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44964

P.O. Box 2040
Muscle Shoals, Alabama 35660 U.S.A.

REVIEW OF THE FERTILIZER DISTRIBUTION AND HANDLING SYSTEM IN BANGLADESH

Prepared by

W. E. Clayton

Transportation/Distribution Specialist

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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
BADC	Bangladesh Agricultural Development Corporation
BARI	Bangladesh Agricultural Research Institute
BCIC	Bangladesh Chemical Industries Corporation
BIWTA	Bangladesh Inland Water Transport Authority
BIWTC	Bangladesh Inland Water Transport Corporation
BTS	Bangladesh Transport Study
CPS	Consultant Packaging Systems
CRH	critical relative humidity
DAP	diammonium phosphate
EIU	Economist Intelligence Unit
FY	fiscal year
GAO	General Accounting Office
GMT	Greenwich Mean Time
IDA	International Development Agency
IECO	International Engineering Company, Ltd.
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Center
IWTS	Inland Water Transport Study
K	potassium
MOP	muriate of potash
N	nitrogen
NEI	Netherlands Economic Institute
NFSP	National Fertilizer Storage Plan
P	phosphorus
PAPR	partially acidulated phosphate rock
PDP	primary distribution point
TSP	triple superphosphate
TVA	Tennessee Valley Authority
USAID	U.S. Agency for International Development

UNITS OF MEASUREMENT

dwt	deadweight	tpd	tons per day
ft	feet	tpw	tons per week
tons	metric tons	tpy	tons per year

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SUMMARY AND RECOMMENDATIONS

Under the USAID-financed International Fertilizer Development Center/ Bangladesh Agricultural Development Corporation (IFDC/BADC) Fertilizer Distribution and Marketing Consultancy Services Contract and in connection with the related Fertilizer Supply and Use Policy Study for Bangladesh, a review has been undertaken of the overall system for supply, distribution, and storage of fertilizers in Bangladesh.

Existing systems for transportation and handling of fertilizers from source locations at production centers and ports up to primary distribution point (PDP) level have been studied. A wide range of recent and current reports and proposals are available covering transportation and fertilizer activities. These have been reviewed in the context of operation of the whole fertilizer system by BADC with the intention of (a) assisting BADC with the interpretation of the various studies and (b) advising BADC and IFDC on how best to proceed in developing the recommended systems.

It is concluded that existing transportation and storage facilities, with improvements projected under USAID, The World Bank, and other donor agency proposals, are adequate to meet requirements up to and beyond the currently projected levels for 1984/85.

In order to make the most efficient use of limited existing transportation and handling facilities, it is recommended that fertilizer should be moved through the system on a completely regular basis, as far as possible towards the point of final consumption. In the case of BADC, this is the PDP level. For the concept to be effective, it is essential that a reliable forecast of demand down to PDP level is available. The system is then conceived as a stock building operation to PDP level, with movements planned in advance and all operations controlled and monitored centrally by BADC. Creation of a central control unit in BADC Headquarters to undertake this function is recommended.

Transport facilities should all be planned on the basis of regular movement throughout the year (with necessary adjustments during the monsoon period). Output from the production units is already on as regular a basis as can be achieved, and imports should also be phased on as regular a basis as possible. Storage at Chittagong and Chalna ports and at the production units is then viewed as buffer storage for <u>transportation</u> purposes only and should be adequate to sustain regular dispatches by the planned transport means. All storage for <u>marketing</u> purposes is at PDP level.

In addition to achieving the most effective and cost efficient use of transport resources, regularity of movement also allows considerable improvements in handling efficiency. For example, it is recommended that the major transit center at Shiromoni should operate in the transit mode to the maximum possible extent and not be considered as a storage point. Supply should be by barge on a regular daily basis from Chalna, and to the extent possible, the product should be transferred direct to rail wagons and trucks, with unit train services operating on a regular, preplanned daily basis.

Particular importance is attached to the development and operation of the unit train system, together with rehabilitation of the key rail ferry at Bahadurabad Ghat, as envisaged under The World Bank improvement project (Section 12.3).

It is recommended that present activities directed towards import of fertilizer in bulk should be coordinated and promoted by BADC, in view of the cost savings to Bangladesh, particularly of foreign exchange. Bulk import systems have been reviewed in the light of port characteristics and constraints. Based on experience and observations in other countries, it is recommended that a bag-on-board method should be adopted to meet the immediate and medium-term situation (Section 10.6).

Warehousing requirements, design, layout, and operation have been reviewed and a number of recommendations are made (Sections 9.4, 9.5). Particular attention is given to warehouse ventilation, where improvements to existing designs are necessary to provide satisfactory conditions for storage of urea.

The structure and operation of the proposed future distribution system is discussed (Section 12). Essential requirements for equipment and physical facilities in the ports, transit centers, transportation, and storage systems are summarized (Section 12.5). Reference is also made to the need for reorganization and improvement in management systems within BADC (Sections 12.6, 12.7).

1. INTRODUCTION

The Government of Bangladesh is receiving grant funds from the U.S. Agency for International Development (USAID) for a fertilizer distribution improvement project initiated in 1978 as a continuation of earlier activities and intended to increase food grain production through increased use of fertilizer on an equitable basis. The principal government agency involved is BADC. The project involves removal of constraints in the supply, distribution, and offtake areas and includes provision for improvement in infrastructure, storage, handling and import systems, import of fertilizer, improvement of management systems, and the use of marketing consultants.

IFDC is supplying technical assistance to BADC in respect to marketing and distribution activities under a contract effective for 15 months from January 5, 1979, and currently effective as amended to the end of August 1981.

Under the contract, two Resident Consultants based in the Dacca Headquarters have been working with BADC on marketing and distribution aspects; various short-term consultants have also been involved. Technical support and facilities are also available from IFDC Headquarters; for example, the recently arranged Seminar on Fertilizer Supply and Use Policy for Bangladesh and the study tour on zinc and sulfur usage.

At the present time, there is one Resident Distribution Consultant and one short-term Marketing Consultant based in Dacca, the latter engaged in phase III of the continuing evaluation of the New Marketing System.

Since the Distribution Consultant has had to cover various organizational and marketing aspects, it has not been possible to cover all the distribution aspects at the required level. In working towards a more efficient distribution system, it was suggested that short-term assistance at the detailed operating level would be useful. In view of the many recent and extensive studies covering storage and distribution aspects, some still in progress, it was considered more helpful to BADC and IFDC at this stage to review the studies and undertake a wider look at the operation of the whole distribution system with the intention of (a) assisting BADC in interpretation of the various studies and (b) advising BADC and IFDC on how best to proceed in developing the recommended systems.

Accordingly, Terms of Reference for a short-term study were developed and discussed in Dacca with BADC, USAID, and the IFDC Resident Consultant, covering movement of fertilizer in Bangladesh from source to primary distribution point. These are shown in Appendix B.

2. FERTILIZER TRANSPORTATION SYSTEM STUDIES AND PROJECTS

2.1. General

Over at least the past decade, studies on the Bangladesh fertilizer system and transportation systems have proceeded on a continuous basis. There have been several major studies, and all aspects of fertilizer import, handling, transportation, and storage affecting BADC interests have been investigated.

2.2. East Pakistan Study

A major study was made by the then Government of East Pakistan for the 1970-75 plan period and covered all aspects of supply, movement, storage, and marketing. The last section included extension, credit, subsidies, prices, and dealer and private sector involvement. Many of the conclusions and recommendations of the study still are good.

2.3. USAID Studies

During the 1960s, AID encouraged fertilizer use in East Pakistan and financed a large part of the imports and has continued since then to play a leading role in increasing usage of fertilizer in Bangladesh.

A study by the Tennessee Valley Authority (TVA) on The Bangladesh Fertilizer Situation was prepared for AID in 1974. During FY 1974 and FY 1975, AID Agricultural Input Projects I and II funded imports of fertilizer.

The fundamental importance of adequate in-country storage was recognized at an early stage by AID and BADC, and the Fertilizer Storage Improvement Project

of AID in 1976 provided for construction of 40 godowns with a capacity of 42,000 tons. At the same time BADC was proceeding with its own construction schemes, and these are discussed in more detail in later sections.

In 1976 AID and BADC jointly conducted the Pilot Distribution Programme concerned principally with factors affecting marketing of fertilizer at the farm level and with the role of dealers. The AID Agricultural Inputs III Project in 1977 was principally for financing imports of urea and triple superphosphate (TSP).

This was followed by the "Bangladesh--Fertilizer Distribution Improvement I" project paper AID/BAS-008 of June 1978. This funded a major project over 3 years covering three main areas: agricultural inputs, fertilizer storage, and bulk handling. The project paper and its appendices are a comprehensive review of activities up to that time, and the project is of major importance in improving fertilizer distribution facilities. A current AID project paper reviews progress to date and proposes funding for a further 2 years.

2.4. Economist Intelligence Unit (EIU) Report

The most comprehensive and important recent study of the total distribution system is the Bangladesh Fertilizer Marketing and Distribution Study prepared for BADC. This was presented in final draft form in September 1977, and the final report was presented in March 1978. The study was prepared by EIU in association with Carl Bro International A/S and Operations Analysis Corporation A/S. This study is subsequently referred to as the "EIU report." The objective of the study was to propose a plan to ensure the efficient marketing and distribution of fertilizer in Bangladesh over the period to 1985/86, to include organization, management, operations, and investment proposals. The final report was submitted in four volumes as follows:

1. Summary of Main Findings, Conclusions and Recommendations
2. The Structure of the Fertilizer Market in Bangladesh
3. Fertilizer Distribution Model; Methodology and Inputs
4. Detailed Conclusions and Recommendations

The EIU report was used extensively in preparation of the AID Fertilizer Distribution Improvement Project mentioned above (where it was

referred to throughout as the "Ashuganj Study"). It is one of the base reference documents for any current study although transport costs naturally require updating.

2.5. Netherlands Economic Institute (NEI) Chittagong Port Entrance Study

This was a major study undertaken by NEI for the Chittagong Port Authority under the Dutch Technical Assistance Programme. The draft final report was submitted in May 1978 as a main report and eight annexes. A variety of alternative port schemes and sites in the Bay of Bengal were considered with the capability of taking vessels of up to 50,000 tons as compared to the existing port limit of approximately 10,000-12,000 tons dwt without lightering. Port traffic patterns, handling systems, capabilities, and costs were examined in detail, as were all inland transport modes.

The basic recommendation was to develop a deepwater port on the north bank of the Karnafuli River entrance, a few miles downstream from the existing port facilities and TSP plant wharf. This will require extensive capital and maintenance dredging. Test dredging is currently in progress under a World Bank project.

2.6. Dutch Technical Assistance

A summary of Dutch Fertilizer Assistance to Bangladesh was prepared by the Development Research Institute of Tilburg University for the Dutch Ministry of Foreign Affairs in June 1979.

2.7. Soros Report

This was a major study undertaken by Soros Associates of New York for BADC in 1978/79, financed by USAID. The basic objective was to identify modes of operation for importation of bulk fertilizer through Chittagong and Chalna and movement from Chalna to a site in the Khulna area. The scope included consideration of alternative manufacturing options for the TSP plant at Chittagong relative to import of bulk TSP and other products. The TSP study

was undertaken by Jacobs Engineering Group, Inc., of Florida. The report was issued in the following volumes in April 1979.

Feasibility Study, Final Report:

Executive Summary, Fertilizer Import Systems

Volume I, Fertiliser Import Systems

Volume I, Fertiliser Import Systems-Appendices

Volume II, Rehabilitation and Conversion Options of TSP Manufacturing Versus Fertiliser Importation

Volume III, Rehabilitation and Conversion Options for TSP Manufacturing Facility, Chittagong, Bangladesh

Following comments on the above Final Reports, addenda were issued by Soros in December 1979 as follows:

Feasibility Study--Final Report:

Addendum No. 1---Commentary on Soros' Recommendations and NEI's Chittagong Port Entrance Study

Addendum No. 2---Commentary on BCIC's Views. Rehabilitation and Conversion of TSP Manufacturing Versus Fertiliser Importation

Addendum No. 3---Illustration of Bulk Handling and Offshore Facilities

The contents of this major report will be discussed in the appropriate later sections.

2.8. National Fertilizer Storage Plan (NFSP)

The NFSP was prepared by the International Engineering Company, Inc., of San Francisco in consultation with BADC, assisted by IFDC consultants, under the USAID Fertilizer Distribution Improvement Project. The outline plan was published in January 1980 and revised, as agreed, following changes in demand projections and reconsideration of the transportation and supply system. The NFSP was then published in July 1980 in three volumes: I-Narrative, II-Tables, and III--Exhibit Maps. Following continuing investigation and discussion, the final plan was issued in May 1981.

The NFSP is a very detailed study of movement of fertilizer from all sources to all PDPs and is an essential document for BADC for all forward distribution planning. Movements are considered from six primary sources[1] to 88 defined

1. (1) Urea from Ghorasal, (2) Urea from Fenchuganj, (3) Urea from Ashuganj, (4) TSP from Chittagong, (5) Urea/TSP/MOP imports through Chittagong, (6) Urea/TSP/MOP imports through Chalna.

PDP and transit locations in 20 districts. Offtake requirements at the 1984/85 level are considered and requirements calculated for all three main products at all PDPs on a wet season and dry season basis.

Movement costs are given from all sources by all modes of transport to all PDPs served, and quantities to be moved are given by mode of transport to all points served.

All existing warehouse categories and capacities are defined and capacities for all transit and PDP locations at 1985 levels calculated as the basis for the engineering program, which is the object of the exercise.

2.9. The World Bank Fertilizer Transport Project

This project is based on The World Bank staff appraisal report of October 1980, submitted to the International Development Agency (IDA) in December 1980 and approved in early 1981 for improvement of systems and facilities throughout the country, involving BADC, Bangladesh Railways, Bangladesh Inland Water Transport Corporation and the Chittagong Port Authority.

This is a key project, concentrating as it does on the most important constraints and limitations affecting fertilizer transportation and handling throughout Bangladesh. The principal components are:

1. Improvements and studies to facilitate import of fertilizers in bulk at Chittagong and Chalna.
2. Test dredging at the mouth of the Karnafuli River at Chittagong.
3. Development of Shiromoni as a key storage and transit point for imported fertilizer.
4. Development of Baghabari as a barge-served distribution center for Pabna and Bogra districts.
5. Establishment of unit train operations, including rehabilitation of wagons, workshop improvements, and management assistance.
6. Rehabilitation of the rail wagon ferry at Bahadurabad Ghat, the key link in east-west movement of urea.
7. Improvements of rail sidings at factories and storage locations.
8. Assistance in establishment of a rail operating control center.
9. Additional storage and technical support for improvement of management and inventory control systems.

2.10. Second Inland Water Transport Study

This current study by Louis Berger International, Inc., and Rahman and Associates, Ltd., for the Ministries of Ports, Shipping, and Inland Water Transport continues earlier recommendations or improvements in equipment and systems, with particular emphasis on the implementation of an improved organizational and management system.

2.11. Maunsell Fertilizer Berth Study for Chittagong

This Report on Fertilizer Berth Study under the Chittagong Port Development Project was submitted to the Chittagong Port Authority in April 1981 by Maunsell Consultants of Australia. This is a practical study for development of an existing berth and warehouse, with conveyors and mechanical packing equipment to handle imported fertilizers. The proposals are discussed later in this report.

2.12. BADC and IFDC Reports

Regular reports by BADC which are of considerable use are:

1. The monthly newsletter, which contains supply, marketing, and storage data.
2. The monthly movements program.

Other reports which have been produced by IFDC consultants working with BADC include:

1. A Review of BADC's 1979/80 Fertilizer Import Program, J. M. Hill, July 1979.
2. Second Evaluation of the Bangladesh New Marketing System, J. M. Hill and R. D. Benton, July 1980.
3. A Review of BADC's Fertilizer Marketing and Distribution Costs (Incidental Costs), R. D. Benton, February 1981.
4. Draft Procedure Manual of Inventory Control and Accounting System of BADC, M. Ismail and R. D. Benton, February 1981.
5. Bangladesh Fertilizer Supply and Use Policy Consensus Report, BADC/BCIC/IFDC, April-May 1981.

6. Annex V to the Consensus Report (5), Phosphate Fertilizer Supply Alternatives for Bangladesh, working draft dated May 1981.

All of the above reports are current working documents containing data and recommendations covering a wide range of BADC activities where continuing action and implementation are necessary.

3. BASIS OF CURRENT STUDY

It is clear from the preceding section that transportation, handling, and storage systems for fertilizer in Bangladesh have been very thoroughly covered indeed, with reports being issued up to and including the present time. There is a wealth of detailed information, but it is not always apparent how this information relates to BADC requirements.

The current study is therefore directed to advising and assisting BADC in analysis of the mass of available data and of the large number of existing recommendations from many sources covering the full range of distribution activities. In line with this approach, the two most important current studies, The World Bank Fertilizer Project and the NFSP study will be related to requirements at 1984/85 levels. The demand levels and supply sources used for these studies are as follows:

Fertilizer Supply to Meet 1984/85 Requirements
('000 tons product)

	Urea	TSP/DAP	MP	Total
Imports				
Chittagong	60	267	107	434
Chalna	80	353	143	576
Total	140	620	250	1,010
Production				
Ashuganj	475	-	-	475
Ghorasal	350	-	-	350
Fenchuganj	75	-	-	75
Chittagong	-	120	-	120
Total	900	120	-	1,020
TOTAL SUPPLY	1,040	740	250	2,030

Present and future transport capabilities have been considered relative to BADC's future requirements for movements of fertilizer. Operation of the total system is also considered in order to define the most practical and economic overall movement patterns. Attention is concentrated on particular areas where there is no consensus opinion and where experience of other systems may usefully be applied to the Bangladesh situation. This applies particularly to certain aspects of warehousing, handling of bulk imports, and operation of unit trains.

Under the New Marketing System, BADC is totally responsible for movement of fertilizer up to PDPs only. BADC has four sales divisions, each with five districts, as shown in Figure 1.

Under the NFSP, 88 PDP locations are identified. The number of PDP locations in each district is shown in Table A-1. (In the NFSP, Chittagong and Chittagong Hill Tracts are counted as one district to give a total of 19 instead of 20 districts.)

It was agreed with BADC that this study should cover movements from source to PDPs. In the 1985 situation there are six primary sources and five transshipment points as follows:

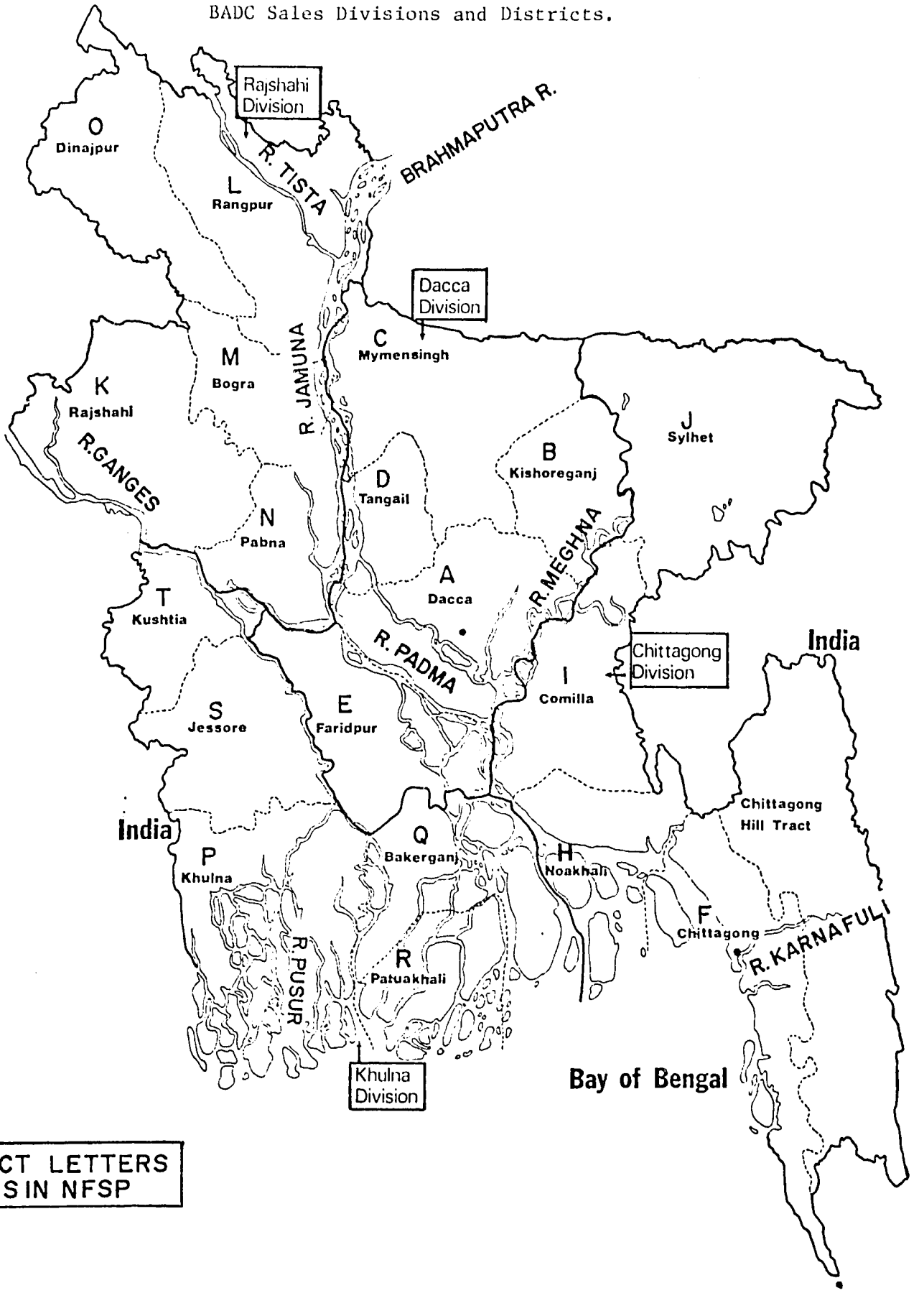
Primary Sources			Transshipment Points		
1.	Ghorasal	Urea production	1.	Shiromoni	Barge to rail and road
2.	Fenchuganj	Urea production	2.	Baghabari	Barge to road
3.	Ashuganj	Urea production	3.	Parbatipur	Meter to broad gauge rail
4.	Chittaganj	TSP Production	4.	Santahar	Meter to broad gauge rail
5.	Chittagong	Import of urea, TSP, DAP, and MOP[a]	5.	Chhatak	Rail to water transport
6.	Chalna	Import of urea, TSP, DAP, and MOP			

a. Muriate of potash.

Narayanganj is currently an important transshipment point but is phased out under NFSP proposals. The above locations are shown in Figure 8, Section 12.

Figure 1.

BADC Sales Divisions and Districts.



DISTRICT LETTERS AS IN NFSP

4. BACKGROUND DATA

4.1. Demand Projections

Some selected projections of demand relevant to 1984/85 requirements are shown in the following table:

Source	Year	Urea	TSP	MOP	Total
		- - - - - '000 tons product			- - - -
USAID Project Paper, June 1978					
1. "Agronomic" demand	NA	1,941	1,728	961	4,630
EIU Report, 1978					
2. Medium	1980/81	477	214	76	767
3. High	1980/81	561	252	91	904
4. (Current estimated	1980/81	580	268	52	900)
EIU Report, 1978					
5. Medium	1985/86	784	402	159	1,345
6. High	1985/86	1,059	543	220	1,822
Consensus Report, April/May 1981					
7.	1984/85	1,078	687	133	1,898
8.	1985/86	1,170	770	150	2,090
BADC/World Bank/Ministry of Agriculture					
9. (NFSP/World Bank project figures)	1984/85	1,040	740	250	2,030

The EIU report "high" estimate for 1980/81 (3) is close to the figure likely to be achieved (4), while the EIU "high" estimate for 1985/86 (6) is around 11% lower than the 1985/86 figure produced by the recent BADC/IFDC policy consensus study group (8). The consensus figure could, however, be attainable by reason of removal of constraints and improvement in facilities as a result of current projects and investment.

The estimates used in the NFSP and as the basis of The World Bank Fertilizer Project (9) at 2.03 million tons in 1984/85 are 7% higher than the consensus figures. Within this range of variation and in view of the amount of current detailed work based on these figures, it is considered that there is no justification for suggesting any change at this stage for distribution planning purposes. The projections are then:

1984/85 Demand (tons)

Urea	1,040,000
TSP/DAP	740,000
MOP	250,000
TOTAL	2,030,000

The breakdown of these quantities by district as used in the above studies is given in Table A-2. The overall movement situation is illustrated in Figure 8 (Section 12).

Minor tonnage of other products, e.g., to cover zinc and sulfur deficiencies, or of ammonium sulfate supplied to the tea estates from Fenchuganj is not included.

It will be noted that the above demand projection is particularly high in potash as compared with the consensus figure and current estimates of consumption for the 1980/81 fertilizer year. Calculated rates of growth are as follows:

	Consumption Current Estimate 1980/81 (4) Base	Consensus Report 1984/85	Growth Rate	NFSP/World Bank Project 1984/85	Growth Rate
	('000 tons)				
Urea	580	1,078	17%/year	1,040	16%/year
TSP	268	687	27%/year	740	29%/year
MOP	52	133	26%/year	250	48%/year
	900	1,898		2,030	

Urea and phosphate projections are in reasonable agreement although the rate assumed for increase in phosphate consumption is high. The projected increase in potash consumption at almost 50%/year appears unrealistically high, despite a low initial consumption level relative to nitrogen (N) and phosphorus (P), and it is possible that only one-half of this rate of increase may be achieved in practice. In that case the estimate could be high by some 100,000 tons MOP at the 1984/85 level. Although a major difference in the potash figure, this represents a reduction of only 5% in total demand and 10% in imported material. The total demand figure of 2,030,000 tons for 1984/85 given earlier will be used for calculation and planning purposes, accepting the probability that the potash figure is too high.

4.2. Production Basis

4.2.1. Overall

The production levels assumed for 1984/85 are as follows:

Ghorasal	350,000 tons urea
Ashuganj	475,000 tons urea
Fenchuganj	75,000 tons urea
Chittagong	120,000 tons TSP

4.2.2. Urea Production

Production achievement to date has not been good, to a large extent due to shortages of spares, mechanical breakdowns, and power failures. If spares and power failures continue to be a problem, there is no chance of the above production levels being achieved. It can only be assumed that the necessary corrective measures will be taken by government.

An additional urea plant of capacity 100,000 tpy is planned for Ghorosal and site preparation has commenced. A larger, export-oriented urea plant to be built at Chittagong is in the planning stage. Assuming that the additional Ghorasal unit is in production by 1984/85, this could balance shortfalls in the other units, and the production assumption for urea would then be reasonable.

4.2.3. Phosphate Production

On TSP production, the situation is much more open and of considerable financial significance to Bangladesh. This subject was addressed by the Supply and Use Policy Study Group in April/May 1981. Annex V of the draft report, "Phosphate Fertilizer Supply Alternatives for Bangladesh," dated May 1981 refers.

There are two units producing powdered TSP at Chittagong, installed about 10 years ago with a design capacity of 152,000 tpy. There have been numerous operating, maintenance, services, raw material, and product movement problems, and a World Bank rehabilitation project is now in progress, together with Dutch financing for installation of a granulation unit. Bangladesh Chemical Industries Corporation (BCIC) is projecting output at 100,000 tpy and World Bank at 120,000 tpy.

One conclusion agreed by the Study Group is that the above supply plan is the most costly of several alternatives investigated. Production alternatives

include manufacture of semigranulated TSP, as proposed in the Jacobs study for the Soros report, and manufacture of partially acidulated phosphate rock (PAPR) and use of ground phosphate rock.

There was some misunderstanding in Bangladesh over the Soros recommendation for "semigranulated" TSP, which is, in fact, a fully granulated product but contains granules in the smaller size ranges. The dedusted product is excellent for hand application, as required for Bangladesh. The production advantage is that the same plant can process about twice as much material when the product is semigranular, as compared to fully granular with obvious cost advantages.

Order-of-cost calculations based on the Soros and World Bank data, with updating of raw material costs, show a saving of $50/ton for production of 300,000 tpy semigranulated TSP instead of 120,000 tpy of the fully granulated product. This gives indicated savings of $60 million over 10 years. Other schemes involving fully granulated TSP (120,000 tpy) and PAPR (345,000 tpy) could generate savings of over $170 million over 10 years. The essential conclusion of the calculations given in the Annex V study is that, in view of the magnitude of the cost savings indicated, a fuller phosphate supply study should be undertaken, with the participation of BCIC, BADC, and Bangladesh Agricultural Research Institute (BARI).

In terms of internal distribution, changes in the TSP production system at Chittagong will have little effect. Basically the same tonnage of product will have to be moved whether the source is local production or imports. If, however, a change is made to phosphate rock for direct application or to PAPR, changes in the distribution system will have to be made.

4.3. Types of Product

4.3.1. Nitrogen

The principal nitrogen source is prilled urea, and Bangladesh is approaching self-sufficiency in this product. Although other forms, such as granular urea, have some superior characteristics, this is not likely to affect the supply position during the period under consideration.

Of more importance is the quality of the domestically produced prills, some of which contain significant quantities of fine material. This makes the

product cake very readily, creating problems throughout the system. IFDC consultants have made recommendations to BADC, and these recommendations should be followed up.

4.3.2. Phosphate

As discussed above, the principal phosphate fertilizer is TSP produced in powder form at Chittagong and imported in granular form via Chittagong and Chalna. PAPR and ground phosphate rock are other possibilities for the future.

Diammonium phosphate (DAP) has been introduced recently because it has a higher nutrient concentration and offers cost savings. Comparing TSP (0-46-0) and DAP (18-46-0), the two products are equivalent in phosphate content, but the DAP contains additional nitrogen, equivalent to 0.39 tons urea/ton DAP. At current world prices, DAP is cheaper per unit of nutrient, and the higher concentration results in reduced handling, transport, and storage costs. Although the two products appear to be similar agronomically as far as phosphate is concerned, the extent to which benefit is obtained from the N content of the DAP is not clear.

On balance, it appears advantageous to continue importing DAP along with TSP. When Bangladesh is self-sufficient in N, there will, however, be less incentive to continue importing DAP.

4.3.3. Potash

The standard grade of potassium chloride--MOP--is the cheapest source, suitable for the majority of crops, and appears likely to continue as the principal product used.

As noted earlier, potash consumption is at a very low level relative to nitrogen. The reasons for this are not clear.

4.3.4. Compounds, Mixtures, and Blends

The EIU report discussed the advantages and disadvantages of the use of compound fertilizers in some detail and concluded that their widespread adoption was a certainty in the long term. Again, this could be equivocal, considering practical aspects of the present and prospective fertilizer situation.

Of the three commonly available, single nutrient fertilizers, urea, and TSP are not compatible in bulk blends unless used immediately. With the small average size of farms, this means that blending or mixing must take place

locally or on the farm before hand application. Around 80% of use is for rice. There seems little, if any, benefit to the farmer in having compounds or blends available when he can purchase the high-analysis single-nutrient types in exact, small quantities, mix them if he wishes, and apply them as easily and as effectively as the mixtures. Recent figures indicate that around two-thirds of the quantities sold are in less than full bag lots.

Equally significant, however, is the basic structure of the fertilizer supply and distribution system, which could be considered as two separate systems. Nitrogen is essentially all supplied as urea by local production from the northeast of the country, with major flows east to west. Phosphorus and potassium are supplied as imports Chittagong and Chalna, with major flows from south to north. Even with physically compatible products, there is logistically no way of bringing these flows together on any measurable scale for mixing or compounding without incurring significant double handling and transport costs. As discussed above, there is in any case no discernible benefit to the farmer, even for two component P-K blends.

It is then assumed that the three main nutrients will continue to be supplied and used in the currently available forms of the single-nutrient fertilizer for the foreseeable future.

5. CONCEPT AND CHARACTERISTICS OF AN EFFICIENT DISTRIBUTION SYSTEM

5.1. Transport

In looking at the total distribution system on a national basis, a number of important basic features must be taken into account in planning and development of an effective and efficient least cost system. In common with other developing countries, capacity limitations in Bangladesh transport systems create constraints in movement of fertilizer. Maximizing use of available facilities is therefore essential. The most effective and efficient way of using any form of transport is to use it continuously. The first basic objective must then be to move product continuously on a regular basis throughout the year.

This concept is consistent with the supply position. Urea is manufactured continuously and on as regular a basis as possible for reasons of

production economics. Imports of phosphate and potash must be phased relatively evenly throughout the year because of limited handling capacities in the ports.

The general concept of movement through the system on a regular basis then dictates that stocks will build up in the consuming areas. We should therefore have a regular flow of products through the system, as far as possible towards the point of final use, for storage. In the case of BADC this is accepted as the PDP warehouse. It is fortunate that this is also the desirable location for marketing purposes.

5.2. Stock Variations

Although supply is on a relatively regular basis, offtake is seasonal. In this situation, the difference between the supply and demand curves obviously dictates a buildup of stocks during a period of low use and a stock drop during high use periods. It must, however, be appreciated that on a total country basis the stock variation pattern over the year, above the base or safety level, is determined purely by the relationship between the supply and demand curves. The offtake pattern thus determines the level to which stocks will build up above the base level. There is very little that can be done to "optimize" or "minimize" stocks on a national basis.

The inevitable stock buildup has to be accommodated somewhere within the system, together with a base or safety stock. The base stock level is determined as a policy matter after due consideration of the characteristics and limitations of the system. Seasonality and stock variations are discussed further in the following section and considered quantitatively later.

5.3. Stock Locations and Type

As discussed above, in terms of efficient use of transport resources, it is necessary to move product through the system on a regular basis as far as possible towards the point of end use. In the case of BADC, this means that stocks will build up at PDP level against forecast demand and this should be seen as the storage level for marketing purposes, to cover all variations in supply, demand, and transport constraints. Stocks at source or dispatch points

must be adequate only to maintain regular dispatches by the chosen transport method all year round, and these are therefore transport buffer stocks. They are not buffer stocks for marketing purposes. With stocks maintained in the districts, there should be no buffer stocks at any other locations held for marketing contingencies. Also, with reasonably accurate demand forecasts, there should be no interdistrict movements.

5.4. Effect of Movement Plan on Chalna and Shiromoni Operations

Adequate buffer stocks are then essential for transport purposes at the three urea factories and at the Chittagong TSP plant. Such buffer stocks are also necessary at Chittagong and Chalna for imports. Considering these six locations, we must retain a clear conception of these sources operating in conjunction with the transport system to maintain regular dispatches on a year-round basis.

Perhaps the best example of this is Chalna, where imports should exceed half a million tons by 1984/85, all to be moved onwards by barge to Shiromoni and other smaller locations. On a regular basis, operating 6 days/week, this means dispatch of some 2,000 tpd all year round. The importance of forward planning of transport resources will then be appreciated, if this quantity is to move efficiently and economically.

Although efforts must be made to phase imports as evenly as possible because of port and handling limitations, it is impossible to ensure even arrivals, and substantial storage must be available at Chalna to accommodate these fluctuations. By regulating the flow from Chalna onwards, however, all transport and handling operations should be on a regular basis. Major benefits are immediately obvious from regular use of transport, in that long-term contracts may be entered into, purpose-designed equipment may be procured, and labor for handling may be organized on a regular basis for dealing with a relatively even throughput, instead of trying to deal with a succession of peaks and troughs.

The concept of Chalna as a main transport buffer storage point, smoothing input of fertilizer into the distribution system to a regular flow, then has important consequenses for Shiromoni. Under The World Bank project, Shiromoni is seen as "the most important transit storage center in the fertilizer distribution system." While agreeing with this, it is suggested that the storage component is of less significance when a regular supply system from main storage at

Chalna is established. Storage at Shiromoni is only necessary to the extent required to be able to guarantee regular dispatch by rail and road, i.e., as secondary transport buffer storage. At 1984/85 levels, Shiromoni is projected to receive 433,000 tons by barge from Chalna, of which 290,000 tons will be dispatched by rail and 143,000 tons by truck. This corresponds to onward dispatch of approximately 1,000 tpd by rail and 500 tpd by truck, on a regular basis. With proper scheduling and use of unit trains, this represents an ideal pattern of one train/day, 6 days/week. Operation of the unit train system is discussed later in more detail. As noted above, elimination of major storage capability at Shiromoni does not reduce its importance as the main transit center in the system, as envisaged by The World Bank.

Similar considerations apply to storage and dispatch systems at other "source" locations and will be discussed when the pattern of future distribution is considered.

In contrast to Shiromoni, the PDP at Baghabari is seen as a marketing storage location to serve Pabna and Bogra districts.

5.5. Overall Concept

Movement is envisaged on a regular basis from source locations to PDPs, with stocks built up at PDP level to meet all marketing requirements. An essential prerequisite is to have adequate storage available at the district or PDP level. This requirement was recognized at an early stage by USAID, and ongoing warehouse construction programs by BADC, AID, and other donors should ensure availability of adequate capacity.

Another obvious and essential prerequisite is a reliable forecast of offtake at PDP level by product and by month. Similarly, a good forecast of fertilizer supply is required.

It is considered that the entire supply, distribution, and storage operation should be coordinated by a central control unit, which plans, monitors, and controls all movements and stock levels at all locations throughout the system. Such a control unit might be considered overcentralized, unworkable, and inflexible, but in fact with regular and reliable transport arrangements in operation and the necessary stocks located in the consumption areas, there should be few major problems. The control unit would operate to a predetermined movement and stock building plan and continuously monitors trends in offtake patterns.

It should be possible to adjust to any changes in a planned manner and without any short-term or "panic" arrangements, which are costly and disruptive.

At district level, management can concentrate on marketing, secondary distribution, and efficient operation of the PDP warehouses. Supply problems should no longer concern them and considerations such as order levels and lead time required for ordering no longer apply.

6. SEASONALITY

Seasonality of demand as related to supply patterns and supply system capabilities determines storage requirements.

Figures for 1976-79 offtake show peaks in urea sales in March, June, and September during the Boro, Aus, and Aman seasons respectively, as shown in Table 1 and as illustrated in Figure 2. Phosphate and potash offtake show a dip in June-July, so that overall offtake is smoothed somewhat.

On a national basis, monthly offtake does not deviate very widely from the average level, and this is distinctly advantageous in terms of storage requirements and use of transportation. Patterns in other countries where demand is tied principally to a one-crop usage season, with the majority of offtake over a few months of the year, create much greater demands on transportation and storage systems.

The national pattern is, of course, an average of the district patterns which would be expected to show greater individual variation. Even greater variations in monthly offtake over the year would be expected at thana level. This is illustrated and discussed in the EIU report, with data for 1972-76.

In recommending movement on a completely regular basis from sources to PDPs, it is appreciated that adjustments are possible to allow for variations in offtake between districts to obtain some modest benefit in total stock levels.

The data available are probably not yet sufficiently accurate and reliable for detailed planning purposes. It is recommended that BADC organize collection of monthly data for offtake, based on the areas served by the 88 PDPs proposed under the NFSP. Such data will enable forecasting techniques to be developed and improved.

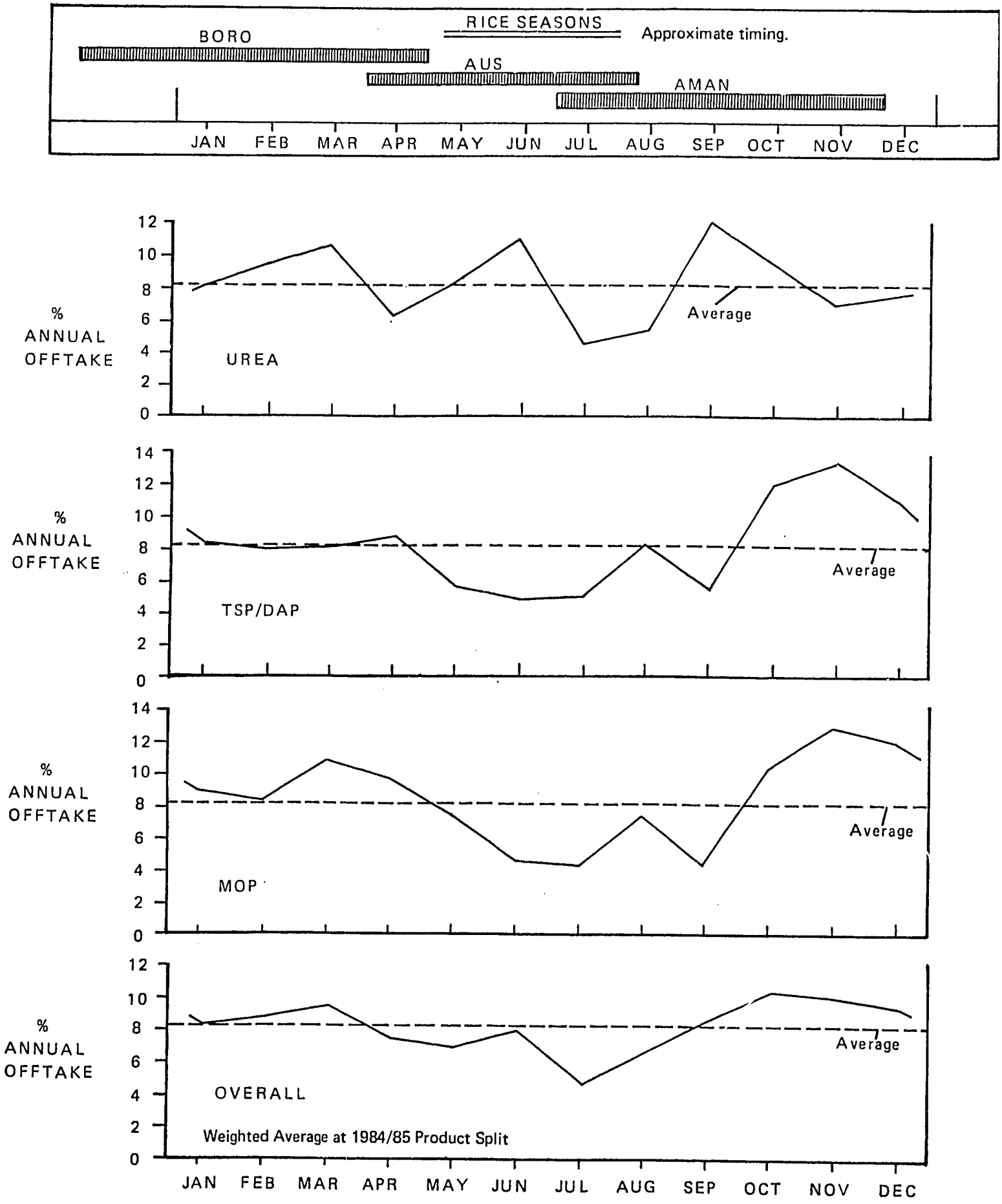
Table 1. Seasonal Offtake Patterns, Average of 1976/77, 1977/78, and 1978/79 Figures (Based on J. Hill note of March 20, 1980)

	% Annual Offtake[a]				
	1976-79			1984/85 Levels	
	Urea	TSP/DAP	MOP	Weighted Average TSP/DAP + MOP (740/250)	Weighted Average All Products (1,040/740/250)
January	8.0	8.3	9.0	8.5	8.2
February	9.5	8.0	8.3	8.1	8.8
March	10.6	8.1	10.8	8.8	9.7
April	6.3	9.0	9.7	9.2	7.7
May	8.1	5.8	7.6	6.3	7.2
June	11.1	4.9	4.4	4.8	8.0
July	4.6	5.2	4.1	4.9	4.8
August	5.6	8.3	7.3	8.0	6.8
September	12.1	5.7	4.1	5.3	8.8
October	9.3	12.1	10.1	11.6	10.4
November	7.0	13.6	12.7	13.3	10.1
December	7.8	11.0	11.9	11.2	9.5

a. Peaks and troughs underlined.

Figure 2.

Seasonal Offtake Patterns (Based on 3 Year Averages 1976-79 Ref. J. Hill. March 1980.)



7. PHASING OF IMPORTS

Because of problems in offloading of imported fertilizer during the monsoon, it is worth considering limiting, perhaps stopping, imports during the wettest months, providing the resulting variations in stocks are acceptable.

Rainfall data for Bangladesh are shown in Figure 3 (and in Table A-3). At Chittagong, from May through August there is an average of 16 days/month with more than 0.1 in of rain, with quantities up to 8 in. in 1 day recorded, while precipitation over 1 in is quite common.

Although even heavy rain may not prevent offloading throughout the whole day, it is worth considering the effect of (a) eliminating and (b) reducing imports from May through August.

Since urea imports are only 14% of the total supply and because of the hygroscopic nature of urea, it is suggested that urea should not be imported during the monsoon. There may also be some reduction in dispatches from local production sources during the monsoon because of movement problems. Imports of phosphate and potash will in any case be reduced during the monsoon because of shipping and handling problems. Consideration can be given to stopping them completely. Supply patterns based on these assumptions are shown in Table A-4. If these supply patterns are related to the offtake patterns shown in Table 1, we get the stock variation patterns shown in Table A-5 for urea and for the two (phosphate plus potash) variations. These are then combined for total fertilizer in Table A-6. The resultant stock variation patterns are illustrated in Figures 4 and 5.

It will be seen by comparison of Figure 4(b) with 4(c) and Figure 5(a) with 5(b), that stopping imports of phosphate plus potash during the monsoon results in far larger stock variations and a much higher overall stock level than continuing to import, although at a reduced level, dictated mainly by handling difficulties. Calculated stock levels are as follows:

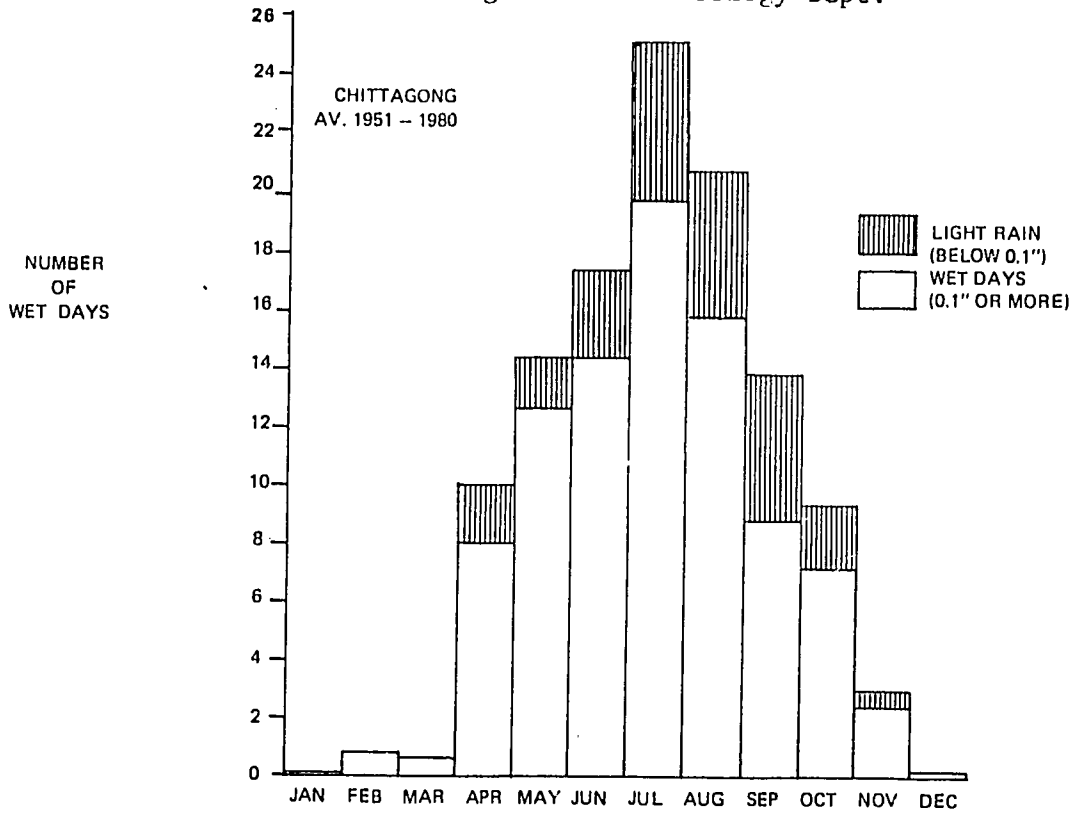
Effects of Stopping TSP/DAP and MOP Imports During Monsoon

1984/85 Level (Annual 990,000 tons)

	Case A No Imports	Case B Reduced Imports
	- - (% annual offtake)- - -	
Maximum stock level	20.0	7.1
Average stock level	9.9	3.4

Figure 3.

Rainfall Data Bangladesh.
Source: Bangladesh Meteorology Dept.



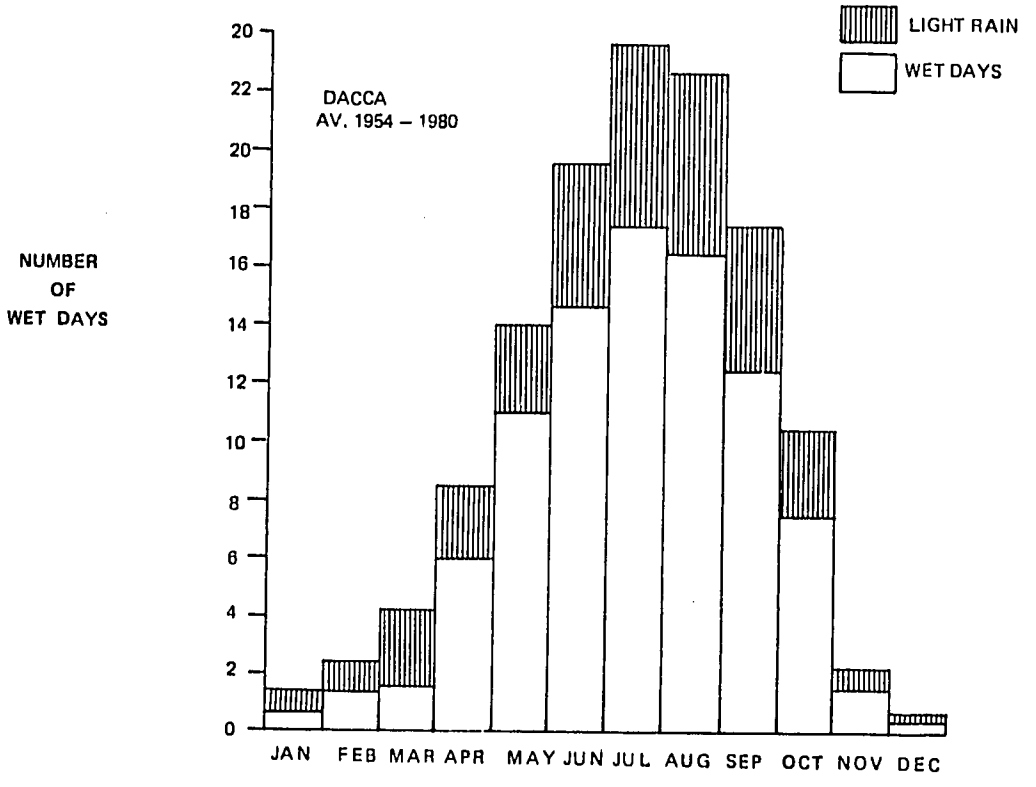


Figure 4.

Stock Variation Patterns Urea and (Phosphate + Potash). 1984/85 Levels.

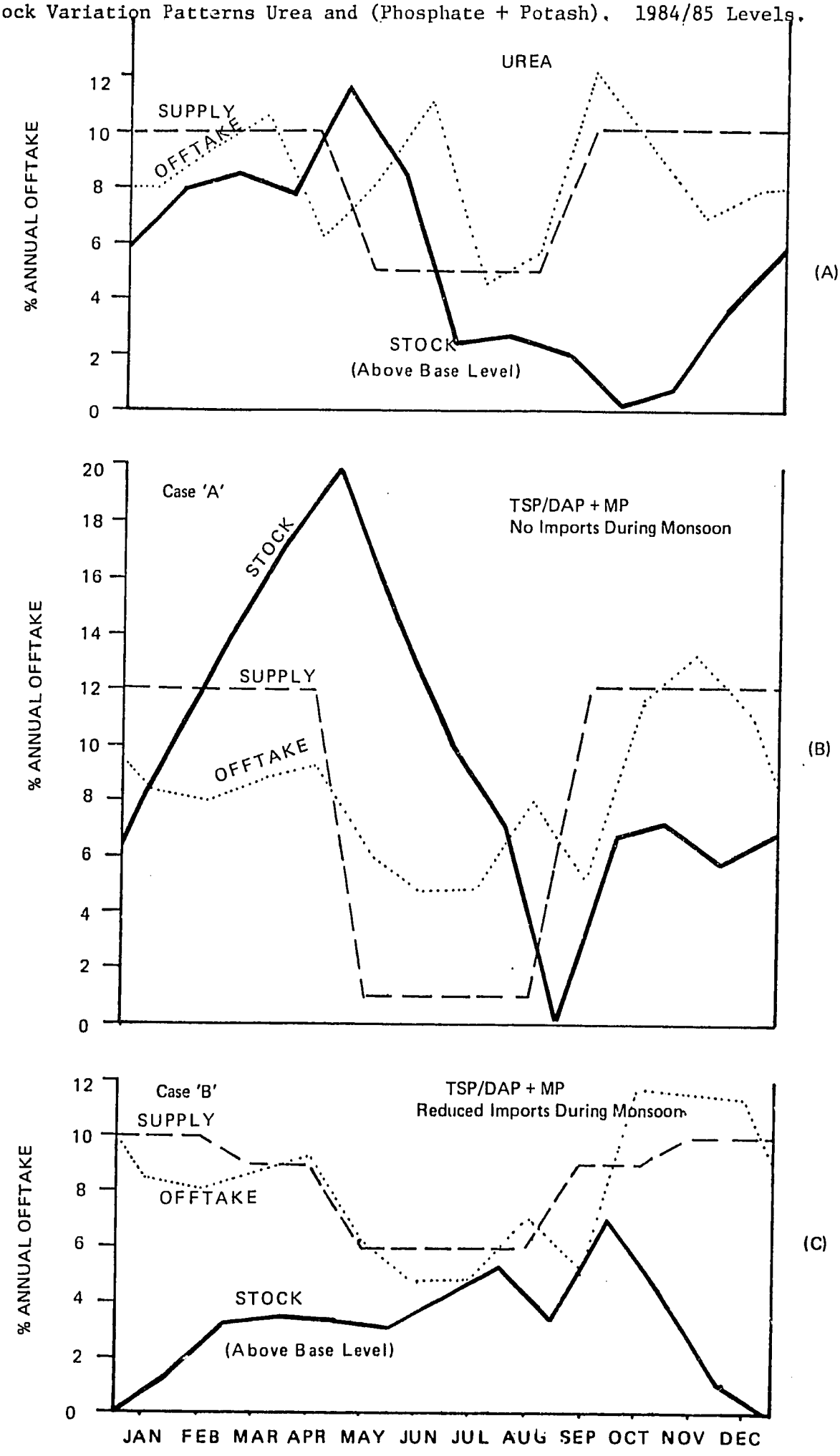
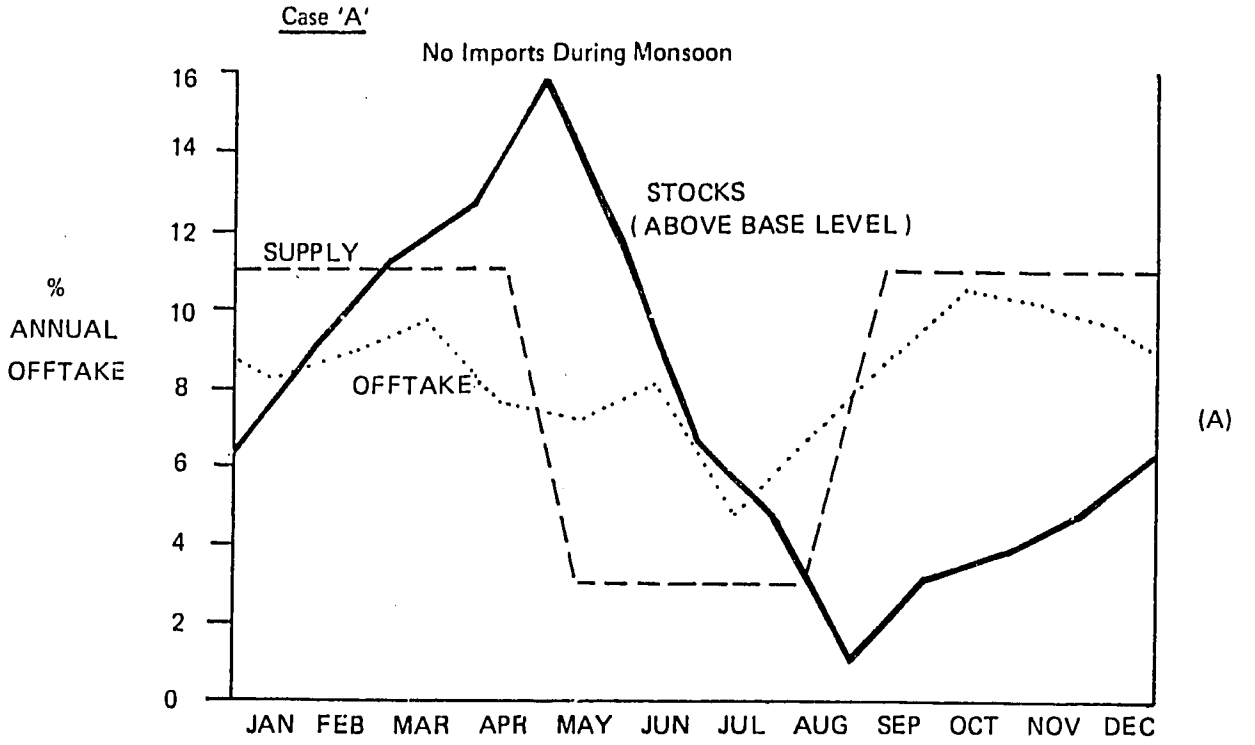
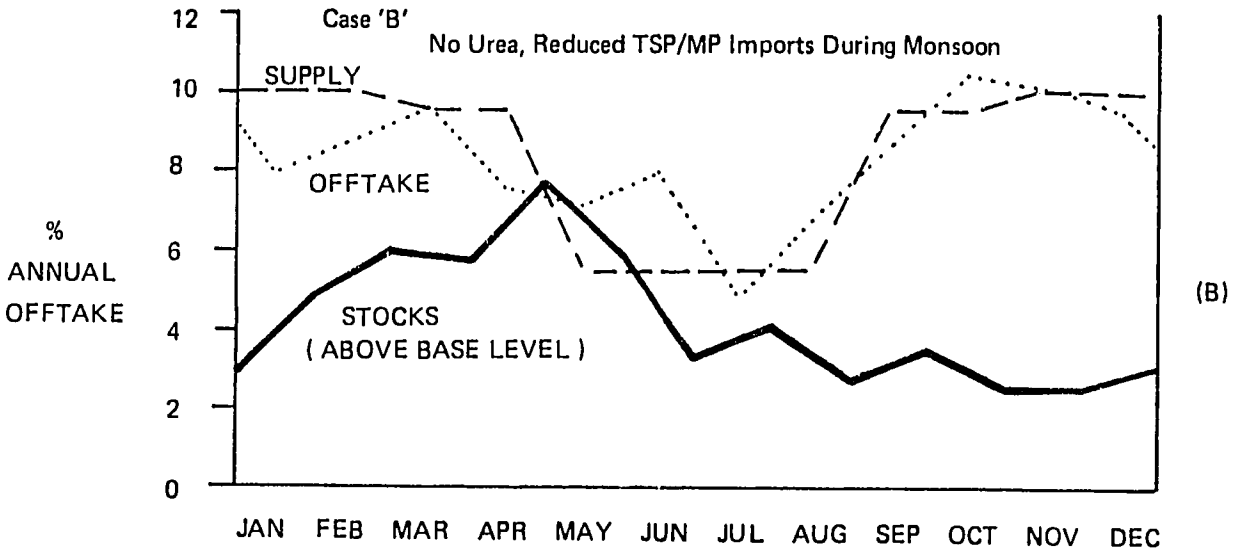


Figure 5.

Stock Variation Patterns Total Fertilizer. 1984/85 Levels.





Significant extra costs are then incurred on two accounts if imports are stopped. First, the maximum stock level is increased by 13% or nearly 130,000 tons, incurring additional storage costs. Secondly, the average stock level over the year is 6.5% or 64,000 tons higher, incurring additional inventory carrying costs as well as the storage charges. If the in-warehouse value is around $300/ton and interest is charged at 15%/year, additional inventory cost is almost $3 million/year. The quantity to be handled during the monsoon would be around 200,000 tons, so that the penalty for stopping inports is $15/ton. This is much higher than any additional costs likely to be incurred by weather delays.

It is therefore economic to continue handling imports of phosphate and potash during the monsoon. It is accepted that they will be at a lower level because of practical difficulties. In fact, this corresponds to the achieved import pattern over the past year.

As tonnage increases, phasing of imports regularly becomes of greater significance in making best use of limited handling facilities. Import planning will take into account variations in offtake patterns of the individual products so that the quantities of each may be varied over the year within the same total tonnage to minimize individual product, hence, total stock levels.

8. STOCK PLANS

The overall stock variation pattern at 1984/85 levels with reduced imports during the monsoon was shown as Case B in Table A-6 and in Figure 5(b), which is a combination of the individual product patterns shown in Figures 4(a) and 4(c).

Stocks only vary by 5% from 2.5% of total offtake in October-November to 7.6% in April-May above "base" or safety stock. BADC has been operating on a stock plan of 3 months' sales of urea and 5 months for TSP and MOP. Under the NFSP, stock plans are based on 2, 3, or 4 months' offtake depending mainly on the location of the PDP and its accessibility. These levels appear reasonable although the provision of 2 months may be just adequate for phosphate and potash as imported materials. Stock security should be improved in the future by regular replenishment associated with improvements in transport systems, particularly rail, by increased domestic production of urea, and by improved phasing of imports. Consideration will then be possible to further adjustments in safety stock levels.

The above discussion is in terms of in-warehouse stocks. Additional reserve is available from material in transit and stocks at source locations.

With improvements in transport systems, particularly use of unit trains, not more than 1 week's supply should be in transit.

Storage capacity available at the production units is as follows:

Nominal Storage Capacity at Plants

	Tons	No. Days Storage at Projected Operating Rate
Fenchuganj		
Bulk urea	10,000	35
Bagged urea	2,500	9
Ghorasal		
Bulk urea	50,000	60
Bagged urea	10,000	12
Ashuganj		
Bulk urea	40,000	28
Bagged urea	8,000	6
Chittagong		
Bulk TSP	15,000	53
Bagged TSP	4,000	14

Additional significant capacity must also be available at Chittagong and Chalna for imports. With the recommended system of completely regular dispatches to the PDPs, it is suggested that stocks at source locations should not be counted as reserves in BADC's stock calculations although they will be fully aware of their existence. As noted earlier, such stocks would be considered as transport buffer stocks to ensure continuity of dispatch in the event of breakdown or shutdown of production units or variations in imported fertilizer supplies.

If production and transport systems are improved as planned, then the most important factor determining stocking requirements becomes the availability of imports on a regular basis. Serious attention must, therefore, be given to development of systems for forward planning of imports and coordination between suppliers to ensure arrival of shipments on as regular a basis as possible.

9. WAREHOUSING

9.1. Total Requirement

Problems of inadequate storage facilities in the consuming areas were recognized at an early stage, and considerable assistance to BADC in provision of warehousing has been provided by a range of donors, in particular USAID, supplementing BADC's own construction programs.

The NFSP identifies a need for 657,500 tons of storage capacity at port, transit, and PDP locations to meet the projected demand at 1985 levels. This is made up of 495,000 tons of PDP capacity at 88 locations based on a specific number of months throughput at each location, plus transit capacity of 162,500 tons at 11 locations based on 1 month's average throughput. The transit capacity requirements are shown in Table 2. Storage at Chalna, Shiromoni, and Parbatipur is for transit purposes only. The other eight locations also operate as PDPs. These figures do not include storage capacity for bulk and bagged product at the urea factories or at the TSP plant in Chittagong.

9.2. Construction Programs

In the early 1970s BADC initiated the Supplementary Scheme for intermediate and large godowns with a total capacity of 75,000 tons. This was followed by the Additional Storage Scheme for smaller godowns at thana level. In 1976 these were consolidated into the Hard Core Programme for 34 godowns ranging in size from 400 to 4,000 tons to a total capacity of 38,800 tons, due for completion in 1981. The USAID Phase I warehouse construction program in the Fertilizer Distribution Improvement Project was for 27 warehouses with a total capacity of 27,000 tons. Other donors are also actively involved in technical assistance and construction programs.

9.3. Current Capacity and Planned Construction

At present BADC owns 198,900 tons of storage capacity, of which 127,800 tons at PDP locations will be incorporated into the NFSP. The balance,

Table 2. Transit Storage Requirements, 1985 Level

Type	Location	Calculated Transit Requirement (1 Month Average Throughput) (tons)
PDP and Transit	A1--Demra	7,356
	C2--Mymensingh	2,007
	C3--Jamalpur	1,794
	F5--Chittagong	36,745
	J5--Sunamganj	309
	J7--Sylhet	1,059
	M1--Santahar	9,777
	N3--Baghabari	7,197
Transit only	05T--Parbatipur	9,675
	P3T--Chalna	47,975
	P4T--Shiromoni	38,735
		162,629

Source: NFSP, May 1981.

mainly smaller godowns and those at thana level, will be transferred to other BADC divisions or otherwise disposed of. BADC also has 232,350 tons of rented storage capacity ranging from large warehouses at the ports down to small units at thana level. Much of this storage, particularly in the districts, is reportedly in poor condition and will be released progressively as new storage is built.

The present program to meet the NFSP 1985 storage requirement is as follows:

	Tons
Existing capacity at NFSP sites, including USAID Phase I	127,800
Remaining BADC Hard Core Programme	14,000
USAID Phase II Program	162,000
USAID Phase III Program	120,000
Other donors: World Bank, ADB,[a] IFAD,[b] German and Dutch financing	104,400
Other construction to be funded	129,300
TOTAL	657,500

a. Asian Development Bank.
b. International Fund for Agricultural Development.

The USAID programs amount to almost 50% of the projected storage capacity.

The overall plan for warehouse construction is soundly based. The function of the transit storage locations may require further consideration, and this is discussed in a later section.

9.4. Design of USAID Warehouses

9.4.1. Type of Structure

The USAID warehouses are built to a high standard, with concrete floors, reinforced concrete columns, brick and mortar walls and flat roofs of reinforced concrete construction. In addition, each site has separate auxiliary buildings of similar construction for:

a. Office quarters and housing for managers,
b. Living accommodation for guards, and
c. Accommodation for visiting officials.

Even with a high standard of construction supervision, flat roofs always present a risk of water leakage in the tropics under monsoon conditions.

Fertilizer storage buildings are prone to settlement under full load conditions and any cracking or defect in this type of roof seems to be impossible to cure on a permanent basis. In the EIU report, engineers recommended a sloping roof structure with corrugated iron or corrugated asbestos sheets of local manufacture rather than flat roofs. An IFDC engineer also recommended a sloping roof construction for a preengineered metal warehouse with corrugated sheeting for roof and walls. Both types are significantly less costly than the reinforced concrete flat-roof type, and both have proved satisfactory in service in tropical conditions.

The BADC and EIU views were noted in the EIU report as follows:

> BADC very strongly favours flat concrete roofing, citing risk of corrosion to the sheets and associated trusses and risk of high-wind damage. But correct installation, treatment and maintenance of the metal-work would obviate risk of corrosion; and for (rare) wind damage, contingency sheeting could be held. The consultants continue, therefore, to advocate the use of angled, sheeted roofs, more especially as these are very much more susceptible to quality control.

Costs for the sloping roof design given in the EIU report were some 10%-20% less than the reinforced concrete flat-roof type.

Figures available for USAID Phase I warehouse locations indicate a completed cost of $\$21/ft^2$ of warehouse space. Costs indicated for new construction were $\$20/ft^2$ for warehouse and $\$17.5/ft^2$ for auxiliary buildings (which seems very high). Against this, the cost for a 1,200-ton fertilizer warehouse completed in 1980 and visited recently in South India was $\$7.5/ft^2$. This was of local design and generally of the type recommended by EIU, with concrete floor, brick and mortar walls, and a sloping roof with corrugated sheeting.

Provision of the full range of auxiliary buildings at all Phase I warehouse locations in the 500- and 1,000-ton sizes would not appear altogether necessary. In Phases II and III, with larger warehouses, there is perhaps more justification for such provision, and they will also form a smaller proportion of the cost.

It is recommended that BADC together with AID, International Engineering Company, Ltd. (IECO), and other advisors should reevaluate the basic warehouse design and also the need for auxiliary structures. It appears that savings could be achieved, or perhaps more usefully, extra storage capacity may be obtained for the same investment. Experience most appropriate to Bangladesh conditions is available with Indian fertilizer manufacturers and engineering companies, and

BADC could use existing contacts to obtain data. Other considerations affecting design and layout are discussed below.

9.4.2. Handling Arrangements and Site Layout

Although design and construction of the USAID warehousing is to an excellent standard, further attention is required to layout from BADC's point of view as the operator.

First, it is essential for efficient operation of the warehouses and of the distribution system as a whole that uninterrupted, all-weather fertilizer loading and offloading is possible by road, rail, or barge. Suitable covered loading bays must be provided. Secondly, particularly for the larger sites, the warehouse and loading areas should be fenced off from all other auxiliary buildings and operations and from public access. There should be one entrance gate with access strictly controlled. The office would normally be situated at or near the entrance gate so that only authorized personnel and documented vehicles are allowed through. Attention must also be given to adequacy of truck waiting, movement, and parking areas.

The warehouse and loading areas should be provided with lighting. The larger warehouses should also have internal power points to permit operation of portable conveyors or bag elevators. These aspects should be considered by BADC with the assistance of the IFDC Resident Consultant, USAID, and IECO.

9.4.3. Warehouse Ventilation

This subject is of particular importance, since existing BADC warehouses and existing and proposed AID warehouses are not of the best design for storage of fertilizer, particularly urea, under tropical conditions.

The controlling factor for storage purposes is the critical relative humidity (CRH) of the fertilizer, which may be defined as the humidity of the atmosphere above which the fertilizer will pick up moisture, with attendant wetness and caking problems. Below the CRH it will not pick up moisture. Some values are as follows:

	Critical Relative Humidity
Urea	78% at 70°F; and 70% at 100°F
DAP	82% at 86°F
TSP	94% at 86°F
MOP	84% at 86°F

At relative humidities above about 75%, urea will therefore pick up moisture. These figures merely confirm practical experience, i.e., urea presents the greatest problem while phosphate and potash are not significantly affected by high humidities.

Humidity data for Dacca and Chittagong at 6 a.m. and 6 p.m. are shown in Figure 6. (Data were obtained for noon and midnight. Unfortunately, these were for Greenwich Mean Time [GMT], not local time.) Relative humidity rises as the temperature falls in the evening, and it will be seen that overnight humidities of at least 90% can be expected throughout the year. Humidities of 70% or more are also likely during the early hours over at least 6 months of the year. Reduction and, if possible, control of moisture levels in the warehouses is therefore necessary.

Conventional methods for control of humidity levels include air-conditioning, dehumidifying, and heating of the air. These methods are uneconomic or inappropriate as applied to Bangladesh. The only practical option is then to attempt to control and limit entry of humid air to the warehouse. This was recognized in the EIU study which specifically recommended that:

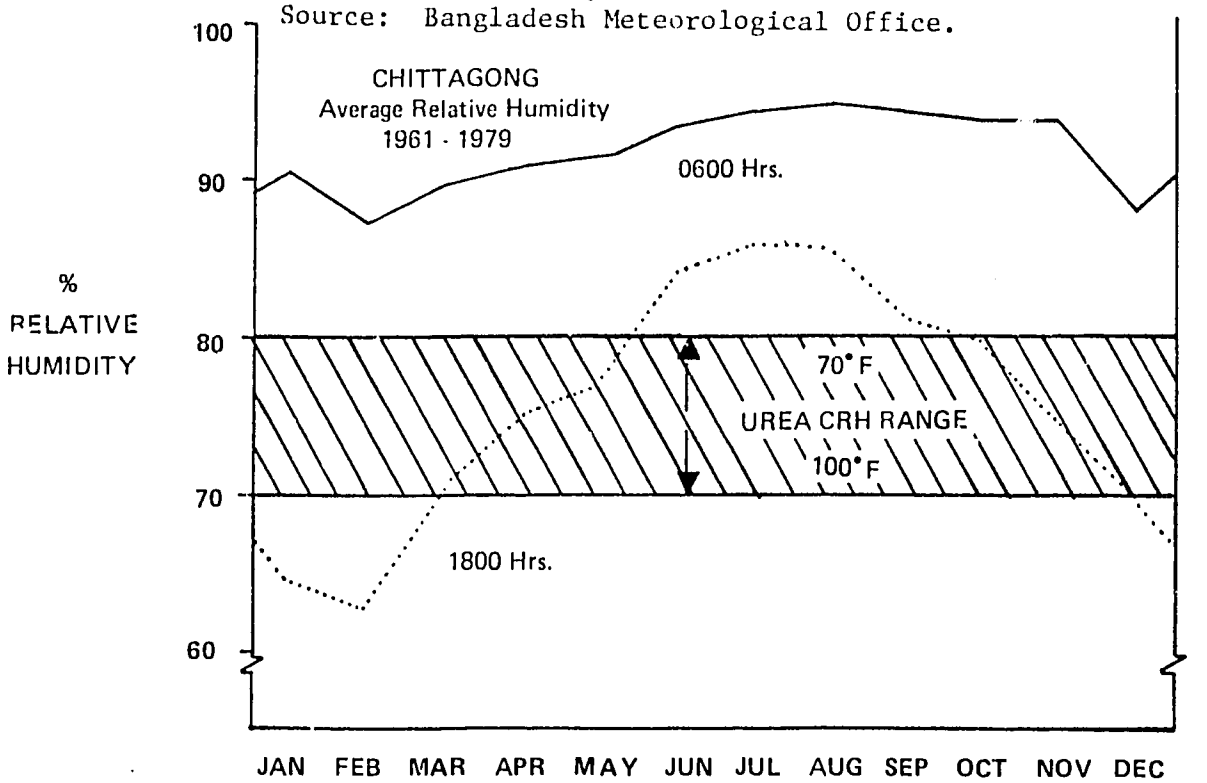
> Ventilation openings should be provided, but in such a way that ventilation can be shut off during the monsoon period and in hot and humid weather conditions which would tend to damage the stored fertilizer. The ventilation openings should be covered by grids to keep out birds, vermin, etc. They should also be located at sufficient height to prevent ingress of floodwater.

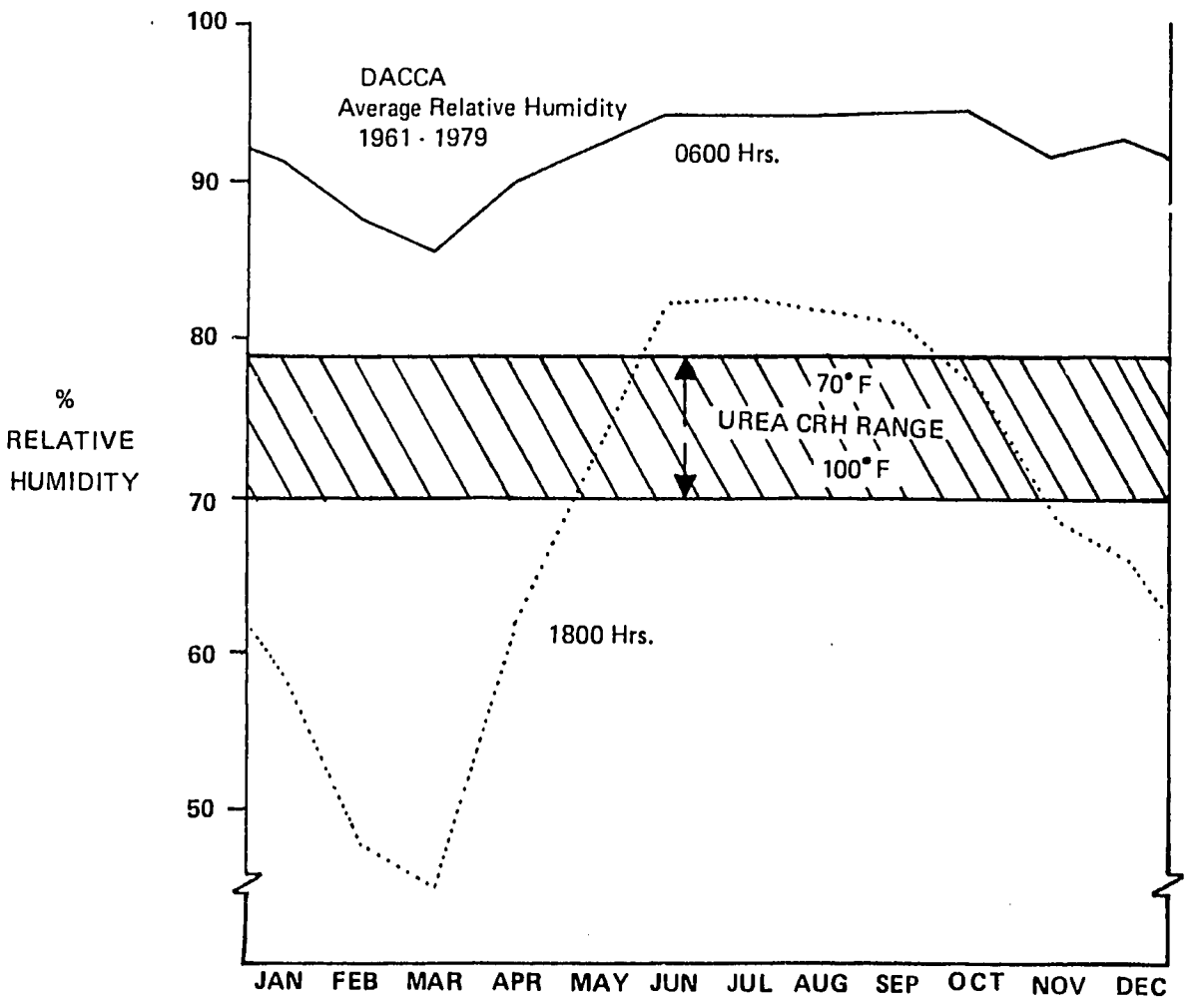
This advice was not followed since BADC warehouses have permanent ventilation at eaves level while USAID Phase I warehouses have permanent ventilation at both eaves and floor level on both sides. Damp and hard-caked bags of urea have been observed in many of these warehouses.

It has been recommended in a separate communication to BADC that fertilizer warehouses <u>should not</u> be permanently ventilated but should be capable of being ventilated. Advice given in very broad terms is that when the sun is shining and conditions are dry the warehouse should be ventilated. At all other times the warehouse should be kept closed up, except for working access or unless working conditions are unacceptable. Modifications to the structures will be necessary to make this possible.

Figure 6.

Humidity Data.
Source: Bangladesh Meteorological Office.





Once the warehouse is closed up, the urea will pick up some moisture from highly humid air, but will then remain in equilibrum at the CRH level without picking up any further moisture.

It is understood that IECO has carried out a study of humidity conditions and effects in the warehouses. This was, however, from the point of view of possible condensation and corrosion effects upon the structure. As far as the fertilizer is concerned, this is addressing a secondary problem.

9.5. Inventory Control

Present BADC inventory control and stock accounting procedures are deficient in a number of ways reflecting organizational and communications problems. A recent draft procedure manual by the IFDC Resident Consultant addresses all of the key problems and provides detailed documentation procedures. A summary of the proposals is shown in Appendix C. It is important that BADC proceed with implementation of these recommendations.

10. HANDLING OF BULK IMPORTS

10.1. The Case for Bulk Imports

The economic advantages and benefits to the local economy of importing fertilizers in bulk and bagging at the point of import in developing countries are well known and have been recognized by the principal agencies operating in Bangladesh.

An indication of the cost benefits is shown in Table 3, where it will be seen that imports in bulk give a calculated saving of about $30/ton on overall cost and nearly $50/ton in foreign exchange costs. In considering a level of 1 million tpy by 1984/85, these are very large potential savings.

Because of provision of a large proportion of fertilizer imports under aid programs, there may not be the same incentives to achieve savings that exist in the commercial world. In view of the scale of savings possible, it is, however, essential that BADC should encourage and coordinate existing efforts to

Table 3. Indicative Import Cost Comparisons, Bags Versus Bulk (U.S. $/ton) (Shipment of urea, TSP, and DAP from U.S. Gulf to Chittagong and Chalna)

Currency	Imported in Bags		Imported in Bulk	
	Foreign Exchange	Local	Foreign Exchange	Local
Bagging and handling, U.S.	16	-		
Cost of bags	13	-	-	13[a]
Transport to dockside and stevedoring/ shiploading	15	-	1	-
Freight	65	-	60	-[b]
Discharge	-	5[c]		
Bagging and handling, Bangladesh				10[d]
Handling losses		e		e
TOTAL	109	5	61	23
GRAND TOTAL	$114/ton		$84/ton	

a. Assuming woven polypropylene/polyethylene liner, U.S., and jute/polyethylene liner, Bangladesh (Bangladesh Government-controlled price is artifically high; Indian price is used).
b. Assuming load/offload bags 2,000/1,000, bulk 8,000/1,000. Loss of cube for bags 2½% costing $1.50, saving of ship's time, $3.50.
c. Including lighterage from anchorage. Ship's hold to loaded transport on wharf.
d. Assuming manual bagging methods, including lightering.
e. Assumed same level, current overall losses on bagged cargo already higher than should be accepted for bulk handling.

convert all fertilizer imports to bulk as soon as practicable. These efforts should receive the full support of the Bangladesh Government.

10.2. Studies for Handling of Imports in Bulk

The two main studies involving major infrastructural development are the Soros report, which recommended the offshore platform concept for Chittagong, and the NEI study for Chittagong Port, which recommended development of a port at Patenga at the mouth of the Karnafuli River. Test dredging in connection with the latter proposal is underway as part of The World Bank project.

Of the two, the Soros proposal appears to offer the best long-term solution to efficient handling of imported bulk materials, such as grain, cement, fertilizer, and oil products. The proposal was not, however, acceptable to the Chittagong Port Authority. The NEI proposal requires further data, particularly on siltation rates and is some way from an investment decision. Both of these major projects are, therefore, considered unlikely to affect decisions on facilities for handling of imported bulk fertilizer within the next 5 and probably the next 10 years.

Current schemes on a smaller scale include proposals for use of portable bagging machinery at Chittagong and at Chalna by USAID and IFAD. The World Bank Study is also funding studies of handling bulk imports at Chalna, and provisions are included for final engineering studies if appropriate.

The most recent report is the Chittagong Fertiliser Berth Study of April 1981 by Maunsell Consultants for the Chittagong Port Authority. This recommends reconstruction of berth 15 in the port to carry traveling hoppers and a conveyor system feeding over the wharf area to shed 15, which will be provided with mechanical packaging equipment. Costs are approximately $1 million for wharf reconstruction and $5 million for fertilizer equipment.

This is a sound and practical report on the handling and engineering aspects, but some reservations are held on the type of shipping operations assumed. This will be discussed and put into perspective in later sections.

Practical experience of bulk imports in Bangladesh was obtained in 1980 when two shipments, each of approximately 10,000 tons of bulk DAP, were brought in on the Al Raouf and Alex Stephens under the auspices of USAID. A type of bag-on-board operation was employed, and offloading rates of 865 tons

and 1,278 tons, respectively, per working day were achieved. A U.S. General Accounting Office (GAO) report was critical of this operation, but in the Consultants' view this was a commendable and successful operation, considering that it was a trial run and in view of some special problems encountered. These problems were due partly to the way in which responsibilities were assigned under the contract and partly to equipment difficulties. These could have been adjusted in later operations if further imports in bulk had been encouraged.

10.3. Import Shipping Arrangements to Chittagong and Chalna

Bangladesh has only two significant maritime ports, Chittagong and Chalna, both of which have draught restrictions constraining access by vessels normally employed in deep-sea fertilizer movements.

Draught restrictions were studied in the NEI and Soros reports. Chittagong is limited by draught to fully loaded ships of around 12,500 tons, with a length restriction of 580 ft on the Gupta bend, corresponding to a maximum size of around 30,000 tons. These larger vessels have to lighter at least half of their cargo at the outer anchorage, about 16 miles from the port.

Chalna has a similar draught restriction but no length restriction. However, since Chalna/Mongla jetties are about 90 miles up the Pusur River from the ocean anchorage, lightering is slow and costly.

Supply systems were considered in the Soros report and a triangular pattern proposed. In the case of a 25,000 tonner carrying fertilizer, required approximately 50/50 at Chittagong and at Chalna, the ship would proceed to Chittagong outer anchorage and discharge approximately half of its cargo into lighters. It would then proceed across the Bay of Bengal and up the Pusur River to the Chalna/Mongla anchorage and discharge the remainder of the cargo into lighters. There are currently siltation problems alongside the new jetties at Mongla, and until further information is available, there is no assurance that a loaded 12,000-13,000 tonner can berth alongside. Lightering is therefore assumed.

On current deep-sea freight rates, ship costs, and lightering costs, it is is more economic to employ a 25,000 tonner on the triangular basis than to employ two 12,500 tonners with direct port access. On shipments from the U.S. Gulf, the current freight differential is in the region of $10/ton, of which about $2 would be canceled by the higher ship's cost per day for the bigger

vessel during unloading. Imports of phosphate from Europe, North Africa, or Singapore and potash from Singapore at lower freight rates would show a smaller differential, but it would still normally be less costly to use one 25,000 tonner rather than two 12,500 tonners. On the basis of opportunity costs in a fluctuating shipping market, it could still, however, be possible to charter in the 12,500 tonner range economically, and this would presumably be done whenever possible, particularly for Chittagong, where offloading within the port area is far easier and less costly than lightering.

For discussion purposes, it is, however, assumed that over the next few years the majority of fertilizer imports will be in vessels in the 25,000-ton range operating on a triangular pattern, discharging half of their cargo into lighters at the Chittagong outer anchorage, then proceeding to the river anchorage at Chalna and discharging the remainder of the cargo into lighters.

10.4. Handling Quantities, Rates, and Port Facilities

10.4.1. Handling Quantities

The quantities to be imported for 1984/85 as defined for The World Bank project and as used in the NFSP study are as follows:

Fertilizer Imports, 1984/85

	Chittagong	Chalna
Urea	60,000	80,000
TSP/DAP	267,000	353,000
MOP	107,000	143,000
	434,000	576,000
TOTAL	1,030,000 tons	

10.4.2. Handling Rates

Whether the fertilizers are imported in bags or in bulk and however the bulk is to be handled, it is important to assess the overall scale of operations.

In broad terms, we are dealing with 1 million tpy, split roughly equally between Chittagong and Chalna. If this is all in 25,000-ton shipments, it represents 40 shipments/year with the vessels calling at both ports. There

will be a natural reduction in imports during the monsoon. This may be approximated as follows:

Assume: 1,000,000 tpy imports
= 40 x 25,000 ton shipments/year.

Split equally Chittagong/Chalna
= 40 x 12,500 ton shipments/year each.

20% in 4 monsoon months = 2 shipments/month

80% in 8 normal months = 4 shipments/month.

Consider offloading of 12,500 tons during normal months:

A. At 1,000 tpd = 12½ workdays + 50% nonworkdays = 19 days

B. At 2,000 tpd = 6 workdays + 50% nonworkdays = 9 days

With one vessel arriving every week in normal months, then at the 1,000 tpd offloading rate, there must always be three vessels in port offloading at the same time, on average.

At the 2,000-tpd offloading rate, there would be two vessels in port roughly half of the time and one vessel for half of the time, on average.

Clearly it is quite unrealistic to talk of average rates when dealing with imports, since regular arrivals are almost impossible to schedule and quite impossible to achieve in practice. Depending on the arrival pattern assumed, the probability of twice the number of vessels indicated above being in port at one time is significant.

This means that in offloading of future import shipments it is essential to achieve at least a rate of 2,000 tons/workday/vessel, with the facility to work two vessels at any one time. This applies to both Chittagong and Chalna.

Another way to look at this situation is to consider handling of 500,000 tpy at each port, with 80% being handled in 8 non-monsoon months. This corresponds to a rate of 12,000 tpw, or 2,000 tpd, 6 days/week on average. Allowing for the variabilities in arrival of import shipments experienced in practice, we must have the capability to work at least double this rate, i.e., 4,000 tpd.

If one-third of the available time is taken for stoppages (weather, berthing and unberthing, transport availability problems, breakdowns, etc.), we then require the practical capability for working at the 6,000 tpd rate. In view of the difficulties and hazards associated with working throughout the night, particularly in the operation of lighters, it is assumed that two shift operations will be used. We then require for Chittagong and Chalna:

a. The ability to work two vessels at any one time.

b. An offloading capability of at least 1,500 tons/full working shift, operating two shifts/day, 6 days/week, with two vessels working.

10.4.3. Port Facilities

In terms of port facilities, it is then necessary to have two berths permanently allocated at Chittagong for handling of fertilizer imports. Each of these berths must be capable of handling at the rate of 1,500 tons/shift, working on two shifts. It is anticipated that the majority of offloading will be by lighters from the outer anchorage. Some oceangoing vessels could, however, be expected to berth alongside so the requirement is for normal berths and not for barge-only berths.

Similar berth requirements apply to Chalna, assuming discharge of ocean vessels at the river anchorage into lighters either for transfer to shore or for direct onward movement. Two permanent berths will be required for transferring fertilizer from lighters to storage plus facilities for reloading from storage to lighters. This last berth should be covered to permit all-weather loading from shore storage to barges.

Operating methods and equipment requirements are discussed in later sections.

BADC should, however, initiate high-level discussions with the Chittagong Port Authority and the Port of Chalna Authority concerning permanent allocation of berth and storage space for handling of future fertilizer imports.

10.5. Methods for Handling Bulk Imports

10.5.1. General

Experience of handling imported fertilizers in bulk is now available in many of the developing countries. The greatest concentration of experience is in India, where imports in bulk in 1980/81 were 4.7 million tons, or 90% of the total of 5.25 million tons. This material is bagged by a variety of manual and mechanical methods with widely varying efficiencies at both port and offshore locations. The Consultant has recently visited a number of these locations; the lessons learned are directly applicable to the Bangladesh situation.

10.5.2. Consideration of Methods

There is a very wide range of practical possibilities when considering methods for handling and bagging of imported bulk fertilizer. Some of the principal options are shown in Table 4. These may be grouped into three main types of operation, the application of which in India is as follows:

	Method (Ref. Table 4)	Location
I. Slings filled by manual labor in hold and dumped on wharf. Manual bagging, weighing, and sewing	5a-5b	All major ports
II. Shore-mounted mechanical offloaders, feeding conveyor systems to mechanical bagging systems	10	Kandla and Haldia
III. Bag on board at offshore location and transfer to shore by lighter	2	Various East and West Coast minor ports

Type I Operation---From observation of a number of manual bagging operations, it is apparent that the most important single factor determining the efficiency of the total operation is the quality of management.

A properly managed manual offloading and bagging operation can achieve high rates at relatively low cost, producing bags of standard weight with low levels of loss. One manual bagging operation observed was achieving 75 tons/shift in 50-kg bags/10-man team, at a direct labor cost of approximately U.S. $0.50/ton (in a low-cost area). A few simple, practical precautions are necessary, which illustrate the need for effective management control. For example, in offloading by sling from the hold, it is important to ensure that the hatches are closed during rain showers and during the night when not working. It is necessary to limit the size of heaps accumulating on the wharf to prevent waste and deterioration of quality due to pick up of moisture, particularly with urea. It is important when weighing to ensure that the platforms of the beam scales normally used are not heaped with spilled material. The use of portable sewing machines is strongly preferred over manual stitching, since this makes subsequent interference with the package much more difficult and has higher customer acceptance. Last, and perhaps most important, it is necessary to ensure that hooks are not used for handling of the bagged material. In the major Indian

Table 4. Principal Options for Bagging of Fertilizers Imported in Bulk

Bag on Board at Offshore or River Anchorage	
1. Fill to correct weight	Weigh, sew (manual or machine), lighter to shore.
* 2. Fill by volume to approximate weight. Hand sew.	Lighter to shore, transfer to warehouse. Open, standardize and machine sew.
Bag Alongside at Offshore or River Anchorage	
3. Sling bulk into hopper of "portable" mechanical equipment on barge platform alongside (river anchorage).	Mechanical bagging, weighing, and sewing. Lighter to shore.
4. Factory ship alongside offloads bulk with grabs into hold and packing hopper (offshore or river anchorage).	Mechanical bagging, weighing, and sewing. Loaded by crane into lighters.
Bag Alongside at Wharf	
5. Sling bulk onto wharf, using * a. Ship's gear, canvas or jute sling. * b. Wharf cranes, canvas or jute slings. c. Ship's gear, grabs. d. Wharf cranes, grabs.	Manual bagging and weighing. Hand or machine sewing to close bag.
* 6. Sling bulk into hopper on wharf. (a*), (b), (c), (d) as above.	Manual bagging from hopper. Manual weighing. Hand or machine sewing.
7. Sling bulk into hopper of "portable" mechanical equipment on wharf. (a), (b), (c), (d) as above.	Mechanical bagging, weighing, and sewing on wharf.
* 8. Sling bulk into hopper feeding conveyor system from wharf to packaging shed. (a), (b*), (c), (d) as above.	Mechanical bagging, weighing, and sewing.
Bag Away From Wharf	
* 9. Sling bulk into hopper on wharf feeding into trucks, or directly into trucks.	Transport to warehouse, inside or outside port area. Bag manually.
*10. Shore-mounted mechanical offloader to conveyor system.	Mechanical bagging and sewing. Inside or outside port area.

*Operation and equipment observed in India.

ports, where the labor is highly organized and difficult to control, hooking is widespread. Thanks to excellent work over the past 2 years in Chittagong by the USAID Logistics Officer, dock labor in Bangladesh is now cooperating in handling of bagged fertilizer without using hooks. Continuing attention should be given to this problem area.

A simple but significant improvement on the basic manual method is to use a hopper with a manually controlled spout or spouts to fill the bags (Method 6). This almost eliminates spillage on the wharf and automatically limits the amount exposed to the atmosphere.

An even greater improvement from the labor management point of view is to empty the sling loads of bulk fertilizer directly into trucks and move the material outside the port area for bagging (Method 9). This gives the fertilizer agency importing the material full control of the bagging operation, with freedom of choice in agencies employed for bagging, in methods and locations used, and in choice of contract labor. This is not possible when operating inside the port area with dock labor.

Type II Operations---Mechanical offloading systems are not likely to be of interest to Bangladesh in the short and medium term but may be of interest in the longer term at both Chittagong and Chalna if port and infrastructure developments being discussed are implemented.

Type III Operations---Bag-on-board methods are operating successfully in India, achieving over 1,000 tpd during day hours (Method 2).

In the most effective system and the one which is recommended for Bangladesh, bags are filled in the hold to an approximate weight by volume, temporarily handstitched, and transferred to shore by lighter. They are then moved by truck to locations inside or outside the port area, opened, adjusted to the correct weight ("standardized"), and machine sewn.

Although double handling is involved, considerable employment is provided for which the cost penalty is low. Ship offloading is speeded up by performing the operations of weighing and machine stitching on shore, where virtually unlimited labor and space is available, as compared to attempting the same operations in the ship's hold. The actual filling operation in the hold is handling-efficient since the bag is filled and stitched in place and lifted only once into the cargo net. A greater number of bagging teams can operate in the hold, possibly up to the limit of the ship's lifting gear.

The USAID bag-on-board operation of early 1980 (Method 1), mentioned earlier, achieved highly creditable rates in spite of requiring the bags to be

weighed and stitched on board. In addition, the shipowner was required to assume responsibility for provision of the bagging equipment and for the bagging operation. This is not within the normal range of knowledge and expertise of shipowners and is considered impractical for larger numbers of shipments from a variety of sources. BADC should undertake responsibility for coordination of the overall operation and appoint contractors for the various activities.

In one efficient Indian operation, with the vessel anchored 2-3 miles offshore, it is interesting to note that arrangements were made for the required labor to live on board for the duration of discharge. Costs were some $10-$12/ton from ships hold to ex shore warehouse, including the cost of lightering.

10.5.3. Bagging in Vessels Alongside

Other methods which have been proposed in other countries for bulk import operations include barge platforms and factory ships (Methods 3 and 4). A barge platform or platforms could be appropriate for Chalna if vessels are not able to berth alongside because of siltation. In this case a pontoon jetty could be more appropriate.

The factory ship concept could also be used for fertilizer but is more appropriate to handling of products, such as grain, which can be handled relatively easily at high rates by suction/pneumatic or "Vacuvator" type of equipment. The factory ship can fill its holds rapidly and continue packing and discharging to lighters, or to the wharf in port, after the deep-sea vessel has sailed. Fertilizer cargoes, however, tend to compact and cannot be handled with suction equipment. In addition, pneumatic conveying causes physical damage to prilled and granular products and exposes moisture-sensitive products to large volumes of humid air. Fertilizer could be discharged at fairly high rates by cranes with clamshell grabs mounted on the factory ship. To avoid loss of product quality, it would then be desirable to bag the product as soon as practicable, and bagging equipment to sustain high packaging rates should be installed rather than using the holds of the factory ship for bulk storage.

The factory ship is an untried concept, but at the present time consideration is being given to provision of two such vessels in India. It is suggested that BADC observe Indian experience before considering the system further.

10.6. Recommended Systems for Bangladesh

10.6.1. General

Methods of handling bulk imports of fertilizer in Bangladesh are heavily conditioned by port access limitations and the constraints which these impose upon shipping arrangements. As discussed in previous sections, a triangular shipping pattern is assumed, with 25,000- to 30,000-ton vessels discharging approximately half of their cargo at the outer anchorage at Chittagong, before proceeding to Chalna to discharge the remainder of the cargo at a river anchorage. Vessels of around 12,500 tons or less could enter Chittagong Port direct or proceed to the anchorage at Chalna without lightering. Ships in the intermediate range would require less lightering to achieve the necessary draft for entrance.

To meet the projected 1984/85 level of imports, it will be necessary for both ports to have the capability to work two ships at the same time, each at a rate of 1,500 tons/shift, two shifts/day.

The above conditions will have to be met whether the fertilizer is imported in bags or in bulk. It is, however, recommended that all imports should be converted to bulk as rapidly as practicable in view of the cost savings which can be made, particularly in foreign exchange. In addition, significant local employment will be generated. The recommended systems are discussed in the following sections.

10.6.2. Handling of Bulk Imports at Chittagong

It is recommended in the immediate and medium term for vessels over 12,000 tons dwt that the bag-on-board method at the outer anchorage should be adopted, as described in Section 10.5.2 under "Type III Operations." Bags would be filled volumetrically, handstitched, and transferred by lighters to shore. They would then be opened, adjusted to correct weight ("standardized"), and closed using sewing machines.

Two berths will be required, equipped with cranes for offloading from lighters to trucks. These berths should also be capable of handling vessels alongside as required. Initially, the recommended bag-on-board method could be used for vessels alongside in the port. For vessels of 12,000 tons dwt or less, portable wharf hoppers and mechanical packaging equipment should be used (Table 4, Method 7).

One of the berths used should be Berth 15, reconstructed as recommended in the Maunsell report at a cost of approximately $1 million, with some additional cranes to allow full-rate offloading from lighters. This would leave open the possibility of further development using the bulk handling system proposed by Maunsell at a later stage. The Maunsell proposals are not appropriate to the future import shipping arrangements as currently seen, with the majority of the tonnage being offloaded at the outer anchorage. Movement of bulk fertilizer in lighters from the outer anchorage into the port for bagging is not supported on practical and handling grounds.

The bags of fertilizer landed in the port will require transfer to a warehouse for standardization and final sewing before storage or onward dispatch. It is recommended that BADC should undertake this operation in their own warehouses outside the port area. Weighing equipment and sewing machines will be required, together with the necessary management and labor force.

Bagged product will therefore need to be transferred by a shuttle service of trucks from the wharf to the shore warehouse, or warehouses, where bags will be "standardized," at a rate matching the ship's discharge rates. If investment in an adequate number of cargo nets is considered justified, the loads of bags in the nets (probably 1-ton units) lifted from the ocean vessel could be moved through the system to the BADC "standardization" warehouse as a unit. This would improve handling rates and reduce handling damage.

In the longer term, consideration may be given to use of a factory ship at the outer anchorage and of fixed mechanical packaging facilities in the port, if justified by the tonnage brought directly into the port in oceangoing ships in bulk. This is not seen to be justified at the present time.

10.6.3. Handling of Bulk Imports at Chalna

In the immediate situation, the same method of bagging on board is recommended for Chalna as for Chittagong. As at Chittagong, two permanent berths will be required to handle the projected tonnages. Transfer of bags may be by lighters from the river anchorage to the berths, which would then require cranes for offloading the lighters.

Until the rail system is extended to Chalna, and this appears to be a doubtful or longer term project, all fertilizer will continue to be moved onward from the port by barge to the transit facility at Shiromoni and to PDP destinations, although a small proportion may go by truck when the road now under construction is completed. It is therefore necessary for at least one berth to

be available for loading out "standardized" bags to barges at a high rate, preferably with mechanical equipment and on an all-weather basis. In addition to the two import berths, there is then a requirement for a third, special barge loading berth.

In order to "standardize" and resew the bags, BADC will require a large working area in a warehouse, together with major storage for the finished bagged product. Size of storage required will be considered in the following section. The main warehouses at Chalna are still under construction, and it is therefore important that BADC discuss their requirements with the Port of Chalna Authorities as soon as possible.

In order to facilitiate handling at Chalna and to enable the required throughput rates to be achieved. bag conveyors should be provided:

a. From the two offloading berths to the working area in the warehouse,
b. From the working area to the barge loading berth,
c. From the working area to the storage warehouse, and
d. From the storage warehouse to the barge loading berth.

Conveyors (a) and (b) are the most important. As much product as possible should be processed through the working area and loaded directly to barge, thereby avoiding double handling into and out of storage.

10.6.4. Future Handling Systems

In the medium and long term, mechanical offloading and bagging arrangements can be considered for Chalna if the vessels are able to moor alongside, either at a pontoon berth or at permanent berths. In the first instance "portable" mechanical bagging equipment could be used of the type marketed by Consultant Packaging Systems (CPS) of Atlanta, Georgia, U.S.A., which is specifically designed for bagging alongside at sea ports. This is seen as a continuing development of current IFAD and USAID schemes. As a subsequent development, wharf-mounted mechanical offloading equipment, conveyor systems, bulk storage, and packing equipment could be considered. This is a major project which will require separate consideration.

10.6.5. Control of Conversion to Bulk Imports

It is recommended that BADC organize a team to coordinate activities on conversion to bulk imports, assisted and advised as necessary by the IFDC Resident Consultant, the USAID Logistics Officer, The World Bank, Chittagong

Port Authority and Port of Chalna Authority representatives, and others involved in bulk-handling proposals. It is further recommended that representatives of this team should undertake a study tour of Indian installations at as early a date as possible. IFDC, through the Ministry of Agriculture and The Fertiliser Association of India, would be able to provide the necessary contacts.

11. EXISTING TRANSPORT SYSTEM

11.1. General

As indicated earlier, there is a wealth of current data available on transport systems. It is not therefore of value to reproduce information readily available to BADC in existing reports, rather it is intended to evaluate the data and consider only the essential factors relative to present and future fertilizer movement systems.

11.2. Transport Availability

11.2.1. Overall

BADC is currently handling almost 1 million tpy of fertilizer from import and local production sources to PDP and thana-level warehouses. This is in the face of transport difficulties and problems with organization, communications, handling, and storage. Although there have been some local shortages and delays in lifting material from the ports and production units, the overall system has worked remarkably well considering the above problems.

Brief notes are given below on availability of transport by the principal modes for movement of fertilizer. Although a significant transport user, fertilizer movements account for only about 10% of total interdistrict traffic. Fuller descriptions of transport systems are available in reports listed earlier.

11.2.2. Road Transport

Movement of goods and passengers by road has developed from a minor to a major mode of transportation since Independence, in spite of a poorly developed

highway network interrupted by numerous ferry crossings and restricted bridges. There are around 2,500 miles of paved roads, mostly built or improved since Independence, together with some 10,000 miles of fair-weather district roads and a much greater mileage of local dirt roads. The major part of the highway network comprises single-track roads of only 12 ft or less. Maintenance requirements are high, particularly to repair flood and water damage. Overall traffic speeds are therefore low and costs relatively high.

Most trucks are assembled locally and have a nominal capacity of 5 tons. Trucks are operated both by the private sector and the government-owned Bangladesh Road Transport Corporation. There are thought to be around 9,000 trucks available in Bangladesh. Adequate numbers are currently available for movement of fertilizer, provided that appropriate contract and payment levels are maintained. As far as can be judged, adequate numbers will continue to be available to meet future fertilizer movement requirements.

11.2.3. Rail Transport

The state-owned railway system is mainly single track and of two gauges. The broad gauge system serves the western half of the country with nearly 600 miles of track, extending from Khulna northwards through Jessore to Dinajpur and Rangpur districts in "North Bengal." The meter gauge system with 1,190 miles of track serves mainly the eastern half of the country, in the Chittagong and Dacca divisions. It is linked to North Bengal by the Bahadurabad Ghat-Tistamukh Ghat ferry crossing of the Jamuna River and meets the broad gauge system at Parbatipur and Santahar.

The system is generally in poor condition with low availability and utilization of locomotives and rolling stock. The potential of the system for movement of goods, including fertilizer is therefore not currently being achieved. Considerable development aid is being received from several international and national sources. Together with emphasis in The World Bank Transport Project on improvement of rolling stock specifically for fertilizer use, operation of unit trains, and improvements to the Bahadurabad Ghat ferry crossing, there is little doubt that future rail-carrying capacity should be more than adequate for fertilizer movement requirements. Of particular importance is the concept of unit train operation, and this is discussed in detail later.

11.2.4. Inland Waterway Transport

With its four major and numerous minor rivers and its maritime coastline, Bangladesh is as well provided as any country in the world for inland

waterway transport. There are some 3,300 miles of waterways navigable during the monsoon and about 2,300 miles navigable during the dry season. These are under the control of the Bangladesh Inland Water Transport Authority (BIWTA).

The largest operator of mechanical equipment is the government-owned Bangladesh Inland Water Transport Corporation (BIWTC) which carries around 50% of the freight and 10% of the passenger traffic. The remainder is carried by private sector operators.

A variety of studies have been undertaken c[illegible] aspects of equipment, operation, and management, including the recently c[illegible]ed Second Inland Water Transport Study (IWTS). The Government of Bangladesh [illegible]A, the Netherlands, and Norway are all involved in improvement programs.

Although equipment is generally in a poor state of repair and operating efficiency is low because of management and communication problems, there is no shortage of carrying capacity. The IWTS indicated that both waiting and working time are excessive for inland barges. Figures for 1980 show:

Barge Operating Time, 1980

	Days/Year	
Awaiting cargo and orders	165	45%
Under repair	26	7%
Working cargo	138	38%
Being towed	36	10%

There is then major scope for improvement. It is generally agreed that existing capacity is adequate to meet all forecast requirements for movement of major commodities, including fertilizer. BADC contracting procedures and operating problems are being addressed by the IFDC Resident Consultant.

11.3. Transport Costs

Considerable historic and current cost data on transportation is available with BADC. An early major report was the Bangladesh Transport Study (BTS) of 1972-74, subsequently updated. The EIU report of 1978 described the existing systems for fertilizer transport by all modes. Costs were calculated for the main routes by all appropriate modes. Handling losses and costs were also considered.

Water transport-related studies have also included land transport system studies. Examples are (a) the NEI Chittagong Port Entrance Study of 1978 which devotes one volume to transport, including in-depth analysis of road and rail transport costs and (b) the Second Inland Water Transport Study, by Louis Berger, recently available, which analyzes costs by all modes.

The most recent study and the most relevant to BADC's requirements is, however, the NFSP report of May 1981. This gives movement data by all modes from all sources to all PDPs and a complete movement plan for 1984/85 tonnages, with some consideration of alternative routings. This is the format which BADC should follow for distribution planning purposes.

Surprisingly, some of the movement costs used in the NFSP reports are quite different to rates currently quoted by BADC, although NFSP includes in its sources BADC, Bangladesh Railways, the Bangladesh Transport Survey, BIWTA, and BIWTC. Rates for road and barge transport are in reasonably good agreement, but some rates for rail movement over greater distances are considerably different. These differences are being checked with BADC. The NFSP figures are at least 1 year old and could well be in need of immediate revision because of rapid changes in rates. For example, the IFDC Distribution Consultant working with BADC has recently calculated an average increase on rail rates of 169% since 1979.

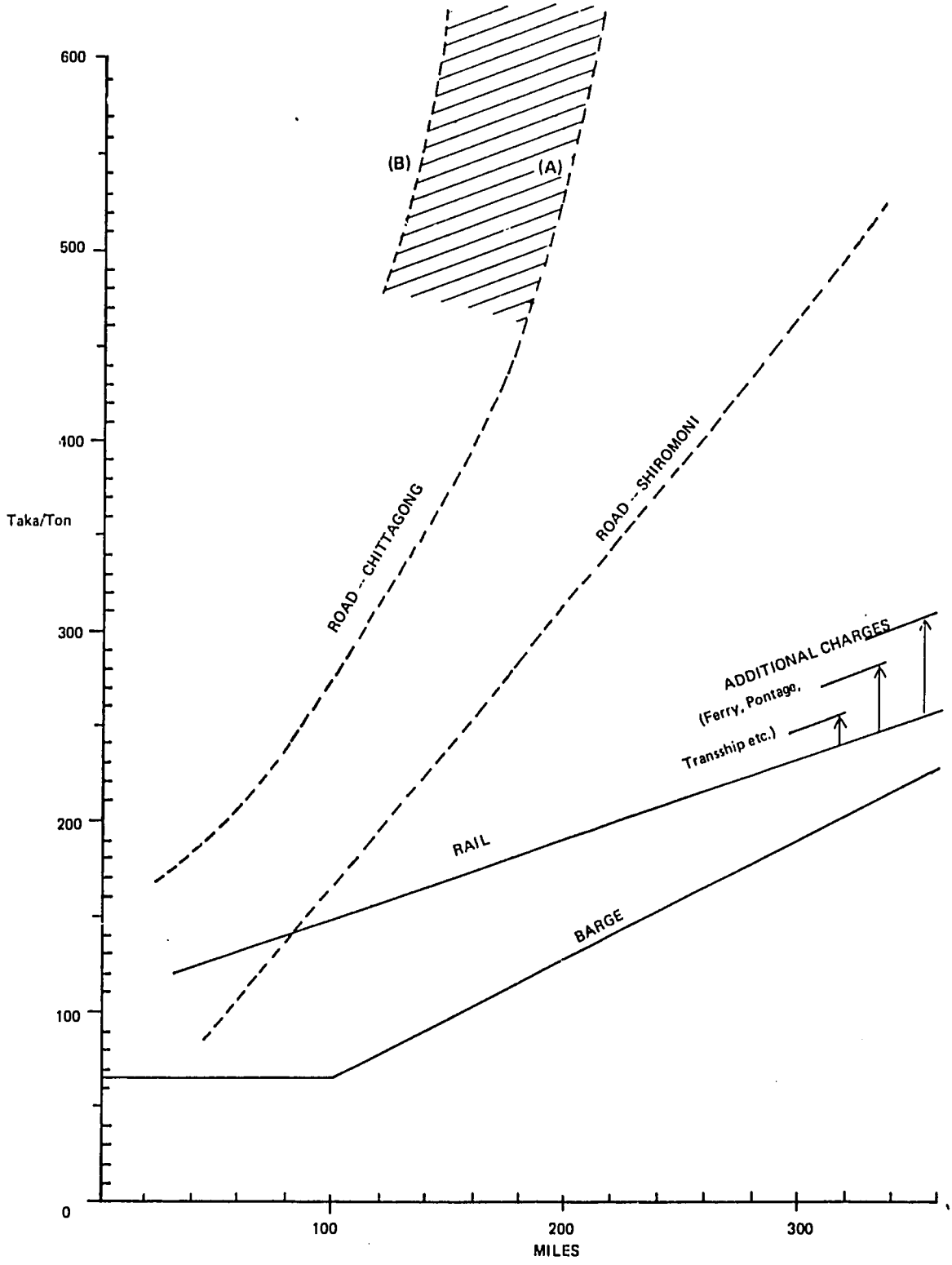
This does illustrate the difficulty of defining transport costs for Bangladesh. The EIU and NEI analyses of cost factors are still relevant, although actual cost levels have increased very considerably due mainly to increases in the cost of diesel fuel.

The most recent and internally consistent cost data available are those given in the NFSP report; and as indicated above, it is recommended that this report should be used as the basis of further work by BADC. Costs from the NFSP report are shown in Figure 7, with curves giving reasonably good indications of the cost levels. It will be seen that barge costs are lowest over all working distances with rail next lowest. Road costs from Shiromoni are significantly lower than road from Chittagong for reasons which are not known, and considering the districts served, the reasons do not appear to be related either to return traffic or use of ferries. Similarly, on longer distance movements from Chittagong, (curve "b") costs to Dacca and Tangail districts are considerably higher than to districts in Chittagong division. These differences are somewhat academic since the rail and barge alternatives with transshipment are so much less costly on these routes that road should not be employed.

Figure 7.

Comparative Movement Costs by Mode.

Source: NFSP May, 1981.



11.4. Transport Subsidies

Various attempts have been made to address the problem of transport subsidies, but this is more of a problem than usual when the actual cost levels are difficult to define and some are changing rapidly, as discussed above.

Calculations of transport costs in commercial and economic terms were made by the BTS, recalculated in the EIU study, and updated by the planning commission in 1978/79. The recently published IWTS by Louis Berger updated the earlier calculations to 1979/80.

Commercial costs are those borne by the transport user, while economic or resource costs attempt to evaluate the transport services in terms of real costs to the economy as a whole. This requires assumptions on economic costs of imported equipment, such as barges or truck chassis, on the exchange rate, and on the economic cost of locally produced items, which may be heavily subsidized. The earlier reports concluded that the economic costs for inland waterway vessels are higher than the commercial costs, with the reverse holding true for road and rail. The IWTS considers these conclusions to be incorrect, taking a different view of assumptions made for imported and locally produced equipment for waterway, road, and rail systems.

The IWTS figures for economic and commercial costs are shown in Table 5, together with transport rates as projected in the EIU study for 1981 and as given by the NFSP. The IWTS calculated economic costs are slightly higher than the commercial costs for water transport and slightly lower for the other two modes. The IWTS conclusions concerning the relative levels are confirmed by current commercial practices for road and waterways, although the absolute levels are considerably higher than rates given in the NFSP. The EIU projected rates are lower again than the NFSP rates.

In the Consultant's view, it will require considerable further work in order to obtain a consensus opinion on true transport costs and rates and on determination of subsidy levels, if any. It is not considered appropriate to this study or to BADC operations to attempt such an analysis. It is recommended that BADC continue to negotiate transport rates on a commercial basis, leaving considerations of subsidy to the appropriate government departments.

In view of current private sector involvement in road and water transport, it would appear that rates by these modes are at a commercial level. Relative to road and water transport freight rates, rail freight rates are

Table 5. Commercial and Economic Transport Costs by Mode

Source	Taka/Ton Mile 100 Miles	200 Miles	300 Miles
NFSP, May 1981			
Barge	0.64	0.64	0.64
Rail	1.5	0.95	0.78
Road ex Shiromoni	1.65	1.57	1.55
ex Chittagong (a)	2.65	2.65	-
(b)	3.93 for 150-250 miles		
EIU Final Report, Volume 3, Page A26, Projection for 1981			
Water	0.51	0.32	0.26
Rail	0.45	0.31	0.28
Road	0.62	0.58	0.57
Second Inland Water Transport Study, L. Berger, 1980/81			
A. Commercial Costs			
River Barge	2.30	1.26	0.91
Rail--Broad gauge	3.79	2.04	1.45
Meter gauge	4.84	2.56	1.81
Road	2.31	1.86	1.71
B. Economic Costs			
River barge	2.40	1.31	0.95
Rail--Broad gauge	3.82	2.07	1.48
Meter gauge	4.88	2.61	1.85
Road	2.13	1.73	1.60

around the level that would be expected, and there is no indication of any major subsidy.

It has been suggested that inadequate allowance is being made for depreciation and replacement of equipment, and this seems quite possible in view of some of the equipment observed in use. Against this, however, the IWTS notes that the demand to finance vessels by investors in the private sector is greater than the number allocated by the government program.

11.5. Control of Transport

It has been stated in other publications that BADC has neither an adequate fleet of transportation vehicles nor any control over transportation charges. This is common to the majority of fertilizer distributors in most parts of the world and indeed to all other industries. Because of difficulties in lifting of fertilizer on occasion, it has been suggested that BADC should consider acquiring an adequate number of transport vehicles.

The problems on availability of trucks to BADC are, however, related to contract arrangements and prices paid and not to vehicle availability as such. This was noted in the AID Project Proposal of June 1978, and BADC is currently implementing specific proposals on contract improvements, assisted by the IFDC Resident Consultant. BADC already owns 65 trucks, which are located in the districts and are reportedly not fully utilized. From experience in other countries, it is recommended that BADC should not acquire further transport equipment but should concentrate on making suitable contractual arrangements with professional transport operators, whether public or private sector, and improvement of their own management systems for procurement and control of transport.

11.6. Choice of Transport Mode

Within the fertilizer distribution system, there is little real freedom of choice on mode of transport. In many cases there is only one mode of transport that can be used to supply a particular location. Where there is a choice, the least cost route will be known, but if capacity is not available, then there is no alternative but to use a higher cost mode. Once established,

the routing would not normally be expected to change, except in the case of some of the water routes, which are not available during the dry season. Also, some of the road or rail routes will encounter difficulties and delays during the monsoon.

In the NFSP study, distribution patterns are calculated in 6-month periods for wet-season and dry-season conditions. It is suggested that these periods should be viewed as guidelines only and every effort made to maintain regular movement by the preferred method over as much of the year as possible. Alternatives can be defined at the planning stage, and questions of modal choice should not then arise during operation.

The importance of movement on a regular planned basis to achieve economic and efficient distribution was discussed earlier. Such planning will also include consideration of alternatives and, if necessary, initiate action to reduce or remove physical limitations.

12. FUTURE DISTRIBUTION SYSTEM

12.1. Overall Concept

As discussed in Section 5, capacity limitations in Bangladesh transport systems create constraints on movement of fertilizer. The most effective and efficient way of using any form of transport is to use it continuously. The basic objectives is then be to move product through the system throughout the year on as regular a basis as possible. This objective is fully consistent with input characteristics and marketing requirements for the fertilizer system in Bangladesh and is a practical basis for development of an efficient distribution system. In the case of BADC, this relates to movement from production and import sources to storage at the PDP level, together with coordination of procurement and marketing activities.

The concept of regular movement through the system, as far as possible towards the point of final consumption, dictates that stocks will accumulate in the consuming areas, which is the desired location for marketing purposes. Adequate storage is then needed in these areas. This requirement was recognized at an early stage by USAID, and the continuing warehouse construction program under the Fertilizer Distribution Improvement Project, together with BADC and

other construction programs, should ensure adequate in-country storage for the foreseeable future.

Production from the urea factories and the TSP units at Chittagong is already on as regular and continuous a basis as possible for reasons of production economics. Imports should also be scheduled on as regular a basis as possible throughout the year so that limited port facilities may be used in the most effective and efficient manner. Account must, however, be taken of the practical problems encountered in working during the monsoon period. If imports are assumed to be reduced to half rate during the monsoon, then the resulting pattern will be 5%/month of annual imports during each of the 4 months May-August and 10%/month during each of the remaining 8 months of the year. It is fortunate that the demand for phosphate and potash, which form the bulk of the imports, is at a reduced level during the monsoon period.

A clear concept must be retained of the role of stocks held at the source locations and at the PDP level. The stocks at source locations (the four production units and the two main ports) are necessary to maintain regular dispatches throughout the year and may therefore be considered as transport buffer stocks. The main storage level is at the PDPs and this is marketing storage, which must accommodate all seen and unforeseen fluctuations in offtake.

It follows that the most important prerequisite for such a system to operate effectively is an accurate and realistic forecast of demand. The forecast should be by product by month, for at least 1 year ahead for each of the PDP locations defined in the NFSP. The forecast must be updated on a continuous basis as an integral part of the operating system.

It is also essential that the total system is controlled and monitored centrally. This would logically be from BADC Headquarters.

Operations are then directed towards moving material through the distribution system on as regular a basis as possible, working to a predetermined stock building plan for every PDP. This plan should not be subject to change at short notice. Regular communication from all parts of the system, preferably on a daily basis, to the central control unit is necessary.

With forward planning and centralized control, it will be appreciated that marketing management at district level does not order supplies. These are sent forward according to the prearranged plan. Concepts such as reordering levels and order lead times no longer apply.

The concept of moving material regularly to the PDP locations against a forward plan goes against marketing principles which would apply in a developed economy, with a competitive situation and a choice of supply sources. In Bangladesh, however, where the entire system for procurement, distribution, and marketing of fertilizers is managed by a single government agency, the recommended system of centralized planning and control of distribution operations is considered most appropriate and effective for the existing organization at this time. It is clear, however, that the effectiveness of the whole operation is heavily dependent upon the effectiveness of the central control unit. BADC should obtain the best possible advice in establishing and operating the unit and in assessing its functions and effectiveness on a continuing basis.

12.2. Movement Plan

The overall movement plan at the 1984/85 level as calculated in the NFSP is shown in Table 6 and illustrated in Figure 8. A further breakdown of movements from Chalna and Shiromoni is shown in Tables 7 and 8, respectively.

In attempting to establish systems for regular movements, we are concerned principally with the major flows by rail and barge. Truck movements are generally at lower levels and usually easier to arrange at the individual source locations. The main flows are as shown in Table 9.

Total dispatches from Chittagong and Chalna are reduced during the wet season because of the reduction in imports at this time. The most pronounced change in dispatches between dry and wet seasons is from Ghorasal, where barge is the least cost route to many destinations, but is considered in the NFSP to be available only for a few months in the wet season because of draught restrictions. Compensating adjustments in the system then lead to a decrease in barge movements from Ashuganj in the wet season and an increase in rail movements, which then counterbalances the reduction in rail movements out of Ghorasal crossing on the Bahadurabad ferry, as seen in Table 9. In planning future movements, BADC may consider concentrating rail dispatches on Ghorasal and barge dispatches on Ashuganj. Rail dispatch systems should then be planned, generally on the rates applying during the "dry" season. During the remaining monsoon months, operating difficulties are likely to reduce rates so that the reduction in quantities planned to be moved is in line with the actual situation.

Table 6. Overall Fertilizer Movements, 1984/85 Levels ('000 tons product)

Source	Method of Delivery	Dry Season Urea	Dry Season TSP	Dry Season MOP	Wet Season Urea	Wet Season TSP	Wet Season MOP	Total Urea	Total TSP	Total MOP
Ashuganj	Rail	112.8 (39.4 ferry)			149 (103 ferry)			261.8 (142.4 ferry)		
	Truck	13.0			8.7			21.7		
	Barge	111.7			79.8			191.5		
		236.5			237.5			475.0		
Ghorasal	Rail	164 (122.5 ferry)			27.8			191.8 (122.5 ferry)		
	Truck	11			7.4			184.0		
	Barge	-			139.8			139.8		
		175			175.0			350.0		
Fenchuganj	Rail	37.5			37.5			75.0		
	Truck	-			-			-		
	Barge	-			-			-		
Chittagong (Imports + 120 TSP production)	Rail	-	112.9	37.1	-	73.8	24.2	-	186.7	61.3
	Truck	52.7	33.0	12.3	-	20.0	7.3	52.7	53.0	19.6
	Barge	7.5	79.7	15.3	-	67.2	11.3	7.5	146.9	26.6
		60.2	225.6	64.7		161.0	42.8	60.2	386.6	107.5
								TOTAL	554.3	
Chalna (Imports)	Rail	-	-	-	-	-	-	-	-	-
	Truck	-	-	-	-	-	-	-	-	-
	Barge	79.8	219.6	85.7	-	133.8	56.8	79.8	353.4	142.5
								TOTAL	575.7	
Totals		590.0	445.2	150.4	450.0	294.8	99.6	1,040.0	740	250
Overall Production		450	60	-	450	60	-	900	120	-
Imports		140	385.2	150.4	-	234.8	99.6	140	620	250
Totals								1,040	740	250
								TOTAL	2,030	
Bahadurabad Ghat Ferry---ex Ashuganj			39.4			103			142.4	
(all urea) ex Ghorasal			122.5			0			122.5	
								TOTAL	264.9	

Source: NFSP study, May 1981.

Figure 8.

Overall Fertilizer Movements by Source, Product and Mode. 1984/85 Levels.

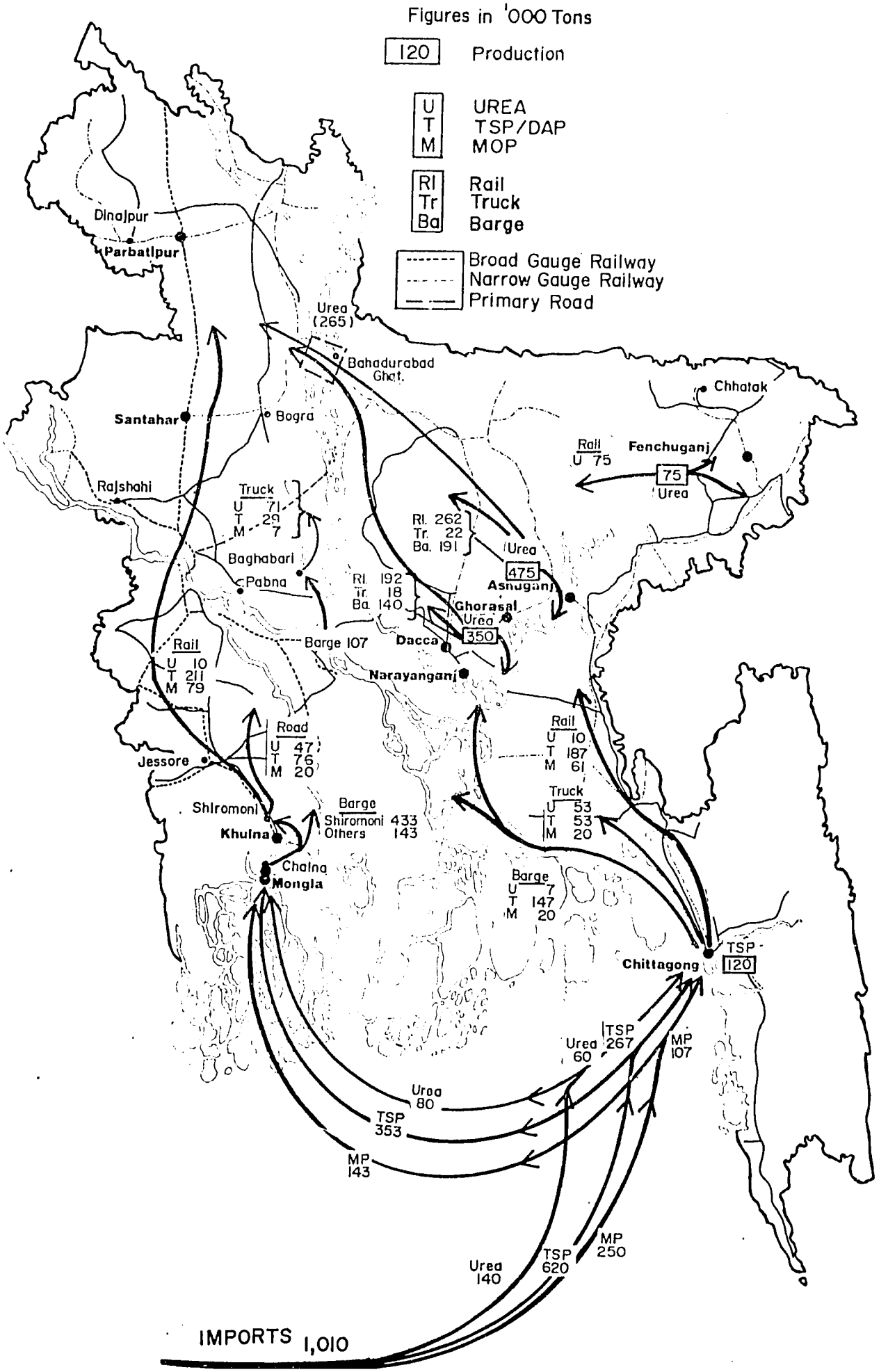


Table 7. Movements Ex Chalna, 1984/85 Levels (All by Barge)
('000 tons product)

Product	Dry Season		Wet Season		Total	
	To Shiromoni	Others	To Shiromoni	Others	To Shiromoni	Others
Urea	47.3	32.5	-	-	47.3	32.5
TSP/DAP	172.0	47.6	115.1	18.7	287.1	66.3
MOP	59.1	26.6	39.6	17.2	98.7	43.8
	278.4	106.7	154.7	35.9	433.1	142.6
TOTAL	385.1		190.6		575.7	

Source: NFSP, May 1981

Table 8. Movements Ex Shiromoni, 1984/85 Levels ('000 tons product)

Product	Dry Season		Wet Season		Total	
	Rail	Road	Rail	Road	Rail	Road
Urea	0	47.3	0	0	0	47.3
TSP/DAP	126.7	45.3	84.8	30.3	211.5	75.6
MOP	47.4	11.7	31.7	7.9	79.1	19.6
TOTAL	174.1	104.3	116.5	38.2	290.6	142.5
GRAND TOTAL						433.1

Source: NFSP, May 1981.

Table 9. Quantities for Dispatch by Rail and Water, 1984/85 Levels ('000 tons)

Source	Dry Season		Wet Season	
	Rail	Barge	Rail	Barge
Ashuganj	112.8	111.7	149.0	79.8
Ghorasal	164.0	-	27.8	139.8
Fenchuganj	37.5	-	37.5	-
Chittagong (production + imports)	150.0	102.5	98.0	78.5
Chalna				
To Shiromoni		278.4		154.7
Others		106.7		35.9
Shiromoni	174.1		116.5	
Bahadurabad Ghat Ferry	161.9		103.0	

It should be remembered that the NFSP concept of a dry season of 6 months and a wet season of 6 months is convenient for planning purposes, but in practice the most economic arrangements will be continued as long as conditions permit in either season.

The greatest improvement in transport capacity in Bangladesh should be achieved by operation of an effective unit train system. Before considering the equipment and systems to move the forecast tonnages, operation of unit trains will first be discussed.

12.3. Operation of Unit Trains

It is apparent from The World Bank project document and discussions with Bangladesh railways management that the concept of effective unit train operation is clearly understood. The Consultant has had experience of operation of a unit train (or block train or company train) system in the United Kingdom and has been involved in proposals and discussions concerning unit train operations in developing countries. In view of a number of common misconceptions, it is considered advisable to outline the basic features for the benefit of BADC and other interested parties.

The unit train concept is best suited to large tonnage movements over fairly long distances on a regular basis. Distance is a factor because under normal conditions, for distances up to about 100 miles, a road shuttle service can be as economical and more convenient.

The unit train operates regularly as a complete trainload of wagons on both outward and return trips on a preplanned, timetabled path in both directions. Efficient terminal operations are essential to maintenance of an efficient service. Four common misconceptions are as follows.

12.3.1. Return of "Empty" Wagons

In every practical situation, it is much more efficient to return the wagons empty and not attempt to use the "free" carrying capacity on the return trip since this destroys the efficiency of turnaround and results in considerably more wagons being required in the total traffic. A suitable matching back traffic with highly efficient handling at both ends is virtually impossible to find.

12.3.2. Costs

Although a special service, this is not a high-cost operation. Trainloads are moved direct from private siding to private siding, with no shunting in marshaling yards or local stations. Overall railway operating costs are lower because of the much higher overall efficiency, and a reduction of one-fourth to one-third on normal (unsubsidized) rail rates may be negotiable. A contract for regular operation should set the cost by the trainload, including return of empties on a scheduled service, with no added charges or levies. Contracts are negotiated at headquarters level, and train operations are controlled by contact at headquarters and regional level.

12.3.3. Running Speeds

Trainloads should not run at high speed because this usually creates running gear problems and is counterproductive. The benefit is gained from uninterrupted movement, possible because of advance planning, at normal running speeds. Movement is on as continuous a basis as possible, on a passenger train-type schedule. Traveling at an average of only 30 km/hour (approximately 20 miles/hour) almost all destinations in Bangladesh nominated for fertilizer traffic could be reached in 24 hours, including allowance for the Bahadurabad Ghat ferry crossing.

12.3.4. Wagon Availability

Wagon supply is no longer a problem for the dispatch points. The required number of wagons equivalent to the number of complete trains operating plus spares is permanently allocated and must always return direct to base (except for stoppages for maintenance). It is preferable if each source controls its own specific stock of wagons.

Overall efficiency in terms of wagon utilization may be considered relative to current performance. An AID study indicated outward journey times of up to 3 weeks for loaded wagons by rail, which is in line with other rail systems for normal wagon dispatches. Since matching return loads are not always available at destination points, a return load factor must be applied. This has been estimated to be in the region of 40%-50% for Bangladesh so that wagons are in service for about 30 days to achieve one round trip. On a unit train service, if 1 day is allowed for loading, 1 day for discharge, and 1 day each way for traveling for a total of 4 days, then a practical turnaround time of 1 week/train (or wagon) is achievable. This is a potential fourfold improvement in wagon utilization.

Other important factors include the need for on-site facilities for minor maintenance and repair of wagons. This is recognized in The World Bank project.

For operating in Bangladesh, provision is required for all-weather loading and offloading to ensure regularity of operation. Arrangements for efficient handling are also necessary. At source locations, capacity should be available to load one train/day during daylight hours. At receiving locations, offloading should be completed within 24 hours for 60 wagons or within 12 hours for 30 wagons when the train is split. It is desirable to keep the destination locations to the absolute minimum so that full physical facilities may be developed, together with a corresponding management organization. Direct transfer by truck from the offloading point to locations up to 50 miles distant is indicated where suitable roads are available.

Perhaps the most important factor in a unit train service is regularity of operation. Any particular location receiving, say one trainload every week, should receive that train on the same day every week. Similarly for source locations, a regular program with dispatch to the same location on the same day each week promotes efficient operation. We then establish regular practices at both source and offloading locations enabling regular arrangements to be made for transportation and handling services.

At destination locations, the first essential is to offload and release the wagons for return on time. This dictates covered facilities for all-weather operation, which can also serve as temporary storage. After offloading the fertilizer rapidly at the receiving siding, in the case of a weekly service, there is then 1 full week for disposal of the material. This can be arranged at an even rate throughout the week to storage, to other PDPs, or to dealers, according to the prearranged plan.

It is noted in the NFSP that movements by rail are considered in terms of both unit train and "normal block train movements." It is suggested that all movements from source locations are planned on the unit train system only.

12.4. Major Traffic Flows

12.4.1. Overall

The major primary traffic flows for which BADC must plan were shown in Table 9. The dry season throughput rates, on which calculation is based for

rail and barge requirements, are shown in Table 10, together with trainload requirements.

In line with the unit train concept and the principle of regular movement through the system, the main rail movement patterns for 1984/85 tonnages are then:

Ashuganj	Five trains/week, one each working day. (One may be canceled on alternate weeks.)
Ghorasal	Six trains/week, one every working day, including Saturday.
Bahadurabad Ghat Ferry	One full train each way every day, 6 days/week.
Fenchuganj	One or two trains each week. (Because of the shorter hauls, one train may service this requirement.)
Chittagong	
TSP Plant	One train/week. This should be scheduled to the same, possibly split, locations on the same day every week.
BADC/Port	One trainload every working day.
Shiromoni	Seven trains/week (phasing discussed below).

There are also barge movements from Chalna to Shiromoni at the rate of 2,100 tpd.

As noted earlier, it is clearly necessary for BADC to initiate and coordinate planning for these movements. In order to assist in this process, application of the distribution principles recommended in this review may be applied to operations from Chalna and Shiromoni to demonstrate the essential factors. Development of these examples is not meant as a recommendation for modification of NFSP or World Bank proposals. These proposals will, however, require reevaluation when BADC has to convert the NFSP to a working system.

12.4.2. Movements From Chalna to Shiromoni

If imports are in bulk and are handled by the bag-on-board method recommended earlier, all cargo will be handled through the shore warehouse at Chalna.

For movement of 2,100 tpd, it is recommended that BADC acquire purpose-designed barges on long-term contract for movements from Chalna to Shiromoni. Discussion with an inland waterways consultant suggests that a suitable type may be a 1,000-ton self-propelled barge. By loading and offloading during day hours and traveling overnight (not current practice for safety reasons), a 2-day turnaround should be achieved.

Table 10. Major Traffic Flows by Rail and Barge

Rail	Dry Season Rate ('000 tons)	Approximate tpw	Trains/Week
Ashuganj	112.8	4,400	4-5
Ghorasal	164.0	6,300	6
Bahadurabad Ghat Ferry	161.9	6,200	6
Fenchuganj	37.5	1,400	1-2
Chittagong			
TSP	27.0	1,000	1
BADC/Port	123.0	4,700	5
Shiromoni	174.1	6,700	7
Barge			
Chalna to Shiromoni	278	10,700	N/A (2,100 tpd)

The plan would then be to load 2 x 1,000-ton barges at Chalna every working day. A suitable covered barge wharf will be required, equipped with loading conveyors, to operate on an all-weather basis. Other barges would also be loaded at this facility. On a 2-day turnaround, a minimum of four such barges is required.

At Shiromoni, the base plan is to offload 2 x 1,000-ton barges every working day. As at Chalna covered all-weather facilities will be required. An offloading conveyor system is recommended to take bagged fertilizer direct from the barge holds to the rail and truck loading areas, not to storage. This minimizes handling, with a reduction in both cost and handling damage. The conveyor system should also serve the buffer storage area and allow recovery from storage and movement to the rail and road loading area. As discussed in the next section, rail dispatches by unit trainload should be on a regular, evened out basis. The objective is then to transfer the maximum amount of product directly from barge to rail wagon or to truck.

12.4.3. Rail Movements From Shiromoni

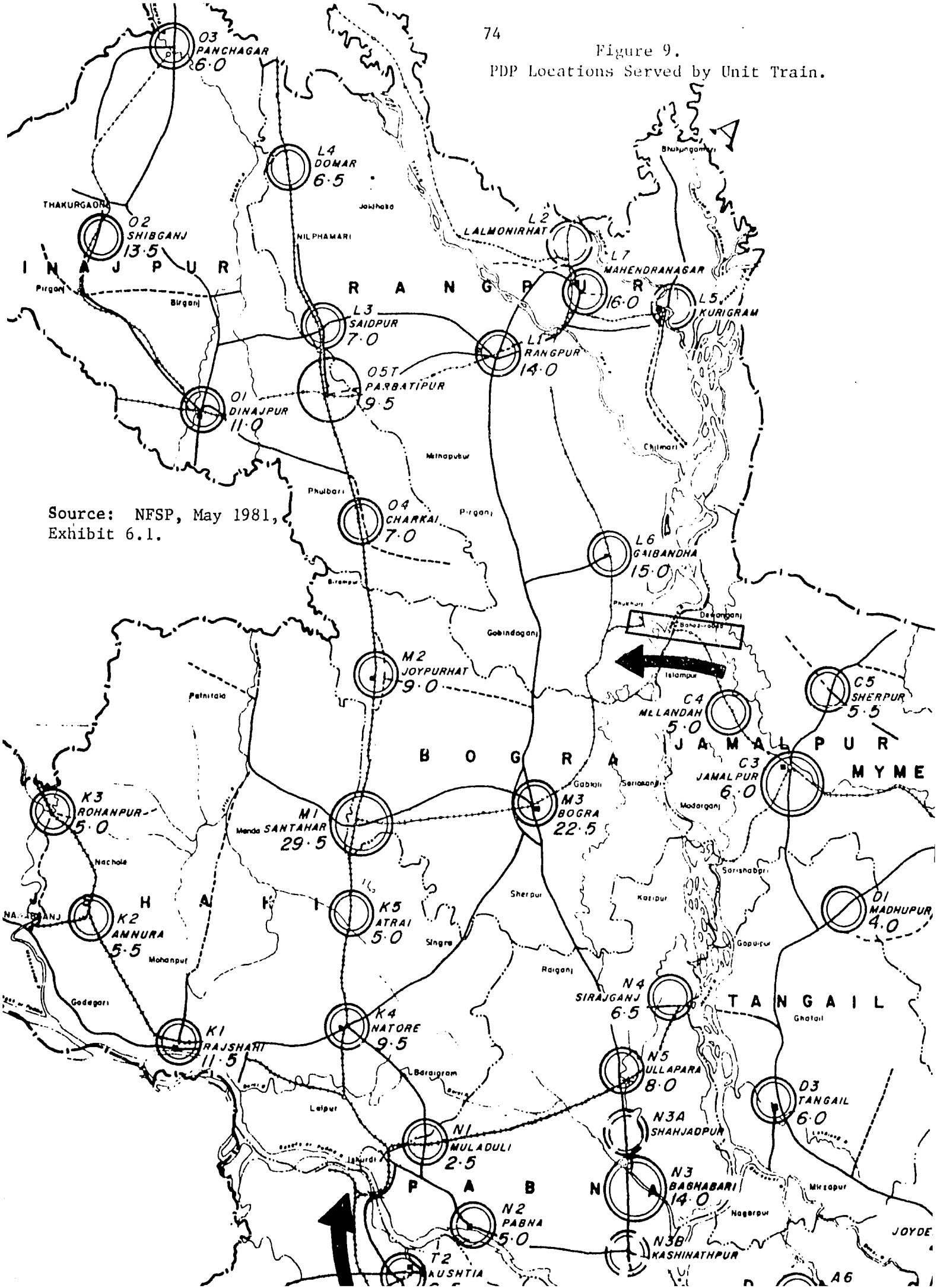
Without wishing to go to too detailed a level in considering unit train movements from Shiromoni, this traffic forms a good case study and example for BADC in planning their future system. A map of part of the area served is given as Figure 9, showing the PDP locations involved. Natore is 141 miles and Parbatipur 228 miles from Shiromoni.

The World Bank project and NFSP refer to seven unit train destinations from Shiromoni as follows:

1. Ishurdi or Muladuli
2. Natore
3. Rajshahi
4. Santahar
5. Joypurhat
6. Parbatipur
7. Saidpur

Considering the locations and throughputs at these locations, it is suggested that they could be cut down to four as follows:

Figure 9.
PDP Locations Served by Unit Train.



Source: NFSP, May 1981, Exhibit 6.1.

Location	Features
1. Natore	Serving Muladuli by road.
2. Rajshahi	Serving Amnura and Rohanpur by road.
3. Santahar	Serving Atrai and Joypurhat by road (assuming suitable roads available). Transfer to Bogra by road shuttle, not meter gauge rail.
4. Parbatipur	NFSP refers to meter gauge line to repair yard at Saidpur. If this can be used for access, make Saidpur district center. Dinajpur, Shibganj, Panchagar, Domar, Rangpur served by road.

The tonnages and weekly movement requirements to these locations are then as follows:

Unit Train Destination	Dry Season Supply Ex Shiromoni (tons)	Unit Trains/Week
1. Natore	13,000	½
2. Rajshahi	24,000	1
3. Santahar	59,000	2½
4. Parbatipur	78,000	3
		7

One possible train program for dispatches from Shiromoni to supply this requirement is as follows:

Unit Train Service

Day	Train Number and Destination
Monday	1. Santahar
Tuesday	2. Parbatipur[a]
	3. ½ Santahar--½ Natore
Wednesday	4. Parbatipur
Thursday	5. Santahar
	6. Rajshahi
Friday	7. Parbatipur

a. Or Saidpur.

This program spreads the load at both dispatch and receiving points.

A special feature of this part of the system is that it contains the two meter gauge/broad gauge crossing or transfer points, where the meter gauge east-west urea flow via Bahadurabad Ghat meets the northward broad gauge TSP/MOP flow from Shiromoni. The quantities involved are:

1984/85 Transfer Tonnages as in NFSP

	Dry Season	Wet Season
Meter Gauge to Broad Gauge (Urea)		
Santahar	40,357	21,573
Parbatipur	5,972	7,529
Broad Gauge to Meter Gauge (TSP/MOP)		
Santahar	33,177	22,218
Parbatipur	58,291	39,039

It appears there is an obvious opportunity to exchange wagon loads between gauges at the transfer points for onward or backhaul of fertilizers. It would, however, probably be better from an operating point of view to keep separate "local" wagons for such onward movements. The integrity and efficiency of the longer distance, unit train operation is then retained by returning complete trains of empties directly to the dispatch point.

A further consideration is how much of this transfer should in fact take place. For urea consigned as above to Parbatipur, by operating meter gauge trains on a split train basis to Gaibandha, Rangpur, Parbatipur, and Dinajpur with proper arrangements for onward movements by road, there is no need for transfer to broad gauge. On urea movements to Bogra and Santahar, there should be no need for transfer to broad gauge except for material moving southward by rail from Santahar beyond Natore.

On TSP/MOP broad gauge movements from Shiromoni, most locations can be served by road from the four previously nominated destinations. Gaibandha may be worth serving by rail. In that case, it may be worth establishing one broad gauge/meter gauge transfer station at Santahar and operating a separate trainload meter gauge service to Bogra, Gaibandha, Rangpur, Parbatipur, and Dinajpur.

12.5. Summary of Requirements: Equipment and Physical Facilities

Based on the distribution system envisaged, assumptions made, and proposals in previous sections, the following list outlines the main physical facilities required to handle total fertilizer requirements at the 1984/85 level. Where conveyor systems or "mechanized" loading is specified, this assumes manual stacking in the rail wagon, barge, or truck, but movement by conveyor systems up to that point.

1. Ashuganj Urea Plant
   a. Covered, mechanical, rail loading facilities capable of loading one 60-wagon train/shift.
   b. Covered barge loading facilities capable of loading 1,000 tpd (day hours).
2. Ghorasal Urea Plant
   As for Ashuganj, above.
3. Fenchuganj Urea Plant
   a. Covered rail loading facilities capable of loading 30 wagons/shift.
4. Chittagong Port Area
   a. Two berths in port dedicated to receiving (hand) bagged fertilizer imports, each capable of receiving at 1,500 tons/shift rate from lighter or from vessel alongside. Truck shuttle service to BADC warehouses outside port area.
   b. BADC working area in warehouse outside port area, for "standardizing" fertilizer bags at import handling rate using two berths (2 x 1,500 tons/shift), with direct movement to rail, road, and barge loading facilities from standardizing area, and to storage.
   c. Warehouse accommodation for at least 1 month average throughput.
   d. Facilities in port for loading to bay crossing barges and coasters at minimum rate of 1,000 tpd (from BADC and/or TSP plant).
   e. Covered mechanized loading facilities for rail and road at BADC site, supplied directly from import handling area (b) and also from storage (c). Rail loading to handle one 60-wagon train/shift. Truck loading to handle minimum 200 x 5-ton trucks/day.
5. Chittagong TSP Plant
   a. Covered rail loading facilities capable of loading one 60-wagon train in 24 hours, one/week.
   b. Truck loading to handle minimum 60 x 5 ton trucks/day.
6. Chalna Port
   a. Two berths in port dedicated to receiving bagged fertilizer imports from lighters or from pontoon berth at rate of 1,500 tons/shift each on two-shift operation.
   b. Conveyor system from berths to BADC working area in warehouse for "standardizing" fertilizer bags at import handling rate. Conveyor system to barge loading and to storage.

c. Third dedicated berth for all-weather loading out to barges, with mechanized/conveyor loading to handle 2 x 1,000-ton barges/day (to Shiromoni), during day hours plus 1,000 tpd average into other barges. Conveyors from working area (b) and from storage (d).

d. Warehouse accommodation for at least 1 month's average throughput.

7. Shiromoni transit center

a. Covered facilities for offloading 2 x 1,000-ton barges/day during day hours. Conveyor system direct to rail and truck loading out facilities, also to storage.

b. Covered, mechanized, rail loading facilities, capable of loading 2 x 60-wagon trains/day, during day hours.

c. Covered mechanized, road loading facilities, capable of handling a minimum of 200 x 5-ton trucks/day, during day hours.

d. Buffer storage capacity for at least 2 weeks throughput at average rates.

8. All source locations for rail dispatches (<u>all above except Chalna</u>)

a. Adequate rail siding capacity for storage of wagons and marshaling of trainloads.

b. Shunting facilities.

c. Wagon maintenance facilities to handle minor and running repairs.

9. All unit train destinations (PDPs)

a. Covered offloading area, strongly recommended capable of handling full 60-wagon train at one time.

b. Storage in immediate offloading area capable of accepting one full trainload.

10. Bahadurabad Ghat rail wagon ferry

a. Essential improvements as in The World Bank project.

b. Capacity to move one full trainload in each direction <u>every</u> day for 1984/85 levels as minimum requirement.

12.6. Establishment of Central Control Unit

The concept of the supply and distribution system developed in earlier sections envisages regular movement through the system throughout the year. This requires effective forward planning together with effective operation once

established. BADC must be fully committed to and involved in the planning of this system and its subsequent operation.

It is recommended that a central control unit should be established, most logically located in BADC Headquarters.

The basic function of the unit is to control and monitor all operations involving supply, transportation, storage, and offtake of fertilizers. Data should be transmitted to the control unit on a daily basis from all source lcations, i.e., ports and production units, transit locations, all storage points, and BADC offices as appropriate. Data would include information on transport operations, stock levels, receipts and dispatches at all locations as well as situation reports on conditions which may affect operations.

An important function of the unit is to act as a central data bank, providing essential information to many divisions in all wings of BADC. The data function is coordinated with a transportation control section, as well as providing information for procurement, distribution, marketing, financial, stock planning, and auditing purposes.

In view of the quantity and range of use of the information to be processed, it would appear appropriate to plan for the system to be constructed around a computer. At present BADC has no computer facilities. Specialized assistance is therefore necessary in planning, commissioning, and operation of the control unit.

12.7. BADC Organization

It is beyond the scope of this review to evaluate the management structure and organization involved in fertilizer operations within BADC.

It is, however, apparent that problems exist in administering the supply, distribution, and storage systems because of the division of responsibilities for these operations between the various Wings and Divisions of BADC. In addition, there are not enough managers available with the required experience to undertake development and planning work.

It is suggested that BADC require assistance in building the organization necessary for planning and operating the future fertilizer supply system. Such assistance would cover the following four main areas: (1) Overall Organization and Management Systems, (2) Fertilizer Procurement, (3) Distribution,

and (4) Marketing. This assistance should be on the basis of consultants working within BADC and it is not proposed that there should be a further study. There are already a large number of studies, and many recommendations have been made. The problems for BADC are in evaluating these recommendations and in attempting implementation in the face of a shortage of experienced management and with the limitations and constraints inherent in a Government organization.

Table A-1. PDP Locations Proposed Under NFSP, May 1981

Ref.	District	Number of PDPs	Transit Locations Included
A	Dacca	7	
B	Kishoreganj	6	
C	Mymensingh	6	
D	Tangail	2	
E	Faridpur	5	
F	Chittagong and Chittagong Hill Tracts (G)	5	
H	Noakhali	4	
I	Comilla	5	
J	Sylhet	7	Chhatak
K	Rajshahi	5	
L	Rangpur	5	
M	Bogra	3	Santahar
N	Pabna	5	Baghabari
O	Dinajpur	5	Parbatipur
P	Khulna	6	Chalna and Shiromoni
Q	Barisal	4	
R	Patuakhali	2	
S	Jessore	4	
T	Kushtia	2	
		88	

Table A-2. 1984/85 Sales Targets by District ('000 tons)

District	Urea	TSP	MP	Total
Dacca	65	52	18	135
Kishoreganj	57	38	15	110
Mymensingh	75	57	18	150
Tangail	32	23	10	65
Faridpur	28	20	7	55
Chittagong	64	40	16	120
Chittagong Hill Tracts	8	4	2	14
Noakhali	53	36	9	98
Comilla	90	79	25	194
Sylhet	50	26	9	85
Rajshahi	75	57	22	154
Dinajpur	62	48	20	130
Rangpur	75	65	25	165
Bogra	56	37	11	104
Pabna	48	34	8	90
Khulna	26	14	5	45
Barisal	57	25	8	90
Patuakhali	29	13	4	46
Jessore	50	40	10	100
Kushtia	40	32	8	80
TOTAL	1,040	740	250	2,030

Table A-3. Rainfall Data--Bangladesh

	Chittagong Average 1951-80		Dacca Average 1954-80	
	Total Number of Wet Days	Number of Wet Days of 0.1 Inch or More	Total Number of Wet Days	Number of Wet Days of 0.1 Inch or More
January	0	0	1.3	0.7
February	0.8	0.8	2.3	1.4
March	0.6	0.6	4.1	1.5
April	9.9	8.1	8.4	6.0
May	14.3	12.7	14.0	10.9
June	17.4	14.4	19.5	14.7
July	24.8	19.8	23.6	17.4
August	20.8	15.8	22.6	16.4
September	13.8	8.7	17.3	12.4
October	9.3	7.1	10.4	7.4
November	2.4	2.4	2.1	1.5
December	0	0	0.6	0.4

Source: Bangladesh Meteorology Department, Dacca, Bangladesh

Table A-4. Supply Basis--Reduced Imports During Monsoon (1984/85 Level) (% annual offtake)

	Urea			TSP/DAP + MP					
	Imports, 140,000 tons--14% Production, 900,000 tons--86%			Imports, 870,000 tons--88% Production (TSP), 120,000 tons--12%					
	No Imports During Monsoon (May-August) and Reduction in Domestic Dispatches			Case "A" No Imports During Monsoon (May-August)			Case "B" Reduced Imports During Monsoon		
	Imports	Shipment From Production	Total	Imports	Shipment From Production	Total	Imports	Shipment From Production	Total
January	2	8	10	11	1	12	9	1	10
February	2	8	10	11	1	12	9	1	10
March	1.5	8.5	10	11	1	12	8	1	9
April	1.5	8.5	10	11	1	12	8	1	9
May	0	5	5	0	1	1	5	1	6
June	0	5	5	0	1	1	5	1	6
July	0	5	5	0	1	1	5	1	6
August	0	5	5	0	1	1	5	1	6
September	1.5	8.5	10	11	1	12	8	1	9
October	1.5	8.5	10	11	1	12	8	1	9
November	2.0	8	10	11	1	12	9	1	10
December	2.0	8	10	11	1	12	9	1	10
	14.0	86.0	100	88	12	100	88	12	100

Table A-5. Stock Variation Patterns (1984/85 Level), Urea and (Phosphate Plus Potash) (% annual offtake)

	Urea			TSP/DAP and MP					
	Imports 140,000 tons Production 900,000 tons 1,040,000 tons			Imports 870,000 TSP and MAP Production 120,000 TSP 990,000 tons					
	Assuming (a) No Imports During Monsoon (May-August) and (b) Reduction in Domestic Dispatches During Monsoon			Case "A" No Imports During Monsoon (May-August)			Case "B" Imports at Reduced Level During Monsoon		
	Supply	Offtake	Stock[a]	Supply	Offtake	Stock[a]	Supply	Offtake	Stock[a]
	Opening stock 5.9			Opening stock 6.6			Opening stock 0		
January	10.0	8.0	7.9	12.0	8.5	10.1	10.0	8.5	1.5
February	10.0	9.5	8.4	12.0	8.1	14.0	10.0	8.1	3.4
March	10.0	10.6	7.8	12.0	8.8	17.2	9.0	8.8	3.6
April	10.0	6.3	11.5	12.0	9.2	20.0	9.0	9.2	3.4
May	5.0	8.1	8.4	1.0	6.3	14.7	6.0	6.3	3.1
June	5.0	11.1	2.3	1.0	4.8	10.0	6.0	4.8	4.3
July	5.0	4.6	2.7	1.0	4.9	7.0	6.0	4.9	5.4
August	5.0	5.6	2.1	1.0	8.0	0	6.0	8.0	3.4
September	10.0	12.1	0	12.0	5.3	6.7	9.0	5.3	7.1
October	10.0	9.3	0.7	12.0	11.6	7.1	9.0	11.6	4.5
November	10.0	7.0	3.7	12.0	13.3	5.8	10.0	13.3	1.2
December	10.0	7.8		12.0	11.2		10.0	11.2	
	Closing stock 5.9			Closing stock 6.6			Closing stock 0		
	Average 5.1%			Average 9.9%			Average 3.4%		
	Figure 4(a)			Figure 4(b)			Figure 4(c)		

Table A-6. Stock Variation Patterns--1984/85 Levels, Total Fertilizer
(Weighted average figures based on Table A-5)

	Case A			Case B		
	No Imports During Monsoon (May-August)			No Urea Imports, Reduced TSP/MOP Imports During Monsoon		
	Supply	Offtake	Stock[a]	Supply	Offtake	Stock
January	11.0	8.2	9.0	10.0	8.2	4.8
February	11.0	8.8	11.2	10.0	8.8	6.0
March	11.0	9.7	12.5	9.5	9.7	5.8
April	11.0	7.7	15.8	9.5	7.7	7.6
May	3.0	7.2	11.6	5.5	7.2	5.9
June	3.0	8.0	6.6	5.5	8.0	3.4
July	3.0	4.8	4.8	5.5	4.8	4.1
August	3.0	6.8	1.0	5.5	6.8	2.8
September	11.0	8.8	3.2	9.5	8.8	3.5
October	11.0	10.4	3.8	9.5	10.4	2.6
November	11.0	10.1	4.7	10.0	10.1	2.5
December	11.0	9.5	6.2	10.0	9.5	3.0
			Average 7.5%			Average 4.3%
	Figure 5(a)			Figure 5(b)		

a. Above base level.

APPENDIX B

Bangladesh Least Cost Transportation System

Terms of Reference

1. To review existing systems on transportation and handling of fertilizer in Bangladesh, covering activities throughout the system from source, i.e., point of import or production unit to PDP.
2. To make an assessment of the existing transportation infrastructure and relate potential capabilities and capacities to the future requirements of BADC for supply of fertilizer throughout the country on a timely basis.
3. To assess, in conjunction with resident IFDC consultants, the organization and procedures of BADC relating to control of import, transportation, and handling systems.
4. To advise on the physical distribution system required by BADC for efficient and timely supply of fertilizer, i.e., the least cost system consistent with assured availability of the product, including import systems, transportation by road, rail, and water, and storage facilities.
5. To recommend action on systems and procedures for control and monitoring of fertilizer movements, including phasing of imports, movement planning, control procedures, warehousing, and inventory control.
6. To recommend further action by IFDC to assist BADC in development of the recommended systems.

APPENDIX C

FOREWORD FROM "DRAFT PROCEDURE MANUAL OF INVENTORY CONTROL AND ACCOUNTING SYSTEM OF BADC"

Prepared by M. Ismail/Robert D. Benton
IFDC/Dacca, February 1981

"In accordance with the terms of reference of the BADC contract with IFDC providing technical assistance, this fertilizer stock control and accounting system has been developed.

"Some of the major deficiencies of BADC's current stock control and accounting system are:

1. All reporting of sales, stock positions, quantities dispatched, etc., are reported for information only and are only relatively accurate (sales quantities reported are more accurate). The quantities reported are not linked up with previous balances, year to date quantities, and closing balances so cannot be verified and must always be accepted at face value.
2. There is no assurance that fertilizer dispatched from one location is ever received and included in the stock of the receiving location. Dispatches and receipts cannot be linked up.
3. There is absolutely no control or accounting of fertilizer in transit between locations. The quantity of stock in transit at any time, even at the time of the annual physical verification, is never known, but only estimated.
4. Field locations are not reporting in standard format, much reporting is on an irregular basis, and there is much duplication of reporting.
5. Stock losses and recovery for these losses from responsible parties are not reported in any form.
6. No attempt is made to reconcile sales with receipts and bank deposits at the national level.
7. The national annual physical verification program is a huge undertaking that requires the audit teams to fully audit the stock records for the previous year, collect data from those records, and physically assess the quantity of fertilizer stock. Due to shortage of time, the audit is half-heartedly done. The physical verification data reported cannot be verified or linked up with district or national totals, so must be accepted as submitted.

8. Storekeepers and others spend a tremendous amount of time copying data into and from bound registers.
9. All fertilizer is purchased in metric tons, converted to maunds, seers, and chattaks for internal accounting, and then converted to long tons for reporting. After all this converting, the farmer still buys 25-kg and 50-kg bags. There is an immeasurable waste of time and sacrifice of accuracy in all of this conversion process.

"The stock control and accounting system developed here will correct and satisfy all of the above deficiencies by:

1. Requiring that all data will be maintained in standard accountable form and reported in such a manner that it can be verified, must tie in with year-to-date quantities, and can be linked up with other reports.
2. Providing a system of linking up dispatches and receipts to verify all deliveries and maintain a control of stock in transit.
3. Replacing the old "invoice" system whereby the official transfer of fertilizer from location to location took place much later than the physical transfer making audit very difficult and grossly distorting stock position levels reported.
4. Combining the many, many reports currently made into a few standard forms that provide not only more accurate information but also stock accounting.
5. Reporting stock losses and recovery from responsible parties regularly.
6. Providing sufficient data on sales quantities and amounts permitting the accounts section to regularly audit and reconcile sales revenue and bank deposits.
7. Simplifying the physical verification procedure to such an extent that it can be conducted in hours instead of the days it now takes. It will no longer be necessary to close the godown during physical verification.
8. Providing all registers in multicopy bound forms for permitting storekeepers and others to send actual carbon copies of their registers instead of copying data for reporting purposes.
9. Providing for all stock accounting and reporting to be in the metric system (kilogram), a single unit of measure rather than maintaining records and preparing reports in five different units of measure as now is done.

"It is envisaged that, with full implementation of this system, full accountability for fertilizer will be maintained at all levels and information reporting will be more reliable, accurate, complete, and timely. No data or

information is being required in this system that is not currently being collected in irregular and nonstandard form with much duplication, so it is anticipated that the total workload will be reduced and can be handled with the current staff if properly trained."