka	110.8	295.7	−184.9	6.4	164.4	−158.0	95.5	117.2	555.6	−438.4
Kerala	179.4	59.8	119.6	102.0	34.8	67.2	47.9	281.4	142.6	138.8
Tamil Nadu	516.6	378.9	137.7	296.1	145.4	150.7	143.9	812.7	668.3	144.4
Pondicherry	—	8.0	−8.0	—	2.8	−2.8	4.1	—	14.8	−14.8
West	**1929.8**	**1114.6**	**815.2**	**774.5**	**471.2**	**303.2**	**165.0**	**2704.2**	**1750.8**	**953.4**
Gujarat	924.1	286.5	637.6	430.7	109.3	321.4	25.6	1354.8	421.3	933.5
Madhya Pradesh	6.0	253.2	−247.2	35.9	152.8	−116.6	25.8	41.9	431.9	−390.0
Maharashtra	645.4	410.6	234.8	145.4	151.3	−5.9	107.2	790.8	669.1	121.7
Rajasthan	163.0	160.8	2.2	37.9	55.5	−17.6	4.6	200.9	220.9	−20.0
Goa, Daman & Diu	191.3	3.3	188.0	124.5	2.2	122.3	1.8	315.8	7.2	308.6
Dadra & Nagar Haveli	—	0.24	−0.24	—	0.14	−0.14	0.02	—	0.40	−0.4
Others	—	**54.1**	**−54.1**	—	**20.5**	**−20.5**	**34.6**	—	**109.2**	**−109.2**
All India	**4322.9**	**5811.4**	**−1488.5**	**1430.2**	**2063.3**	**−633.1**	**847.3**	**5753.1**	**8722.1**	**−2969.0**

@ = Provisional.

Note: 1. K_2O consumption is treated as deficit since entire requirement is met through imports.

2. Production refers to the nutrient 'N', 'P_2O_5' manufactured in the State values, consumption takes into account both sources of availability viz., import and indigenous production including inter-state movement of materials.

X

Appendix IX

Transport Matrix Showing Haulage Distances from Origin States to Destination States by Rail (Kms)

Origin States	Destination States: Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan
Assam	213	1670	1245	1376	2619	2820	2648	2561	4500	4079	3882	3584	2300	3020	2870
Bihar	1205	362	767	389	1261	1462	1290	1587	2585	2707	2510	2239	1033	2043	1570
Orissa	2196	1040	848	614	2040	2247	2075	792	2333	1912	1715	2516	1114	2673	2297
West Bengal	1520	402	526	63	1443	1640	1423	1249	2735	2369	2172	2390	989	1708	1690
Haryana	2822	973	1486	1439	67	296	270	2014	2086	2769	2639	1214	1342	1211	500
Punjab	2951	1232	1737	1698	192	359	232	2265	2345	3020	2890	1538	1684	1470	751
Uttar Pradesh	1929	446	1291	912	594	791	619	2355	1957	3248	2351	1552	1831	928	842
Andhra Pradesh	2246	1400	503	974	2263	2464	2292	212	1753	1332	1135	1756	523	1913	2514
Karnataka	4328	3124	2186	2658	3251	3447	3275	1472	1441	351	698	2443	2207	2600	3502
Kerala	4143	2939	2000	2473	3066	3262	3090	1287	1684	275	513	2258	222	2415	3317
Tamil Nadu	4083	2879	1941	2413	3006	3202	3030	1227	1624	612	365	2198	1962	2355	3257
Gujarat	3485	1841	1650	2212	1117	1318	1146	1458	1128	2219	2150	256	1287	567	1177
Madhya Pradesh	2222	1415	387	949	1428	1629	1457	758	1723	1878	1681	1377	32	695	1679
Maharashtra	3350	1660	1503	2089	1550	1905	1579	950	619	1716	1641	273	1149	430	1652
Rajasthan	2825	1345	1868	1811	621	826	650	1858	1528	2619	2550	656	1865	1339	872
Goa	4088	3281	2343	2815	3408	3609	3437	1629	190	1178	1408	1062	1938	1219	3650
Delhi	2360	880	1354	1346	156	357	185	1921	1993	2676	2546	1121	1249	1118	407
Calcutta	1368	561	564	95	1601	1798	1594	1091	2577	2211	2014	2232	831	1559	1848
Kandla	3474	1994	2069	2631	1380	1737	1565	1877	1547	2638	2569	675	1706	986	1596
Bombay	3337	1656	1503	2079	1540	1895	1569	939	669	1700	1631	263	1139	420	1642
Madras	3428	2264	1286	1758	2351	2552	2380	572	969	548	351	1563	1307	1700	2602

<u>APPENDIX X</u>

Transport Matrix Showing Freight Charges paid from Origin States to Destination States by Rail (in Rs.)
(1979-80)

Origin States	Destination States: Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan
Assam	22.8	140.86	105.01	116.06	220.91	237.86	223.35	216.02	379.57	344.06	327.44	302.31	194	254.773	242.08
Bihar	101.64	37.86	77.23	40.86	106.36	123.31	18.81	133.86	218.04	228.33	211.71	188.85	87.13	172.32	127.53
Orissa	185.23	87.72	85.39	61.82	172.07	189.53	175.02	79.95	196.78	161.27	144.66	212.22	93.96	225.46	193.75
West Bengal	128.21	42.04	52.96	11.97	121.71	138.33	120.03	105.35	230.69	199.82	183.20	201.59	99.59	144.06	142.55
Haryana	238.03	97.98	125.34	121.43	12.73	30.96	28.24	169.88	175.95	233.56	22.59	102.40	113.19	102.14	52.30
Punjab	248.91	103.91	146.51	143.22	26.88	37.55	24.26	191.05	197.80	254.73	243.77	129.73	142.04	123.99	75.62
Uttar Pradesh	162.71	46.95	108.89	91.83	59.81	79.65	62.33	198.64	165.07	273.96	198.30	130.91	154.44	93.44	84.78
Andhra Pradesh	189.45	121.46	50.65	98.08	190.88	207.83	193.33	22.17	147.86	112.35	95.73	148.11	44.11	161.36	212.05
Karnakaka	365.06	263.05	184.38	224.20	274.22	290.75	276.24	124.16	121.54	36.71	70.28	206.06	186.16	219.31	295.39
Kerala	349.46	247.90	168.70	208.59	258.61	275.14	260.64	108.55	142.04	28.76	51.65	190.46	170.55	203.70	279.78
Tamil Nadu	344.40	242.84	163.72	203.53	253.55	270.08	255.58	103.49	136.98	61.62	36.75	185.40	165.49	198.64	274.72
Gujarat	293.95	155.28	139.17	186.58	94.21	111.17	96.66	122.98	95.14	187.17	181.35	26.77	108.55	57.09	99.27
Madhya Pradesh	187.42	119.35	40.48	95.56	120.45	137.40	122.89	76.33	145.33	158.40	141.79	116.14	6.08	69.98	141.62
Maharashtra	282.57	140.02	127.61	176.20	130.74	160.68	133.18	95.66	62.33	144.23	138.41	28.55	96.91	36.27	139.34
Rajasthan	238.28	113.45	157.56	152.75	62.53	83.17	65.45	156.72	128.88	220.91	215.09	66.05	157.31	112.94	87.81
Goa	344.82	276.75	197.63	237.44	287.46	304.41	289.91	137.40	26.6	99.36	118.76	89.57	163.47	102.82	307.87
Delhi	199.06	88.61	114.20	113.53	21.84	37.34	25.90	162.03	168.10	225.72	214.75	94.55	105.35	94.30	42.57
Calcutta	115.39	56.49	56.79	18.05	135.04	151.66	134.45	92.02	217.36	189.28	169.88	188.26	83.68	130.74	155.87
Kandla	293.03	168.19	174.52	221.92	116.40	146.51	132.00	158.42	130.48	222.51	216.69	67.97	143.90	99.29	134.62
Madras	289.15	190.96	108.47	148.28	198.30	215.26	200.75	57.60	97.57	55.18	36.71	130.15	110.24	143.39	219.47

Appendix XI

Transport Matrix Showing Freight Charges paid from Origin States to Destination States by Rail (in Rs.)
(1985-86)

Origin States	Destination States: Assam	Bihar	Orissa	West Bengal	Haryana	Punjab	Uttar Pradesh	Andhra Pradesh	Karnataka	Kerala	Tamil Nadu	Gujarat	Madhya Pradesh	Maharashtra	Rajasthan
Assam	60.25	395.95	295.18	326.24	620.96	668.60	628.84	607.24	1066.95	967.13	920.42	849.76	543.33	716.00	680.47
Bihar	285.70	102.31	208.93	110.0	298.98	346.64	305.85	376.27	612.90	641.82	595.12	530.86	244.92	484.39	358.49
Orissa	520.67	246.58	230.99	167.25	483.68	532.76	491.98	215.74	553.15	451.33	406.62	596.54	278.35	633.76	544.60
West Bengal	360.39	133.68	143.28	25.13	342.13	388.84	337.39	296.13	648.46	561.68	514.98	566.66	296.40	404.96	400.69
Haryana	669.00	265.00	352.33	341.18	26.73	83.70	76.35	477.51	494.59	656.52	625.70	287.83	318.18	287.12	141.40
Punjab	699.68	292.10	411.84	402.59	62.20	101.52	65.60	537.00	555.99	716.00	685.21	364.65	399.27	348.53	204.51
Uttar Pradesh	457.36	126.12	366.00	248.42	161.80	251.46	168.61	558.37	464.00	770.10	557.42	367.97	434.13	252.78	229.36
Andhra Pradesh	532.56	341.42	137.00	265.31	536.55	584.21	543.43	59.95	415.63	315.81	269.10	416.34	142.46	453.51	596.00
Karnataka	1026.76	740.70	518.30	530.21	770.81	817.28	776.50	349.00	341.66	99.26	190.13	579.23	523.27	616.46	830.32
Kerala	982.30	696.83	474.20	586.34	729.94	773.42	732.63	305.14	399.27	77.77	139.74	535.37	479.41	572.59	786.46
Tamil Nadu	968.00	682.61	460.21	572.12	712.72	759.19	718.41	290.92	385.00	166.70	103.22	521.14	465.19	558.37	772.23
Gujarat	822.29	436.50	391.21	524.40	264.84	312.49	271.71	345.69	267.44	526.12	509.76	72.39	305.14	154.45	279.00
Madhya Pradesh	526.83	335.49	109.44	258.50	338.57	386.23	345.45	206.47	408.52	445.27	398.56	326.49	12.76	189.31	398.00
Maharashtra	794.28	393.58	356.66	495.30	367.50	451.67	374.38	258.78	168.61	405.44	389.00	77.20	272.46	121.60	391.68
Rajasthan	669.80	318.89	442.90	429.38	169.16	225.00	177.00	440.53	362.28	620.69	604.60	178.69	442.19	317.47	237.53
Goa	969.26	777.92	555.52	667.43	808.00	855.69	814.91	386.23	61.56	279.30	333.83	251.80	459.49	289.00	865.41
Delhi	559.55	239.71	321.00	319.13	50.54	100.95	59.94	455.46	472.54	634.47	603.65	265.78	296.13	265.00	115.00
Calcutta	324.35	152.81	153.63	37.90	379.59	426.30	377.93	258.67	611.--	524.22	477.51	529.20	226.36	367.50	438.16
Kandla	826.68	472.77	490.55	623.81	327.19	411.84	371.00	445.00	366.79	625.46	609.10	183.87	404.49	268.58	378.41
Bombay	791.20	391.21	356.36	492.93	365.13	449.30	372.00	255.78	165.89	403.00	386.71	74.37	270.00	118.77	389.31
Madras	812.77	536.79	304.91	416.82	557.42	605.00	564.20	155.81	263.95	149.27	99.26	365.84	309.88	403.00	616.93