THE UNITED REPUBLIC OF TANZANIA

PRE-FEASIBILITY STUDY REPORT

ON

NATURAL SODA DEVELOPMENT IN LAKE NATRON AND RELATED TRANSPORTATION FACILITIES

PART I

August 1976

JAPAN INTERNATIONAL COOPERATION AGENCY

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PART I

OVERALL EVALUATION

ON

NATURAL SODA DEVELOPMENT

AND

RELATED TRANSPORTATION FACILITIES

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CURRENCY EQUIVALENTS

1 Tanzanian Shilling	=	US$ 0.12	=	Yen 36.7
1 U.S. Dollar	=	Shs 8.16	=	Yen 300

ABBREVIATIONS AND ACRONYMS

MWEM	–	Ministry of Water, Energy and Minerals
Stamico	–	State Mining Corporation
T/Y	–	Metric ton per year
DWT	–	Dead weight ton

COMPOSITION OF THE REPORT

PART I OVERALL EVALUATION ON NATURAL SODA DEVELOPMENT AND RELATED TRANSPORTATION FACILITIES

PART II REPORT ON NATURAL SODA DEVELOPMENT

PART III REPORT ON RELATED TRANSPORTATION FACILITIES

PREFACE

The Government of Japan, at the request of the Government of the United Republic of Tanzania, decided to undertake a study on Natural Soda Development in Lake Natron and Related Transportation Facilities in Tanzania, and Japan International Cooperation Agency carried out the study.

The Agency organized a study team consisting of twenty-two experts headed by Mr. Jiro Kano, Managing Director of the International Development Center of Japan, and sent it to Tanzania on November 6, 1975.

During the study work there for forty-four days, the team visited Ministry of Water, Energy and Minerals, Ministry of Industry, Ministry of Communications, other governmental organizations concerned and the East African Community, and discussed with their officials over the project mentioned above. At the same time, the team performed field surveys in Lake Natron and other places concerned with the full cooperation of the Government of Tanzania.

Hereby presented is a report based upon the findings the team has attained in Tanzania as well as at home, and upon the discussion with Tanzanian officials.

Nothing would be more gratifying to us than if this report could be of any help in shaping the policies for the industrial development in Tanzania and could contribute to the promotion of friendship between the two nations.

Finally, I would like to take this opportunity to express my hearty gratitude to the Government of the United Republic of Tanzania and other authorities concerned for their kind cooperation and assistance extended to the team, without which the study work could not have been carried out so successfully.

August, 1976

Shinsaku Hogen
President
Japan International Cooperation Agency
Japan

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CHAPTER 1 OUTLINE OF THE PROJECT AND ITS SOCIO-ECONOMIC SIGNIFICANCE

1-1 Background

As suggested by its name, the existence of natural soda in Lake Natron has been known for many years. Particularly, since the development of Magadi ash seventy years ago in the Lake Magadi in Kenya, north to the Lake Natron, much attention has been forcussed upon the potential development of Natron soda.

Stimulated by a gradual increase in use of natural soda instead of synthetic soda ash, Japanese private firms organized two survey teams to Lake Natron in 1973. These teams were cordially accepted and helped by the Government of Tanzania. The reports of the teams, submitted in 1974, were duly noted by the Government and aroused wide international interest.

During the two years since submission of the reports, there occurred tremendous change in the international economic environment, incluidng wild price rises and business stagnation. From the necessity to revise cost estimates, and to conduct more comprehensive transport studies and other related investigations, the Government of Tanzania requested the Government of Japan to undertake a more independent, comprehensive study for which purpose Japan dispatched this mission.

1-2 Outline of the Project

The natural soda floating in Lake Natron is sufficient in quantity to develop, and amounts to about 136 million tons converted to $NaCO_3$.

On the basis of comparison of several alternative locations, it is advised that the purification plant be built on the east shore of the Lake for many reasons such as minimizing transportation volume and pollution.

It is expected that most of the purified natural soda will be exported from the Port of Tanga via a newly constructed road and existing railways. The soda must be most carefully carried and stored the entire distance from Lake Natron to Tanga, or about 580 km, because of its character of being easily destroyed or becoming congealed.

The most crucial point of this project is the minimization of purification storage and transportation costs so that the product can be competitive in the world market. Therefore, the scale merit of annual production, more than about one million tons, is a necessary condition to realize this project.

The total amount of initial investment for this project will be about US$320 million or 2,600 million shs. according to one of the alternative plans for the plant and transport facilities, for the scale of annual production of one million tons as follows.

Table 1-1 Total Investment

(Unit: Million)

		US$	shs
(1)	Purification Plant	208.2	1,699
(2)	Tanga Port	38.6	315
(3)	Railway, Improvement	13.4	315
(4)	Railway, New Construction	—	—
(5)	Locomotives and Wagons	24.0	196
	Sub-total (3)-(5)	37.4	305
(6)	Road, Plant-Arusha	24.9	203
(7)	30-ton Semi-Trailer	3.9	32
(8)	Storage Silo, Arusha	5.0	41
(9)	Workshop and Parking Lot	0.6	5
	Sub-total (6)-(9)	34.4	281
	Total (1)-(9)	318.6	2,600

1-3 Socio-Economic Significance

The greatest merit of this project is its ability to earn a great amount of foreign exchange. At the price of US$80 per ton FOB Tanga Port, export of one million tons of purified natural soda will earn, annually, US$80 million.

Of this amount, the equivalent of 83% must be spent to purchase plant equipment, fuel oil, and other necessities, in foreign currency, as estimated in terms of present value computed at 10% interest rate. The remaining 17% is the net foreign exchange earning expressed in terms of annual amount, which is US$13.6 million annually for 30 years, still a considerable amount.

Secondly, it will contribute to the improvement of the structure of foreign trade. Tanzanian exports have been mostly obtained from agricultural projects. These can not be expected to expand at a high rate in the future due to the constraint of supply conditions. On the contrary, natural soda demand will not be subject to supply constraint but rather by the world demand, for use in building construction and durable good industries such as the automobile industry, particularly in industrial countries. Therefore a high rate of growth of demand may be expected and exporting soda to meet this demand will contribute to diversifying and stabilizing the export structure of the ocuntry.

Thirdly, it will contribute to the regional economy, to some extent. Because of comparatively low labor requirements and unfavorable natural conditions in the surrounding areas, the stimulatory effect of the project may be fairly limited at least in the near future. But in the long run this sort of chemical plant will be surely stimulate the Arusha-Moshi-Tanga region.

Also, it will generate some stimulus for the transfer and dissemination of technology in this country.

CHAPTER 2 SCOPE OF WORK

2-1 Objectives

In view of the foregoing circumstances, the objectives of this study are defined as follows:

a) To examine the quality, quantity and distribution of the natural soda deposit in the Lake Natron area and mining and processing thereof, and all other matters directly related thereto with the degree of accuracy and comprehensiveness appropriate for a pre-feasibility study.

b) To identify and evaluate various transportation alternatives which are conceivable for efficient transportation of the products from the Lake Natron site to a port for overseas shipment with the degree of accuracy and comprehensiveness appropriate for a pre-feasibility study.

c) To conduct a coordinated economic and financial evaluation of the whole project, which would furnish a useful basis for a future feasibility study.

d) Develop the terms of reference for a future feasibility study

e) Prepare conclusions and recommendations on feasibility of this project, including other related matters.

2-2 Study Period

November 1975 to August 1976

2-3 Extent of the Study Area

The Lake Natron area and approximately 580 km between Lake Natron and Port of Tanga.

2-4 Study Items

2-4-1 Comprehensive economic study

a) Related national and regional economic studies

b) Review of related development plans

c) Estimation of demand and supply of soda ash

d) Study of transport demand

2-4-2 Study on soda ash processing

a) Natural soda resources

b) Purification plant

2-4-3 Study on transport facilities and cost estimates

a) Port

b) Railway

c) Road

d) Others

2-4-4 Evaluation of the project

a) Evaluation of respective facilities

b) Comprehensive evaluation

2-4-5 Suggestions for further study

2-5 Schedule

a) Field survey; November and December 1975 (about 5 weeks)

b) Submission of the interim report; December 1975, at the end of field survey

c) Report preparation and office and laboratory work; January 1976 to March 1976

d) Submission of the draft final report; April 1976

e) Submission of comments on the draft final report by the Government of Tanzania: June 1976

f) Submission of the final report; August 1976

2-6 Mission Members

Mr. Jiro KANO	General Team Leader International Development Center of Japan

(Infrastructure Team)

Mr. Fumio TAKEDA	Team Leader, Transportation Economist Japan Highway Public Corporation
Mr. Yoshizo CHIZAKI	Railway Engineer Japan National Railways
Mr. Norio MIZUGUCHI	Railway Engineer Japan National Railways
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Mr. Kenji MAEDA	Railway Engineer Japan Transportation Consultants, Inc.
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Mr. Seishiro ISOBE	Utilities Planning Central Glass Co., Ltd.
Mr. Kenichi ASAKURA	Geology Tokuyama Soda Co., Ltd.
Mr. Masamitsu MOROFUJI	Plant Engineering Toyo Soda Manufacturing Co., Ltd.
Mr. Takeo NAMBA	Regional Economic Review Japan International Cooperation Agency
Mr. Hiromi KOJIMA	Coordination Japan International Cooperation Agency
Mr. Nozomu MIYABE	Planning & Liaison Toyo Menka Kaisha, Ltd.

CHAPTER 3 THE ENVIRONMENT OF THE TANZANIAN ECONOMY

3-1 Outline

After the oil crisis, the world economy has been depressed, being subject to the serious conditions of chronic inflation, increases in unemployment, and the worsening balances of payments, particularly in major economic powers.

Under these circumstances, most developing countries suffer from hyper-inflation and decreases in the values of primary commodities for export. Tanzania is not an exception, and can be counted as one of the hardest hit by this critical world economic situation.

The GDP of Tanzania in 1974 was approximately $1700 million, of which 27% is subsistence production; the rest is the production of the monetary economy. With its GDP per capita of $114, it is one of the twenty-five least developed countries, as officially designated by the UN.

In the Second Five-Year Plan (1969-1974), the Government aimed at a 6.5% annual growth rate of the GDP during that period, but it attained 4.4% in real terms, and in particular the annual growth of 1974 was only 2.2%.

Table 3-1 GDP at factor cost

(Unit: shs million)

	1966	1967	1968	1969	1970	1971	1972	1973	1974
1. GDP at current prices	6,514	6,735	7,182	7,460	8,215	8,845	10,130	11,558	13,749
2. GDP at 1966 prices (fixed at 1966)	6,514	6,777	7,128	7,259	7,680	8,005	8,481	8,814	9,006

Source: Ministry of Finance and Planning, 1975

3-2 Economic Structure

The core of the Tanzanian economy is agriculture. The agricultural sector, though its share has been slightly decreasing versus that of the manufacturing sector, constituted 40% of the GDP in 1974 ($678 million), compared to the small share of 11% for the manufacturing sector ($182 million).

In exports too agricultural goods occupy the majority. Among them coffee, sisal and cotton constitute 46% of total exports in 1974, earning $164 million in foreign exchange.

Table 3-2 GDP at factor cost by industrial origin (at current price)

(Unit: shs million)

	1969	1970	1971	1972	1973	1974
Agricultural Sector	3,081	3,381	3,492	4,018	4,574	5,534
	(41.3)	(41.1)	(39.5)	(39.7)	(39.3)	(40.2)
Manufacturing Sector	742	828	937	1,159	1,331	1,487
	(9.9)	(10.1)	(10.6)	(11.4)	(11.5)	(10.8)

Figures in parentheses are contribution to the GDP (percentage)

Source: Ministry of Finance and Planning, Nov., 1975

Regarding the manufacturing sector, the Government has pursued the transformation of its economic structure, giving incentive to the rise of industries mainly for meeting domestic demand. As a result of the rapid growth of this sector, the sector's contribution to the GDP is increasing, in contrast to that of the agricultural sector. But, on the other hand, this sector faces many serious problems, which were the causes of stagnation in 1974. Those problems were low utilization of capacity due to interruptions in the supply of utilities such as water and power, shortages of spare parts, lack of skilled manpower, and price controls.

Table 3-3 Indexes of manufacturing sector

(Unit: shs million at current prices)

	1966	1968	1969	1970	1971
Value of gross output	1,289.3	1,269.0	1,522.6	1,744.4	2,012.9
Value added	295.2	378.3	475.4	560.6	642.8
Gross Investment in manufacturing sector	192.2	76.1	100.1	108.5	157.2

Source: Survey of Industrial Production, 1966, 1968, 1969, 1970, 1971.

3-3 Balance of Payments

Against this economic background, the oil crisis, coupled with the two-year drought of 1973-74, upset the Tanzanian economy. Its overall balance of payments, which was in surplus in 1972 and 1973, turned into a deficit of $157.8 million in 1974.

In contrast both with a rise in the volume of imports (mainly food imports necessitated by the drought) and with the inflation of world market prices for manufactured goods, exports have stagnated, mainly due to the decrease in production and the fall in the relative values of exports, as their terms of trade deteriorated.

Table 3-4 Terms of trade index

(1973 average = 100)

	1972	1973	1974
Terms of trade index (Tanzania)	100.2	100.0	91.4
Africa (excluding South Africa)	97.0	100.0	103.0

Source: International Development Association; UN, *Monthly Bulletin of Statistics*, Nov., 1975

Accordingly, the ability to import manufactured goods is reduced, because of Tanzania's dependence on exports of primary products for its foreign exchange earnings. The trade balance deficit deteriorated from $120 million in 1973 to $308 million in 1974. Imports in 1974 amounted to $658 million, which corresponds to 39.1% of the GDP in 1974. Consequently, the foreign exchange reserves as of March 31, 1975 were only $59.2 million, sufficient for less than one month of imports.

Table 3-5 Balance of Payments

(Unit: US$ million)

	1969	1970	1971	1972	1973	1974
Goods, Services & Transfers	25.2	- 35.6	- 100.1	- 65.7	- 111.8	- 311.3
Long-term Capital	20.7	71.6	138.1	108.7	155.5	113.0
Short-term Capital	- 14.9	- 7.8	- 23.7	- 15.2	- 0.1	- 12.0
Errors and Omissions	- 29.6	- 48.8	- 13.7	10.5	9.1	45.1
Total	1.4	- 20.6	- 13.5	45.2	34.7	- 157.8

Source: *International Financial Statistics*, March 1976

In order to overcome this huge trade gap, Tanzania has cut imports to bare necessities, such as restricting the import of luxury cars and usage of petroleum, and, also, has resorted to extensive foreign borrowing. Taking together Tanzanian use of the special financing facility of 1974, which includes drawing IMF tranches, the Oil facility, and other multilateral and bilateral credit facilities for balance of payments support, the amount comes to $47 million.

In connection with the price rise of imports, oil and other intermediate goods, manufactured products as well as consumer goods, Tanzania suffers a high degree of inflation. In 1974, consumer prices increased 30% over the 1973 level and consumer prices for the first quarter of 1975 increased 76% against the first quarter of 1974.

One of the present crucial questions is the improvement and development of agriculture to enable it to satisfy domestic consumption demand and also produce internationally competitive goods both in quality and quantity, but this can not be achieved in the short run.

In view of the economic structure and the potential of industrial development, together with the above agricultural situation, the balance of international payments situation is not expected to improve in the short term.

3-4 Central Government Finance and Development Expenditure

Under these economic circumstances, the Government has sought to increase agricultural and industrial production through making vast expenditures for development, which have increased the annual financial deficits of the Government, resulting in the deficit of $169 million in 1974.

Table 3-6 Development expenditure

(Unit: shs million)

	1969/1970	1970/1971	1971/1972	1972/1973	1973/1974*
Development expenditure	611	829	739	750	1,480
Own funds	489	559	388	398	612
External sources	122	270	351	352	868

Source: The Economic Survey, 1973-74, 1975
Note: Asterisk indicates approved estimates

Given this growing deficit, the Government has had to finance development expenditure by use of external sources. The Government has financed 41% of the development expenditure from recurrent revenues and local borrowings, and the remaining 59% from external loans and grants.

3-5 Comments

The economic structure of Tanzanian has many built-in constraining factors.

Firstly, there is a problem of a shortage of technical and managerial skills.

Secondly, endowments of natural resources are scarce and moreover are geographically scattered, for example, phosphate is at Minjingu, coal is at Mbeya, hydraulic power is generated at Kidatu and soda ash is present at Lake Natron. Under these conditions, domestic raw materials and foreign exchange earnings obtainable by exporting these can not be expected to be high and project development is often bindered because of the widely scattered sources of raw materials and energy.

Thirdly, as the basic step to the industrialization, much more development of agriculture is needed in respect to productivity, quality and quantity of output, and in variety of products, so that industries processing agricultural products may in turn develop.

Fourthly, in addition to the shortage of social overhead capital stock, the weak interrelationships among industries and the lack of regional development, tends to cancel the multiplier effects of investment. At the same time, the unit cost of a project is increased due to the necessity of investing vast sums for infrastructure.

Finally, under the lack of self-sufficiency for food, shortage of foreign, reserves makes it difficult to import sufficient capital goods and intermediate commodities, which often leads to under-utilization of productive capacity.

All these problems, intermingled together, tend to make a vicious circle in the economy of Tanzania. However, under the gradual formation of centrally planned economy since the Arusha Declaration of 1967, the Government has been striving to increase agricultural and industrial production both for domestic requirements and for exports through new investment and better utilization of existing capacity.

To put this policy in effect, the Government has taken various measures, including manpower development such as through on-the-job-training, establishment of financial and industrial institutions such as National Bank of Commerce, National Insurance Corporation, Tanzania Rural Development Bank, Tanzania Investment Bank, Small Industries Development Organization and so forth.

The present economic difficulties will persist for a considerable time, but will be eventually overcome by the Government's efforts at attaining economic independence through gradual import substitution policy and, to a lesser degree, export expansion policy. In this connection the role of the project herein considered may be defined as a means to help the Tanzanian economy to earn foreign exchange with which to promote its import substitution policy.

3-6 Comments on the Regions Related to the Soda Ash Project

The main regions related to the project of soda-ash development are the Arusha, Kilimanjaro and Tanga regions. These regions are comparatively well developed in Tanzania. In respect of regional distribution of the GDP, the contribution to the GDP in 1967 is estimated to have been 22%.

Table 3-7 Regional Distribution of GDP (1967)

(%)

Industry	Arusha	Kilimanjaro	Tanga	Total
Agriculture	6.6	9.3	9.5	25.4
Manufacturing	6.0	4.5	8.5	19.0
Total	5.6	7.6	9.0	22.2

Source: Second Five-Year Plan, Vol. III, 1970

Endowed with comparatively good meteorological and geological conditions, the agricultural productivity of these regions is high. The problem of these regions as related to the project is that the vast area lying to the west of Arusha city up to Lake Natron is very dry savanna with little and scattered population ond practically no social infrastructure, which makes this area unfavorable for most types of development.

CHAPTER 4 SELECTED ALTERNATIVE PLANS

4-1 Selection of Alternative Plans

For planning the development of soda ash in Lake Natron, and related transportation facilities, many alternative plans are conceivable. However, the following basic conditions have to be taken into account:

(1) Almost all the soda ash to be developed will be exported to the world market at a price acceptable to the potential consumers.

(2) The quality of soda ash must be high enough to satisfy the requirement of consumers

(3) Due to the world market conditions and production costs of soda ash, the production scale of this project will inevitably have an upper limit of around one million tons per annum.

According to the above basic conditons, the following alternatives were considered to be worth technical examination:

(1) Processing Plant

- Production scale	3 cases	(250,000 tons/annum) (500,000 tons/annum) (1,000,000 tons/annum)
- Plant site	3 places	

(2) Transportation

- Port facility sites	6 places
- New railway route	2 routes
- Road route	4 routes
- Other transportation means	2 methods

The following are the results of the technical studies:

(1) Evaluation of the soda ash resource confirmed that the soda deposit in Lake Natron is enough to support a large scale soda ash production, well over one million tons per annum.

(2) The location of the refinery plant was selected at the east coast of Lake Natron in order to eliminate problems such as pollution, transportation costs, etc.

(3) Tanga port was assigned top priority for soda ash exporting port.

(4) From the technical point of view, new construction of a road and railway between Lake Natron and Arusha was considered feasible.

To determine the best transportation means, various transportation alternatives in the form of different combinations of transportation modes were identified and their technical feasibility was evaluated, namely the nature and degree of technical difficulties to be encountered and the uncertainties to be involved were assessed. Also the costs involved in such transportation alternatives, whether costs for construction and improvement of facilities or their operations, were estimated. In developing such alternatives, care was taken to assume that there would be utilization of existing facilities to a full extent, but at the same time, the construction of new facilities, such as rail, road, wharf and pipeline were also considered as necessary and various practical combinations of these transportation modes were sought.

Furthermore, simple cost-effectiveness and cost-benefit analysis were applied to such limited problems as route selection for the new facilities and choice of optimum combination of maximum gradient of railway, type of locomotives and train length so that the transportation alternatives to be presented for final economic evaluation could be limited to a manageable number.

These technical evaluations, both development of natural soda ash resources and related transportation problem, are reported in Parts II and III respectively.

4-2 Features of Selected Alternative Plans

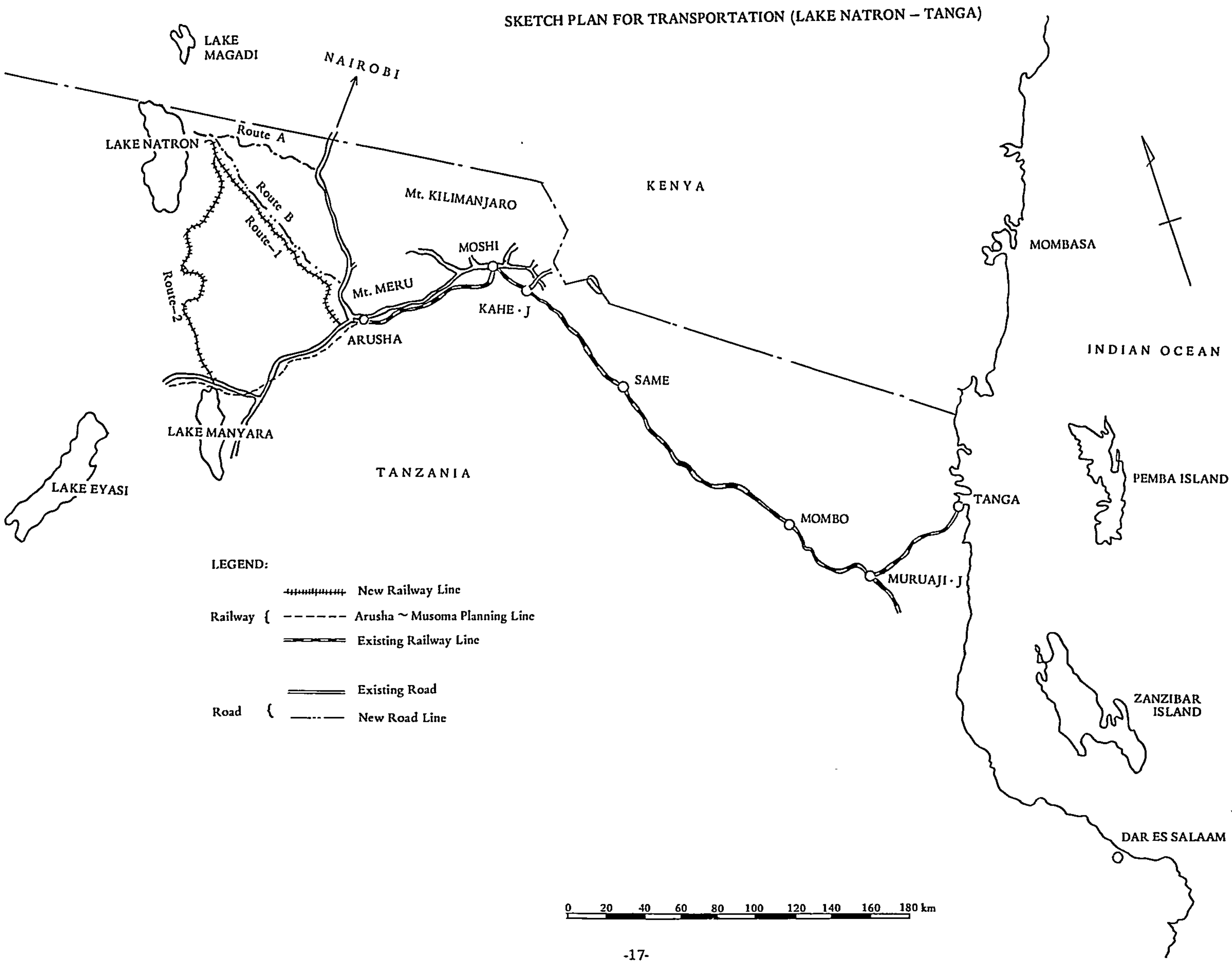
Among the many possible alternative plans, the following five plans were selected for further study of financial and economic analysis.

(1) Case RR 250
(2) Case R 500
(3) Case RR 500
(4) Case R 1000
(5) Case RR 1000

The general features of these plans are tabulated in Table 4-1.

Table 4-1 Outlined Features of Finally Selected Alternatives

Particulars	Case RR 250	Case R 500	Case RR 500	Case R 1000	Case RR 1000
A. Plant					
(1) Production Scale (tons/year)	250,000	500,000	500,000	1,000,000	1,000,000
(2) Plant Location	Lake Natron	Lake Natron	Lake Natron	Lake Natron	Lake Natron
(3) Plant Construction Cost (US$)	107.6 million	137.9 million	137.9 million	208.2 million	208.2 million
(4) Annual Production Cost (US$)	26.9 million	37.9 million	37.9 million	61.5 million	61.5 million
(5) Operating Staff (Nos.)	216	264	264	358	358
B. Transportation					
(1) Port					
(i) Location	Tanga: Inner Habour	Tanga: Inner Habour	Tanga: Inner Habour	Tanga: Outer Jetty	Tanga: Outer Jetty
(ii) Wharf Length and Water Depth	185m, -10.0m	185m, -10.0m	185m, -10.0m	240m, -12.0m	240m, -12.0m
(iii) Capacity of Storage Silos	70,000m^3	70,000m^3	70,000m^3	100,000m^3	100,000m^3
(iv) Construction Cost	31.7 million	31.7 million	31.7 million	38.6 million	38.6 million
(2) Railway					
(i) Section	Tanga - Arusha 439 km	Tanga - L. Natron 589 km	Tanga - Arusha 439 km	Tanga - L. Natron 589 km	Tanga - Arusha 439 km
(ii) Number of Locomotive and Wagons	5 Nos., 65 Nos.	8 Nos., 132 Nos.	6 Nos., 110 Nos.	15 Nos., 263 Nos.	12 Nos., 219 Nos.
(iii) Construction and/or Improvement Costs of Track, etc. (US$)	18.6 million	153.7 million	24.1 million	168.9 million	37.4 million
(3) Road					
(i) Section	Arusha - L. Natron 178.6 km		Arusha - L. Natron 154.3 km		Arusha - L. Natron 154.3 km
(ii) Size and Number of Vehicles	16.5 ton, 31 Nos.		16.5 ton, 61 Nos.		30 ton, 68 Nos.
(iii) Construction and/or Improvement Costs of Road (US$)	23.4 million		26.7 million		34.4 million


SKETCH PLAN FOR TRANSPORTATION (LAKE NATRON – TANGA)
LAKE MAGADI
NAIROBI
LAKE NATRON
Route A
Route B
Route-1
Route-2
Mt. KILIMANJARO
KENYA
MOSHI
Mt. MERU
KAHE · J
ARUSHA
MOMBASA
INDIAN OCEAN
SAME
LAKE MANYARA
LAKE EYASI
TANZANIA
PEMBA ISLAND
TANGA
MOMBO
MURUAJI · J
LEGEND:
New Railway Line
Railway
Arusha ~ Musoma Planning Line
Existing Railway Line
Existing Road
Road
New Road Line
ZANZIBAR ISLAND
DAR ES SALAAM
0 20 40 60 80 100 120 140 160 180 km

CHAPTER 5 FINANCIAL AND ECONOMIC EVALUATION

5-1 Methodology

5-1-1 Objective

The general purpose of the evaluation is, in brief, to sum up the costs of the soda ash processing (as estimated in Part II) and the costs of the transportation of the products up to the point of loading aboard ship at the export port (as estimated in Part III), compare them with the export FOB price of the product at the port (Part II) and thereby examine the financial and economic viability of the project. As for the costs of the processing, financial and economic ex-plant costs are those estimated in Part II for the three production levels of 250,000, 500,000 and one million tons with their respective optimum plant size, mining method and processing method. As for transportation costs, financial and economic costs as estimated in Part III for the same three production levels, with respective optimum methods of transportation, are adopted. These costs are the incremental costs which are necessary for the implementation of the project and would not be incurred without the project. They include costs for mining, plant construction and operation, and the construction, improvement and operation of road, railway, port and transshipment facilities. The benefits of the project, on the other hand, are basically the proceeds of the overseas sales of the soda ash products.

5-1-2 Estimation of time-streams of benefits and costs and benefit cost analysis

As to the benefit estimation, the amounts of annual earnings through sales of the products for 30 years after the opening of plant operation are capitalized at the first year of the plant operation, which means that they are respectively discounted and summed up at the first year of plant operation. With respect to the costs, the costs incurred prior to the opening of the plant operation such as those for construction and improvement of the plant and transportation facilities, and the costs which are incurred for the 30 years period after its opening such as those for the operation of the plant and transportation facilities are all properly increased or discounted to obtain their present values at the first year of the plant operation.

More precisely, all the present values are computed at the middle of the first year of operation in order to avoid the trouble of having to discount the amount for half a year. With this, the benefits and costs of the first year need not be discounted and those of the second year are discounted for one year period only. Similarly, to the costs of the one year prior to the operation (-1 year), one year interest is added. The interest rates used for obtaining the present values of the benefits and costs are as shown below:

Financial evaluation	8.5% 10% 12%
Economic evaluation	10% 12% 15%

Using the present values of benefits and costs thus obtained, (i) benefit-costs difference

(Net benefit) test, (ii) benefit-cost ratio test, and (iii) comparison of unit price of the product with its unit cost, are performed. In order to obtain the unit cost of the product as mentioned above, the present value of the total costs of the product is annualized for the 30 year period with the above interest rates and the amount thus obtained is divided by the applicable annual tonnage of the production.

Further, the internal rate of return (IRR) is calculated which equalizes the present values of benefits and costs at the first year of the operation.

5-1-3 Financial and economic evaluation

The financial evaluation and the economic evaluation both use the same method, as mentioned in 5-1-2 above, but they use different price assumptions in computation of costs and benefits. In financial evaluation, prices of goods and services which are to be actually paid for are used in estimating the benefits and costs. This evaluation attempts, in this manner, to examine whether or not the project insures that all the participating agencies and individuals can get enough return to cover the expenditures incurred for the project. It also examines whether or not the project is finaicially viable by inquiring whether the total revenue of the project will equal or exceed total costs. In the present prefeasibility study, no attempt is made to conduct financial analyses of the participating organizations and individuals as no concrete ideas can be formed as yet about the nature, type and number of participating agencies at this stage, and only the total finaicial viability of the project is examined. Financial evaluation is performed in terms of Tanzanian shillings.

In the economic evaluation, shadow prices or opportunity costs are used in estimating the amounts of some of the benefit and cost items instead of their actual prices so that the true value of such items to the national economy can be reflected in the evaluation. Further, the tax component in the prices of commodities are subtracted from the prices as taxes are mere transfer payments which do not represent any consumption of true resources. Economic analysis examines, in this manner, whether the project will really bring about net saving or increase in national resources, or rather will just result in draining them.

The following shadow factors are used in this study based upon the Tanzanian Government's instruction for use in this analysis:

Foreign exchange	1.3
Construction	1.1
Cement	1.16
Fuel oil	1.3
Electricity	1.19
Railway transport	1.2
Road transport (commercial vehicle)	1.2
Labor, unskilled	0.75
expatriate	0.7
Output (export)	FOB x 1.3

It is noted that the economic evaluation is conducted in terms of U.S. dollars and this makes it necessary for us to estimate the values of imported goods and services and those of the exported products in terms of dollars, estimate those of other cost items in Tanzanian shillings and then convert them into dollars (by dividing them by 8.16 x 1.3). For those items in the above list, other than the export and import items (foreign exchange items), the values are first estimated in Tanzanian shillings with appropriate shadow factors and then they are converted into dollars by being divided by 8.16 x 1.3. It is also noted that, in estimating the construction costs of the plant and transportation facilities and the transportation cost of the product, the above shadow factors of 1.1 (construction), 1.2 (railway transportation) and 1.2 (road transportation, commercial vehicle) are not directly applied. Instead, their costs are broken down into imported items, domestic items, cement, skilled and unskilled (expatriate) labor, and so on to which appropriate shadow factors are applied, and then the results are summed up to make their economic costs.

5-1-4 Internal foreign exchange rate test (Bruno test)

It is generally accepted that the internal foreign exchange rate test (often called the Bruno test) is useful in evaluating the merits of a project like this one where the major purpose is to earn net foreign exchange. The purpose of the test is to see how much domestic resources in terms of local currency must be expended to earn a unit of net foreign exchange under the project and see if this rate is within the limit of the shadow price of the foreign exchange. If the expenditure of domestic resources in terms of Tanzanian shillings necessary to earn one net U.S. dollar does not exceed 10.61 shs (= 8.16 shs x 1.3) which is the shadow price of one U.S. dollar, this project can be considered to be good as a foreign exchange earning project.

To express the above in the form of equation,

$$\frac{PVLC}{PVFR - PVFC} \leq fs = 10.61 \text{ shs}$$

where PVLC = Present value of local costs (expenditure of local resources) .... Tanzanian shillings

PVFR = Present value of foreign exchange revenue .... U.S. dollars

PVFC = Present value of foreign costs (imported goods and services) .... U.S. dollars

fs = shadow price of one U.S. dollar

Interest rates to compute present value are 10% and 12%.

If the above equation is satisfied, it means that the project is a good one in that it earns foreign exchange with an expenditure of local currencies at the rate equal to or below the shadow rate of the foreign exchange. It may be further noted that, in case the above equation is not satisfied, the result would still be useful because it shows how much more the shadow price of foreign exchange need be raised in order for the project to become feasible. For example, if the result is 1.5, one can tell that the project would be feasible if the shadow rate of 1.5 were adopted. In a sense, this amounts, therefore, to the sensitivity analysis of the shadow rating of the foreign exchange.

5-1-5 Effects of inflation

While the forecast of future inflation and its impact on this project is difficult to make, we can not leave it completely out of consideration. The analysis of the effects of inflation is sometimes left out on the ground that the uniform increase in all the prices will affect costs and benefits equally and does not change the project feasibility. In this project that does not apply because the difference in timing of the occurrence of benefits and costs, the former occurring mostly in later stages and the latter mostly in earlier stages, will make the impact of continuing uniform price increase on the project rather favorable.

Needless to say, also, the difference in the rates of increase of the product and the costs will affect the project greatly. If the price of products rises faster than costs, that will affect the project favorably and vice versa. (It is more likely that the price of the product will rise a little more slowly than the prices of the cost items).

As it is so difficult to forecast the degree of continuing inflation in the long range, we must satisfy ourselves by just taking some hypothetical rates of increase and see how they will affect the project, in what degree and in which direction. This will help us understand the nature of the effect of inflation.

5-1-6 Other sensitivity analyses

In addition to the kind of sensitivity analyses performed in the two foregoing subsections, sensitivity analyses of the changes in cost and benefit estimation are conducted to see how they will affect the project evaluation.

In the first place, the effect of change in the price of the product is easy to determine. One can merely change the unit FOB price of the product and compare it with the unit costs of the product under various conditions. The effect of the change in various cost items is more difficult to ascertain without some amount of study. In this study the cost of the plant and the rate of operation of the plant are chosen as two major items for sensitivity analyses. The operating rate of the plant has so far been assumed to be 100%, and if the rate is lowereed the ex-plant cost of the product will rise. The degree of such rise and its effect on the project feasibility are studied in this chapter.

Note: The term 100% operating rate herein used means that the plant of, say, one million tons is operated in such a way as to produce one million tons. Three hundred days of effective operation a year are assumed to produce one million tons in this study.

5-1-7 Required funds and their repayment

In financial and economic evaluation, not only the viability of the project but also the timing and amounts of funds to be required and the feasibility of their repayment have to be analyzed. This is done by computing the annual balance of the revenue and expenditures from the inception of the project through the 30th year of plant operation. If the balance is a negative figure, that much of new funds must be procured and, if it is positive, that much of funds can be repaid.

5-2 Results of Benefit-Cost Analysis

The results of the financial and economic benefit-cost analyses are shown in Tables 5-1 and 5-2. As for the result of financial analysis, Case RR 1,000 (case of one million tons, combined road and rail transportation) with 8.5% interest is the only one which narrowly passes the various tests of benefit-cost analysis. The present value of net benefit (benefit cost difference) at the opening year of plant operation is 215 million shs, its benefit/cost ratio is 1.03, and the revenue and cost per ton of the product are $80 and $77.7 respectively, giving a surplus of $2.3.

If 10% interest is applied to Case RR 1,000 net benefit becomes -265 million shs, the benefit/cost ratio becomes 0.96 and cost per ton becomes $83.1 (inclusive of ex-plant cost of $59.5), indicating that the case is just a little below the passable line. A passing ntoe may be in order here that the ex-plant cost as computed by the cash flow analysis herein used should be roughly equal to the result of conventional industrial cost estimation. The $59.5 which is the result of the cash flow analysis is found to be compatible with the result of the industrial cost estimation as performed in Part II which is $61.5.

The internal rate of return (IRR) of the project is 9.17%, which means that the project can be self-sustaining with provision of funds at an interest rate not higher than 9.17%. While it is true that the going interest rates in most developing countries where there is an acute capital shortage are higher than 9.17, it would not be too difficult to obtain funds with average interest rates below that . . . say 8.5% . . . with various kinds of foreign aid. One might feel that the foregoing surplus, $2.3 per ton, is too small an incentive to prospective investors; he must be cautioned that the surplus is produced after the return of 8.5% to all the funds participating in the project has been paid. In that respect, a rate of return of 8.5% or 9.17% is not a very low figure, and one can state that the project is financially viable if it is at the one million tons production level and the optimum transportation method is used.

The biggest problem, however, is whether the project passes the financial test only in the case of one million tons production. If we take the case of 500,000 tons production, the IRR is as low as 4.49% and it must be extremely difficult to obtain funds with the average rate of interest of 4.49% for a project which requires a huge amount of funds from external sources. In the case of 250,000 tons production, the IRR is negative, which indicates that no financial balance can be attained even with funds of no interest. Economy of scale severely works against this case both in processing and transportation.

The results of the economic analysis appear a little more favorable than those of the

Table 5-1 B-C, B/C, IRR

Financial Analysis

	I.R. = 8.5%				I.R. = 10%				I.R. = 12%				IRR (%)
	B (10^6 shs.)	C (10^6 shs.)	B-C (10^6 shs.)	B/C	B	C	B-C	B/C	B	C	B-C	B/C	
Case RR 250	1,903	3,395	-1,492	0.56	1,692	3,338	-1,646	0.51	1,472	3,270	-1,798	0.45	minus
Case R 500	3,806	5,597	-1,791	0.68	3,385	5,459	-2,074	0.62	2,245	5,368	-2,423	0.55	
Case RR 500	3,806	4,668	-862	0.82	3,385	4,485	-1,100	0.75	2,945	4,327	-1,382	0.68	4.49
Case R 1,000	7,612	8,139	-527	0.94	6,770	7,834	-1,064	0.86	5,890	7,575	-1,685	0.78	7.29
Case RR 1,000	7,612	7,399	+213	1.03	6,770	7,035	-265	0.96	5,890	6,707	-817	0.88	917

Economic Analysis

	I.R. = 10%				I.R. = 12%				I.R. = 15%				IRR (%)
	B (10^6 US$)	C (10^6 US$)	B-C (10^6 US$)	B/C	B	C	B-C	B/C	B	C	B-C	B/C	
Case RR 250	207.4	382.5	-175.1	0.54	180.4	373.4	-193.0	0.48	151.0	373.9	-222.9	0.40	minus
Case R 500	414.8	617.6	-202.8	0.67	360.9	606.9	-246.0	0.59	302.0	606.1	-304.1	0.50	
Case RR 500	414.8	513.8	-99.0	0.81	360.9	496.6	-135.7	0.73	302.0	485.9	-183.9	0.62	5.90
Case R 1,000	829.6	895.1	-65.5	0.93	721.8	864.5	-142.7	0.84	604.1	842.6	-238.5	0.72	8.63
Case RR 1,000	829.6	807.2	+22.4	1.03	721.8	769.7	-47.9	0.94	604.1	737.3	-133.2	0.84	10.64

Table 5-2 Unit Costs

Financial Analysis

Unit: US$/ton

	I.R. = 8.5%					I.R. = 10%					I.R. = 12%				
	Plant	Port	Railway	Road	Total	Plant	Port	Railway	Road	Total	Plant	Port	Railway	Road	Total
Case RR 250	95.3	15.0	13.6	18.8	142.7	103.2	16.9	14.6	22.9	157.6	115.0	19.6	16.0	26.8	177.4
Case R 500	68.2	7.5	41.9		117.6	73.1	8.5	47.4		129.0	80.2	9.8	55.6		145.6
Case RR 500	68.2	7.5	9.2	13.1	98.0	73.1	8.5	9.9	14.5	106.0	80.2	9.8	10.8	16.6	117.4
Case R 1,000	56.0	4.6	24.9		85.5	59.5	5.2	27.9		92.6	64.6	6.0	32.2		102.8
Case RR 1,000	56.0	4.6	7.9	9.2	77.7	59.5	5.2	8.3	10.1	83.1	64.6	6.0	9.0	11.4	91.0

Economic Analysis

Unit: US$/ton

	I.R. = 10%					I.R. = 12%					I.R. = 15%				
	Plant	Port	Railway	Road	Total	Plant	Port	Railway	Road	Total	Plant	Port	Railway	Road	Total
Case RR 250	100.4	15.7	12.5	18.8	147.4	111.3	18.2	13.8	22.1	165.4	131.5	22.3	15.7	28.1	197.6
Case R 500	70.9	7.8	40.4		119.1	77.9	9.1	47.4		134.4	89.9	11.2	59.2		160.3
Case RR 500	70.9	7.8	8.4	11.9	99.0	77.9	9.1	9.2	13.8	110.0	89.9	11.2	10.5	16.9	128.5
Case R 1,000	57.7	4.9	23.7		86.3	62.6	5.6	27.5		95.7	70.8	6.9	33.7		111.4
Case RR 1,000	57.7	4.9	7.1	8.1	77.8	62.6	5.6	7.8	9.2	85.2	70.8	6.9	8.7	11.1	97.5

financial analysis. It is because the economic benefit (revenue) is evaluated at the shadow rate of 1.3 and, on the oher hand, only a part of the economic costs, namely the imported goods and services, is evaluated at the shadow rate. (It is repeated here that, in the actual calculation, the value of output is fixed in terms of dollars and the portion of costs which are estimated in terms of local currency is divided by 1.3). While this is so, we must note that the applicable rates of interest in the economic analysis should be a little higher than those of the financial analysis inasmuch as the economic interest rates are basically the opportunity cost of scarce capital and not the actual rates which may be available with foreign aid. In this analysis they are supposed to range between 10% and 15%.

When we look at the results with these in mind, we will come to generally a same conclusion as that of the financial analysis. This project with its most favorable conditions . . . Case RR 1,000 with interest of 10% . . . narrowly passes the benefit-cost test. (The net benefit is $22.4 million, benefit/cost ratio 1.03 and cost per ton $77.8, the surplus being $2.2) If the interest rate is increased to 12% which is reasonably high, the result does not become too unfavorable; the project is just a little below the passing line. The net benefit in that case is $-47.9 million, benefit/ cost ratio 0.94, and the cost per ton $85.2. If there occur some favorable changes in the surrounding conditions (e.g. some increase in product price), the project will become justifiable. Considering all the above, one can state that the project is economically feasible at the production level of one million tons.

In the case of 500,000 tons, the IRR is as low as 5.90% and a negative judgement has to be passed on it just as in the case of financial evaluation. Such negative evaluation can not be avoided because this project is almost solely an economic project intended to earn net foreign exchange. Social and political external effects as well as those of general technology transfer and dissemination are not so large.

The problem, then, is the prospect of the realization of a larger production scale than 500,000 tons . . . hopefully around one million tons in the final analysis. It must be said that the prospect of the production of that magnitude is quite uncertain at the present stage because the growth of the demand for natural soda ash is slackening recently, its international trade market is fairly limited and there will be various difficulties to attempt to make inroads in the established international sales channels and sell the product through those channels. If a sufficiently large production scale fails to be realized, the project would result in draining of national resources, with no other significant external benefits making up for the economic loss. These risks and uncertainties are the most difficult part of this project.

5-3 Result of Internal Foreign Exchange Rate Test

Table 5-3 shows the relationship of the amounts of domestic resource consumption and those of the net foreign exchange earning for Case RR 1,000. The relationship was obtained by the comparison of the present values of local consumption and net foreign exchange earning with the use of appropriate interest rates. At 10% interest, the result is 8.81 shs . . . 8.16 shs x 1.08. This means that, at 10% interest, the project earns one dollar of foreign exchange by the local consumption of 8.81 shs . . . which is much smaller than the shadow price of one dollar (10.61 shs) . . . a favorable situation.

Table 5-3 Internal Foreign Exchange Rate: Case RR 1,000

Year	Foreign Exchange Earnings (10^6 US$)	Foreign Costs (10^6 US$)					Local Costs (10^6 shs.)					P.V. discounted at 10%			P.V. discounted at 12%		
		Plant	Port	Railway	Road	Total	Plant	Port	Railway	Road	Total	D.F.	F.C.	L.C.	D.F.	F.C.	L.C.
-10		5.0				5.0						2.594	13.0		3.106	15.5	
-9					1.1	1.1				3	3	2.358	2.6	7	2.773	3.1	8
-8					0.4	0.4						2.144	0.9		2.476	1.0	
-7					1.5	1.5				8	8	1.949	2.9	16	2.211	3.3	18
-6		20.0			4.2	24.2				21	21	1.772	42.9	37	1.974	47.8	41
-5			0.4		5.7	6.1		1		24	25	1.611	9.8	40	1.762	10.7	44
-4			1.2	0.2	1.7	3.1		0	1	6	7	1.464	4.5	10	1.574	4.9	11
-3		8.2	4.8	0.4		13.4		5	0	1	6	1.331	17.8	8	1.405	18.8	8
-2		16.3	7.8	3.3		27.4	9	14	29	1	53	1.210	33.2	64	1.254	34.4	66
-1		105.7	16.4	26.2	7.1	155.4	173	39	20	20	252	1.100	170.9	277	1.120	174.0	282
1	80.0	79.6	0.7	1.1	2.1	83.5	49	2	21	6	78	1.000	83.5	78	1.000	83.5	78
2		27.0	0.7		2.1	30.9						0.909	28.1	71	0.893	27.6	70
3			0.5		2.1	30.7						0.826	25.4	64	0.797	24.5	62
4					4.1	32.7						0.751	24.6	59	0.712	23.3	56
5					2.1	30.7						0.683	21.0	53	0.636	19.5	50
6					4.1	32.7						0.621	20.3	48	0.567	18.5	44
7					2.1	30.7						0.564	17.3	44	0.507	15.6	40
8					4.1	32.7						0.513	16.8	40	0.452	14.8	35
9					2.1	30.7						0.467	14.3	36	0.404	12.4	32
10					5.6	34.2						0.424	14.5	33	0.361	12.3	28
11					2.1	30.7						0.386	11.9	30	0.322	9.9	25
12					6.0	34.6						0.350	12.1	27	0.287	9.9	22
13					2.1	30.7						0.319	9.8	25	0.257	7.9	20
14					2.1	30.7						0.290	8.9	23	0.229	7.0	18
15					2.1	30.7						0.263	8.1	21	0.205	6.3	16
16					4.1	32.7						0.239	7.8	19	0.183	6.0	14
17					2.1	30.7						0.218	6.7	17	0.163	5.0	13
18					4.1	32.7						0.198	6.5	15	0.146	4.8	11
19					2.1	30.7						0.180	5.5	14	0.130	4.0	10
20		53.7		25.1	10.7	90.0	104				133	0.164	14.8	13	0.116	10.4	9
21		27.0		-0.1	2.1	29.5	49				78	0.149	4.4	12	0.104	3.1	8
22				1.1	2.1	30.7						0.135	4.1	11	0.093	2.9	7
23					2.1	30.7						0.123	3.8	10	0.083	2.5	6
24					6.0	34.6						0.112	3.9	9	0.074	2.6	6
25					2.1	30.7						0.102	3.1	8	0.066	2.0	5
26					2.1	30.7						0.092	2.8	7	0.059	1.8	5
27					2.1	30.7						0.084	2.6	7	0.053	1.6	4
28					4.1	32.7						0.076	2.5	6	0.047	1.5	4
29					2.1	30.7						0.069	2.1	5	0.042	1.3	3
30		7.0		-10.9	2.1	-1.3						0.063	-0.1	5	0.037	-0.0	3
Total													685.6	1,269		656.0	1,182
P.V. of P.E.E.													829.6			721.8	

I.F.E.R. at 10% rate of interest = 1,269 / 829.6 - 685.6 = 8.81 (shs. / US$) = 8.16 x 1.08

I.F.E.R. at 12% rate of interest = 1,182 / 721.8 - 656.0 = 17.96 (shs. / US$) = 8.16 x 2.20

At 12% interest, however, local consumption as large as 17.96 shs (8.16 shs x 2.2) is requried to obtain one dollar, which makes one feel some instability involved when the project is viewed as a foreign exchange earning project.

If the current critical foreign exchange situation in Tanzania is to continue for a long time, threatening the operation of her economy, the shadow rate of foreign exchange would rise further, and the feasibility of the project would be improved accordingly. The figure of 2.2 is, however, an extreme figure as the shadow rate even under such circumstances. It would be safe to say therefore that the project is a good one from the viewpoint of this test as long as one can regard the inerest of 10 to 11$ as reasonable economic interest.

No attempt to apply this test to the case of 500,000 tons has been made in this study, but the result would be clearly much more unfavorable, if applied, than the case of one million tons at 12% interest because this test is essentially the same as the benefit-cost analysis with the use of shadow prices and the result of the benefit-cost analysis of the 500,000 tons case has been proven much inferior to that of the one million tons at 12% interest.

5-4 Effects of Inflation

While it is widely accepted that the worldwide inflationary trend will continue for a considerably long time to come, it is impossible to forecast the rates of increase in general price level, not speaking of the relative changes by commodities. In view of this, two analyses of the effects of inflation based on hypothetical assumptions are conducted hereunder in order to understand the nature of the effects. The following table shows the past trend of wholesale prices and the price of natural soda ash (ex-plant) in the U.S. The price indices in the table can be converted into annual rate of increase, 3.5% for wholesale price and 2.5% for soda ash respectively.

	General wholesale price	Price of soda ash	
1955	100	100	($30.8)
56		107	($33.0)
57		114	($35.2)
65	109		
69		118	($36.3)
70	125		
72		127	($39.05)
73	154		
74	181		
75	198	150	($46.20)
76(beginning of yr.)		168	($51.7)

Taking these figures for reference, two hypothetical cases are considered. Under case (1) the general price level (and accordingly the costs of the project) and the price of soda ash are assumed to rise constantly at the equal annual rate of 3%, and under case (2) it is assumed that the costs of the project rise at the annual rate of 3% while the price of soda ash rises at the rate of 2%. The result of the calculation of the above two cases is as follows (for details, see Table 5-4);

Unit: Million shillings

Case (1) All prices rise at the rate of 3% (Case RR 1,000, interest 8.5%)
benefit = 10,009 cost = 8,545
net benefit = 1,464
benefit/cost ratio = 1.17

Case (2) Costs of the Project rise at 3% and price of soda ash at 2% (Case RR 1,000, interest 8.5%)
benefit = 9,078 cost = 8,545
net benefit = 533
benefit/cost ratio = 1.06

The above result shows two things. Firstly, continuing rise of all prices at a uniform rate will favorably affect the project in its financial viability. This is because a huge investment is made, on the cost side, at an early stage of project implementation when the rise of the prices is not so big whereas, on the benefit side, the revenues from product sales are obtained in a relatively later period enjoying the benefit of a larger price increase. (In this case, the benefit/cost ratio rises from 1.03 to 1.17 and net benefit from 213 million shs. to 1,464 million shs.).

Secondly, the smaller increase of soda ash price than other prices will affect the project unfavorably but, with the degree of difference as assumed in this case, namely 2% versus 3%, the favorable effect of general inflation more than offsets this unfavorable effect, leaving the financial viability of the project slightly improved. The assumption that the increase of soda ash price lags behind other prices to the extent of 2% versus 3% is aa rather safe assumption and we can generally feel safe about the effect of inflation on the project.

Note: In the computation of the two cases, it has been assumed that the constant annual price increase at 3% under the inerest of 8.5% is of an equal effect to the case of no price increase at the inerest rate of 5.5% (-8.5% - 3%). This assumption is generally accepted as allowable approximation for the sake of simplied calculation.

5-5 Results of Other Sensitivity Analyses

In the foregoing sections we have conducted various sensitivity analyses such as the effect of various interest rates, different production scales, various shadow rates of foreign exchange and price variations. In this section, some more sensitivity analyses are added.. Firstly, let us consider the change in the cost estimate of the plant which is the biggest single item of cost. If the plant cost estimate is revised 20% upward, the total cost of soda ash goes up by $7/ton in the case of one million tons with 10% interest (financial) and by $9.7/ton in the case of 500,000 tons. If it is revised downward by 20%, a decrease in total price in an amount about same as the above takes place. Since the surplus accruing to the project is only about $2 in the most favorable cases, one million tons, with interest of 8.5% (financial) and 10% (economic), the 20% upward and downward revision of the plant investment cost will greatly improve the project's viability and deteriorate it respectively, indicating the need of minimizing this particular item of cost. It is noted, however, that even the effect of this 20% downward revision would be far from sufficient

Table 5-4 Computation Sheet for Effects of Inflation: Case RR 1,000

(10^6 Shs.)

Year	Benefits	Costs					P.V. discounted at 5.5%			P.V. discounted at 6.5%
		Plant	Port	Railway	Road	Total	D.F.	B	C	
-10		41				41	1.708		70	
-9					13	13	1.619		21	
-8					3	3	1.535		5	
-7					23	23	1.455		33	
-6		163			63	226	1.379		312	
-5			4		79	83	1.307		108	
-4			10	2	22	34	1.239		42	
-3		75	45	4	1	125	1.174		147	
-2		150	82	62	1	295	1.113		328	
-1		970	174	237	79	1,460	1.055		1,540	
1	652.8	732	9	33	31	805	1.000		805	
2		270	9		31	343	0.948		325	
3			6		31	340	0.898		305	
4					47	356	0.852		303	
5					31	340	0.807		274	
6					47	356	0.765		272	
7					31	340	0.725		247	
8					47	356	0.687		245	
9					31	340	0.652		222	
10					73	382	0.618		236	
11					31	340	0.585		199	
12					63	372	0.555		206	
13					31	340	0.526		179	
14					31	340	0.499		170	
15					31	340	0.473		161	
16					47	356	0.448		159	
17					31	340	0.425		145	
18					47	356	0.402		143	
19					31	340	0.381		130	
20		542		228	135	911	0.362		330	
21		270		23	31	330	0.343		113	
22				33	31	340	0.325		111	
23					31	340	0.308		105	
24					63	372	0.292		109	
25					31	340	0.277		94	
26					31	340	0.262		89	
27					31	340	0.249		85	
28					47	356	0.236		84	
29					31	340	0.223		76	
30		106		-65	31	78	0.212		17	
Total	19,584	10,069	501	1,382	1,520	13,472		10,009	8,545	9,078

Case 1 P.V. discounted at 5.5%

B = 10,009 10^6 shs.
C = 8,545 10^6 shs.
B-C = +1,464 10^6 shs.
B/C = 1.17

Case 2 P.V. of B discounted at 6.5% and P.V. of C discounted at 5.5%

B = 9,078 10^6 shs.
C = 8,545 10^6 shs.
B-C = +533 10^6 shs.
B/C = 1.06

to make the case of 500,000 tons economically viable.

Regarding the rate of operation of the plant, all the foregoing calculations have been done on the basis of 100% utilization of plant capacity, which is certainly a somehow optimistic assumption. If demand for soda ash slackens or some unusual troubles are generated in the plant or during transportation, the rate of operation will immediately go down. If it goes down to 80%, ex-plant cost per ton will increase by about $6 in the case of one million tons and about $9.7 in the case of 500,000 tons. If the rate is further reduced by 20%, additional increase of $12.7 (one million tons) and $18.7 (500,000 tons) will take place.

While what we term 100% operation is in reality about 20% below the physical maximum capacity of the plant, it is nevertheless fairly difficult to constantly maintain 100% operation, and this possibility of lower rate of operation than so far assumed is another element which makes us a little more conservative about the economic evaluation of the project. (For more details, see Part II, 5-3).

5-6 Requirement of Funds and Their Repayment

In addition to the study of financial and economic viability of the project, it is necessary to study the problem of fund requirements and their repayment. The result of the analysis of this problem is as shown in Table 5-5-1 and 5-5-2. In Table 5-5-1 (Case RR 1,000, interest 8.5%), it is shown that procurement of funds is necessary each year from the inception of the project through the first year of the plant operation as the expenditure always exceeds revenue, if any. The amount of funds required each year is the amount of that difference and the interest payable against the accumulated debts.

The accumulated debts reach their highest amount, 2,950 million shs., in the first year of plant operation and the biggest single year funds requirement takes place in the year prior to it: 1,548 million shs. This scale of fund requirements is certainly great enough to give a great impact on other Tanzanian development projects as well as on the participating international lending agencies and foreign countries.

In and after the second year of plant operation, however, it becomes possible to make repayment as the amount of annual revenue exceeds the amount of operating cost and the interest payable against the accumulated (outstanding) debts. The amount of repayment gradually increase and finally repayment of all the borrowing is completed in the 25th year. Surplus will then starts to accumulate and, if it earns 8.5% interest, the amount of accumulated surplus will reach 2,218 million shs. in the 30th year. This amount, when converted into the present value at the first year of plant operation, becomes 208 million shs. and it coincides with the amount of net benefit in the financial analysis of Case RR 1,000 at 8.5% interest (Table 5-1) which is 213 million shs., the small difference being attributable to the rounding.

It is noted that the same interest rate is applied in this calculation both to debts and surplus while in actuality the interest on debts is normally higher than that earned by a surplus. Also, the calculation is made on the assumption that no working capital is needed except for that required at the initiation of the plant operation. This renders the amount of debts herein calculated

Table 5-5-1 Fund Requirement & Debt Service: Case RR 1,000

(10^6 Shs.)

Year	Benefits	Costs: Plant	Port	Railway	Road	Total	B-C Balance	Interest (IR=8.5%)	Debt	Repay-ment	Outstanding Debt	Accumulated Surplus
-10		41				41	-41		41		41	
-9					13	13	-13	3	16		57	
-8					3	3	-3	5	8		65	
-7					23	23	-23	6	29		94	
-6		163			63	226	-226	8	234		328	
-5			4		79	83	-83	28	111		439	
-4			10	2	22	34	-34	37	71		510	
-3		75	45	4	1	125	-125	43	168		678	
-2		150	82	62	1	295	-295	58	353		1,031	
-1		970	174	237	79	1,460	-1,460	88	1,548		2,579	
1	653	732	9	33	31	805	-152	219	371		2,950	
2		270	9		31	343	310	251		59	2,891	
3			6		31	340	313	246		67	2,824	
4					47	356	297	240		57	2,767	
5					31	340	313	235		78	2,689	
6					47	356	297	229		68	2,621	
7					31	340	313	223		90	2,531	
8					47	356	297	215		82	2,449	
9					31	340	313	208		105	2,344	
10					73	382	271	199		72	2,272	
11					31	340	313	193		120	2,152	
12					63	372	281	183		98	2,054	
13					31	340	313	175		138	1,916	
14					31	340	313	163		150	1,766	
15					31	340	313	150		163	1,603	
16					47	356	297	136		161	1,442	
17					31	340	313	123		190	1,252	
18					47	356	297	106		191	1,061	
19					31	340	313	90		223	838	
20		542		228	135	911	258	71	329		1,167	
21		270		23	31	330	323	99		224	943	
22				33	31	340	313	80		233	710	
23					31	340	313	60		253	457	
24					63	372	281	39		242	215	
25					31	340	313	18		215		80
26					31	340	313	-7				400
27					31	340	313	-34				747
28					47	356	297	-63				1,107
29					31	340	313	-94				1,514
30		106		65	31	78	575	-129				2,218
Total	19,590	10,069	501	1,382	1,520	13,472	6,118	3,900	3,279	3,279		2,218

Table 5-5-2 Fund Requirement & Debt Service: Case RR 500

(10^6 Shs.)

Year	Benefits	Costs					B-C Balance	Interest (IR=8.5%)	Debt	Repayment	Outstanding Debt	Accumulated Surplus
		Plant	Port	Railway	Road	Total						
-10		41				41	-41		41		41	
-9					13	13	-13	3	16		57	
-8					3	3	-3	5	8		65	
-7					20	20	-20	6	26		91	
-6		163			52	215	-215	8	223		314	
-5			5		59	64	-64	27	91		403	
-4			9	2	16	27	-27	34	61		466	
-3		46	25	3	1	75	-75	40	115		581	
-2		92	85	56	1	234	-234	49	283		864	
-1		598	135	136	56	925	-925	73	998		1,862	
1	326	418	7	17	19	461	-135	158	293		2,155	
2		152	7		19	195	131	183	52		2,207	
3			4		19	192	134	188	54		2,261	
4					32	205	121	192	71		2,332	
5					19	192	134	198	64		2,396	
6					31	204	122	204	82		2,478	
7					19	192	134	211	77		2,555	
8					32	205	121	217	96		2,651	
9					19	192	134	225	91		2,742	
10					50	223	103	233	130		2,872	
11					19	192	134	244	110		2,982	
12					43	216	110	253	143		3,125	
13					19	192	134	265	132		3,257	
14					19	192	134	277	143		3,400	
15					19	192	134	289	155		3,555	
16					32	205	121	302	181		3,736	
17					19	192	134	318	184		3,920	
18					31	204	122	333	211		4,131	
19					19	192	134	351	217		4,348	
20		356		116	93	569	-243	370	613		4,961	
21		152		13	19	188	138	422	284		5,245	
22				17	19	192	134	446	312		5,557	
23					19	192	134	472	338		5,895	
24					43	216	110	501	391		6,286	
25					19	192	134	534	400		6,686	
26					19	192	134	568	434		7,120	
27					19	192	134	605	471		7,591	
28					32	205	121	645	524		8,115	
29					19	192	134	690	556		8,671	
30		70		-32	19	61	265	737	472		9,143	
Total	9,780	5,883	385	753	1,020	8,046	1,734	10,877	9,143		9,143	

slightly smaller than it should be.

In Case RR 500 in Table 5-5-2, the revenue never exceeds the amounts of cost and interest in any year, no repayment is possible and the debts merely continue to accumulate until they reach 9,143 million shs. . . . a little less than 70% of Tanzanian GNP in 1974. This amount, if converted into present value at the first year of plant operation agrees with the amount of net benefit, -862 million shs. for Case RR 500 at 8.5% interest (Table 5-1).

5-7 Items for Further Study

In the present study, fairly broad subjects of financial and economic evaluation have been covered, such as (1) net benefit, benefit/cost ratio, comparison of unit price and cost of the product, and internal rate of return, (2) internal foreign exchange rate test, (3) effects of inflation, (4) sensitivity analyses concerning plant investment cost estimate and rate of plant operation and (5) requirement of funds and their repayment possibility. In future study, refinement of the study of the above subjects is required and an emphasis should be particularly placed on the study of the following points.

(1) In the present financial evaluation, only the financial viability of the project as a whole has been studied. In future study, it is necessary, in addition to the above, that the type, nature and number of prospective organizations participating in the project be roughly outlined, such as concerned governments, railway authority, truck transport enterprises, and manufacturing enterprises, and financial analysis be conducted to see how the revenue under the project shall be distributed among these organizations so that the costs they incur for the project be properly recovered.

(2) In the present study, shadow rates proposed by the Tanzanian government have been used. The shadow rate of foreign exchange used may be on the low side in view of the recent development of the Tanzanian foreign exchange situation. Particular emphasis should be placed in future study on determining an adequate shadow rate of foreign exchange, taking into consideration all the up-to-date information on the developments surrounding the Tanzanian economy as this is critical to the economic evaluation of the project.

(3) In the present study of fund requirements and repayment outlook, repayment is assumed to be made as it becomes possible. It is necessary in future study that the conditions of repayment be revised to reflect the actual practice better. Funding and repayment schedules will become more realistic in this manner.

(4) Cost estimates should be further refined and made up-to-date. As to the costs of imported goods, in particular, care should be taken to make the costs reflect the most favorable prices obtainable from among the various supply sources. In the present study, prices of Japanese products have been taken as the basis of cost estimation together with their ocean freight in various instances due to the problem of availability of information. This has resulted in some over-estimation of costs in some instances.

Table 5-1-1 (Computation Sheet for Table 5-1) Financial Analysis: Case R 1,000

(10^6 Shs.)

Year	Benefits	Costs				P.V. discounted 6.5%		
		Plant	Port	Railway	Total	D. F.	B	C
-10		41			41	1.877		77
-9						1.763		
-8				8	8	1.655		13
-7				19	19	1.554		30
-6		163		27	190	1.459		277
-5			4	74	78	1.370		107
-4			10	223	233	1.285		300
-3		75	45	297	417	1.208		504
-2		150	82	284	516	1.134		585
-1		970	174	446	1,590	1.065		1,693
1	652.8	732	9	53	794	1.000		794
2		270	9		332	0.939		312
3			6			0.882		290
4						0.828		272
5						0.777		256
6						0.730		240
7						0.685		225
8						0.644		212
9						0.604		199
10						0.567		187
11						0.533		175
12						0.500		165
13						0.470		155
14						0.441		145
15						0.414		136
16						0.389		128
17						0.365		120
18						0.343		113
19						0.322		106
20		542		287	835	0.302		252
21		270		41	317	0.284		90
22				53	329	0.266		88
23						0.250		82
24						0.235		77
25						0.221		73
26						0.207		68
27						0.194		64
28						0.183		60
29						0.171		56
30		106		-64	48	0.161		8
Total	19,584	10,069	501	3,073	13,643		9,078	8,734
B-C								+344
B/C								1.04

IRR = 6.5 + (8.5 – 6.5) x 344 / 344 + 527
= 7.29 (%)

Table 5-1-2 (Computation Sheet for Table 5-1) Financial Analysis Case: RR 500

(10^6 Shs.)

Year	Benefits	Costs					P.V. discounted at 4%			P.V. discounted at 6%		
		Plant	Port	Railway	Road	Total	D.F.	B	C	D.F.	B	C
-10		41				41	1.480		61	1.791		73
-9					13	13	1.423		18	1.689		22
-8					3	3	1.369		4	1.594		5
-7					20	20	1.316		26	1.504		30
-6		163			52	215	1.265		272	1.419		305
-5			5		59	64	1.217		78	1.338		86
-4			9	2	16	27	1.170		32	1.262		34
-3		43	25	3	1	75	1.125		84	1.191		89
-2		92	85	56	1	234	1.082		253	1.124		263
-1		598	135	136	56	925	1.042		962	1.060		981
1	326.4	418	7	17	19	461	1.000		461	1.000		461
2		152	7		19	195	0.962		188	0.933		182
3			4		19	192	0.925		178	0.890		171
4					32	205	0.889		182	0.840		172
5					19	192	0.855		164	0.792		152
6					31	204	0.822		168	0.747		152
7					19	192	0.790		152	0.705		135
8					32	205	0.760		156	0.665		136
9					19	192	0.731		140	0.627		120
10					50	223	0.703		157	0.592		132
11					19	192	0.676		130	0.558		107
12					43	216	0.650		140	0.527		114
13					19	192	0.625		120	0.497		95
14					19	192	0.601		135	0.469		90
15					19	192	0.577		111	0.442		85
16					32	205	0.555		114	0.417		85
17					19	192	0.534		103	0.394		76
18					31	204	0.513		105	0.371		76
19					19	192	0.494		95	0.350		67
20		356		116	93	569	0.475		270	0.331		188
21		152		13	19	188	0.456		86	0.312		59
22				17	19	192	0.439		84	0.294		56
23					19	192	0.422		81	0.278		53
24					43	216	0.406		88	0.262		57
25					19	192	0.390		75	0.247		47
26					19	192	0.375		72	0.233		45
27					19	192	0.361		69	0.220		42
28					32	205	0.347		71	0.207		42
29					19	192	0.333		64	0.196		38
30		70		-32	19	61	0.321		20	0.185		11
Total	9,792	5,888	385	753	1,020	8,045		5,870	5,749		4,763	5,134
B-C								+121			-371	
B/C								1.02			0.93	

IRR = 4 + (6 - 4) x 121 / 121 + 371 = 4.49 (%)

Table 5-1-3 (Computation Sheet for Table 5-1) Economic Analysis Case R 1,000

(10^6 US$)

Year	Benefits	Costs				P.V. discounted at 8%		
		Plant	Port	Railway	Total	D. F.	B	C
-10		5.0			5.0	2.159		10.8
-9						1.999		
-8				1.0	1.0	1.851		1.9
-7				2.3	2.3	1.714		3.5
-6		20.0		3.3	23.3	1.587		37.0
-5			0.4	7.6	8.0	1.469		11.8
-4			1.3	23.0	24.3	1.380		33.0
-3		8.2	5.2	30.6	44.0	1.260		55.4
-2		17.2	9.1	29.0	55.3	1.166		64.5
-1		122.0	20.1	50.4	192.5	1.080		207.9
1	80.0	84.3	0.9	5.0	90.2	1.000		90.2
2		31.6	0.9		37.5	0.926		34.7
3			0.7		37.3	0.857		32.0
4						0.794		29.6
5						0.735		27.4
6						0.681		25.4
7						0.630		23.5
8						0.583		21.7
9						0.340		20.1
10						0.500		18.7
11						0.463		17.3
12						0.429		16.0
13						0.397		14.8
14						0.368		13.7
15						0.340		12.7
16						0.315		11.7
17						0.292		10.9
18						0.270		10.1
19						0.250		9.3
20		63.4		33.8	97.9	0.232		22.7
21		31.6		3.6	35.9	0.215		7.7
22				5.0	37.3	0.199		7.4
23						0.184		6.9
24						0.170		6.3
25						0.158		5.9
26						0.146		5.4
27						0.135		5.0
28						0.125		4.7
29						0.116		4.3
30		11.6		-9.3	3.0	0.107		0.3
Total	2,400.0	1,184.9	57.5	310.3	1,552.9		972.6	942.6
B-C							+30.0	
B/C							1.03	

IRR = 8 + (10 - 8) x 30.0 / 30.0 + 65.5 = 8.63 (%)

Table 5-1-4 (Computation Sheet for Table 5-1) Economic Analysis Case RR 500

(10^6 US$)

Year	Benefits	Costs					P.V. discounted at 4%			P.V. discounted at 6%		
		Plant	Port	Railway	Road	Total	D. F.	B	C	D. F.	B	C
-10		5.0				5.0	1.480		7.4	1.791		9.0
-9					1.5	1.5	1.423		2.1	1.689		2.5
-8					0.4	0.4	1.369		0.5	1.594		0.6
-7					2.1	2.1	1.316		2.5	1.504		3.2
-6		20.0			5.3	25.3	1.265		32.0	1.419		35.9
-5			0.6		6.0	6.6	1.217		8.0	1.338		8.8
-4			1.1	0.3	1.6	3.0	1.170		3.5	1.262		3.8
-3		5.0	2.8	0.4	0.1	8.3	1.125		9.3	1.191		9.9
-2		10.6	9.6	5.6	0.0	25.9	1.082		28.0	1.124		29.1
-1		75.4	15.5	15.7	6.3	112.9	1.040		117.4	1.060		119.7
1	40.0	47.8	0.8	1.6	1.7	51.9	1.000		51.9	1.000		31.9
2		17.7	0.8		1.7	21.8	0.962		21.0	0.933		20.3
3			0.5		1.7	21.5	0.925		19.9	0.890		19.1
4					3.2	23.0	0.889		20.4	0.840		19.3
5					1.7	21.5	0.855		18.4	0.792		17.0
6					3.1	22.9	0.822		18.8	0.747		17.1
7					1.7	21.5	0.790		17.0	0.705		15.8
8					3.2	23.0	0.760		17.5	0.665		15.3
9					1.7	21.5	0.731		15.7	0.627		28.5
10					4.9	24.7	0.703		17.4	0.592		14.6
11					1.7	21.5	0.676		14.5	0.558		12.0
12					4.6	24.4	0.650		15.9	0.257		13.9
13					1.7	21.5	0.625		13.4	0.497		10.7
14					1.7	21.5	0.601		12.9	0.469		10.1
15					1.7	21.5	0.577		12.4	0.442		9.5
16					3.2	23.0	0.555		12.2	0.417		9.6
17					1.7	21.5	0.534		11.5	0.394		8.5
18					3.1	22.9	0.513		11.7	0.371		8.5
19					1.7	21.5	0.494		10.6	0.350		7.5
20		41.5		13.7	9.7	65.4	0.475		31.1	0.331		21.6
21		17.7		1.0	1.7	20.9	0.456		9.5	0.312		6.5
22				1.6	1.7	21.5	0.439		9.1	0.294		6.3
23					1.7	21.5	0.422		9.1	0.278		6.0
24					4.6	24.4	0.406		9.9	0.262		6.4
25					1.7	21.5	0.390		8.4	0.247		5.3
26					1.7	21.5	0.375		8.1	0.233		5.0
27					1.7	21.5	0.361		7.8	0.220		4.7
28					3.2	23.0	0.347		8.0	0.207		4.8
29					1.7	21.5	0.333		7.2	0.195		4.2
30		7.7		-4.4	1.7	5.5	0.321		1.8	0.185		1.0
Total	1,200.0	690.9	45.2	75.5	100.2	911.8		719.4	635.0		583.6	586.9
B-C								+14.4			-3.3	
B/C								1.70			0.09	

IRR = 4 + (6 – 4) x 64.4 / 64.4 + 1.3 = 5.90 (%)

CHAPTER 6 RELATED DEVELOPMENT PROJECTS AND OTHER EXTERNAL EFFECTS

The desirability of this project will increase if other projects related to it become more feasible, or the transportation facilities constructed or improved for this project are used for other projects and for transport of general cargoes and passengers, or the regional economic activities are stimulated and become brisk owing to the implementation of this project. While it is felt by the mission that the external effects of the project such as those indicated above are not significantly large, a few comments are supplied about them.

(1) Soda ash is one of the basic materials used by industry, for production of many useful chemicals. However, soda ash is in most instances only one of many kinds of chemical materials used for production (except for plate glass), and the mere availability of the soda ash would not make the production of such chemicals economical. It may be that the production of glass bottles and a certain kind of cleanser are a few examples where this project could make other production feasible.

(2) The mission might be asked whether or not a part of the energy and water for this project could be used for other projects or public welfare purpose. As for energy, the possibility is slight because crude oil appears to be the main energy source of this project at the present stage and therefore no substantial surplus energy would be available. And as the Lake Natron region is very remote and not blessed with favorable climate and soil condition, it is highly improbable that other projects will be promoted in this region in preference to other regions. From this point of view, even when geothermal or coal energy becomes available for the project, it may not be used for multiple purposes. As for water, to offer surplus project water to the Masai residents in the nearby region would have a social significance and also would be desirable in that the project might be more easily accepted by them. However, the number of benefited inhabitants is limited.

(3) It is also difficult ot think that transportation facilities built or improved in relation to this project will give great benefits to other projects. The improvement of Tanga Port and Tanga-Arusha railway line is required primarily to increase their capacities for soda ash transportation, and it would not improve the quality of transportation services (e.g. speed and frequency) for other cargoes and passengers automatically. It is not to be denied, however, that such capacity increase will enable the railway authority to meet the future increase in the transport demands of general cargo and passengers with better services than before and the port authority to handle their increasing volume of general cargo a little easier. Secondly, construction of Arusha-Lake Natron road will give benefits to the Masai inhabitants in their daily movement and be also useful for the Masai Ranch development project contemplated for the northern region of the road. Further, it will make it easier to transport phosphate from Minjingn Mine, situated to the south of Lake Manyara, to Tanga with the increase of capacity of Arusha-Tanga railway line and Tanga Port.

(4) The implementation of this project will give various stimuli to the economy of the related regions. While the nature of the production is automated plant operation, the number of employees required for processing and transportation will be around 700. Addition of this persons together with their family members to the region will have certain amount of multiplier effects. Also auxiliary services related to production and transportation will emerge. These effects will be undoubtedly useful to the economy of the regions but it must be pointed out that any investment of so much capital as in this case will produce this type of stimulating effects in equal or probably greater magnitude.

Most of the benefits mentioned above are certain to arise but their magnitude will not be particularly large compared with other projects of the same size as mentioned above. It would be, therefore, extremely difficult to justify this project on the basis of the additional benefits of the project's external effects if its economic feasibility on the basis of direct economic benefit is judged to be insufficient. However, it is felt that further exploratory study should be carried out on this subject in the future.

CHAPTER 7 APPROACH FOR STAGING

In this report, we assumed three levels of production -- 250,000 tons, 500,000 tons, and one million tons -- and chose the most suitable production facilities, transportation methods, and new road routes for each of the three production facilities, transportation methods, and new road routes for each of the three production scales. Then, on the basis of this, we examined the economics of each of the three scales. In this chapter, we add a simple examination of an approach involving transition from one production scale to a larger production scale.

Generally speaking, in the case of a project in which the demand is expected to increase gradually, it is more economical to expand production and transportation facilities gradually in accordance with demand than to prepare facilities of maximum capacity from the beginning. The present project is no exception to this, but one especially difficult problem is that among the three production scales only the one million tons production meets the economic feasibility tests -- and only narrowly at that -- and all other smaller production scales fail to do so. Thus, it becomes theoretically untenable to take the approach of starting with 500,000 tons production and stepping up the production scale as it gradually establishes itself in the world market, finally up to one million tons level, unless 500,000 tons production were limited to just a brief period.

However, to begin immediately with a one million tons production plant involves an extremely high risk. According to the analysis in Chapter 5 of Part II, when a plant of one million tons is operating at 70% of capacity, cost per ton rises by $11 (in case of financial analysis using an interest rate of 10%), and losses would be $13-14 per ton, without taking into consideration the corresponding increases in unit transportation cost. The cost per ton of production in a one-million-ton-capacity plant operating at 70% of capacity would be approximately the same as in a plant of 500,000 tons operating at 100% capacity. If the production of the plant of one million tons were to fall below 70%, it would be more economical to run a plant of 500,000 tons.

After taking all these factors into account, it is felt to be worthwhile to consider starting with a plant having a production scale of 500,000 tons, and increasing production capacity gradually in accordance with market expansion, if the decision is made to implement the project in spite of the considerable risks involved and if scale of one million tons cannot be envisaged for some time. This is to reduce possible losses. Below we outline the manner of preparing the various required facilities and equipment in the event that this phased approach is taken.

(1) Production Facilities

Because the plant has been planned and costs have been estimated on the assumption that it will eventually be expanded to a capacity of one million tons in the present study, transition from a scale of 500,000 tons to one million tons capacity could be carried out without substantial additional costs to those involved if a plant of one million tons capacity had been constructed from the beginning.

(2) Port Facilities

As long as one million tons production can be hoped for from the beginning, there is no doubt that the port facilites f1,000 (one million tons facilities, outer harbor of Tanga) should be chosen as they involve the costs of 314.7 million shs. whereas the port facilities $e_{1,000}$ (one million tons facilities, inner harbor of Tanga) involves 20% higher costs of 378 millions shs. In considering a phased approach, it may appear more economical to select the site e with provision of port facilities for 500,000 tons (e_{500}) and then to enlarge the port facilities to a scale of one million tons when that becomes necessary, unless the period of 500,000 tons production is rather short (For example, less than 10 years). This is possible because the costs involved in e_{500} plan are 259 million shs., about 20% below the costs of f1,000, though this difference will decrease somewhat in stage construction. (It is altogether out of question to start with e_{500} and then later shift to f1,000 huge silo facilities constructed at e would become superfluous later on.)

However, there are several drawbacks in the e_{500} - $e_{1,000}$ plan:

1) The assumption taken in the cost estimate of the plan that the cost of dredging up to -10 m depth will be borne by some one else may be difficult to realize;

2) Inefficient material handling and storage may occur as the soda ash product and other general cargoes are handled at the same or adjacent berths, and

3) Inefficiency and congestion in navigation and waiting may occur as the ships for soda ash and those if other cargoes are together in the same harbor.

In view of these factors, the above remarks concerning the desirability of selecting e_{500} - $e_{1,000}$ plan should be revised so that only in the case where 500,000 tons production would continue for a considerable length of time (For example than 20 years) site e would be selected and that site f would be selected in all other cases where one million tons production is expected to be eventually, realized.

(3) Railroads

The approach here would be the same whether a staging approach were taken or not. The reason for this is that plans and cost estimates necessary for improving the existing railway facilities to accommodate 500,000 tons production are basically the same as those necessary to accommodate one million tons.

(4) Roads

The optimum truck size for a 500,000 tons production is a 16.5 ton semi-trailer and the optimum size for a one million tons production is a 30 ton semi-trailer. However, if it is decided to proceed with the kind of staging approach as outlined above, it would be best to use 30 ton semi-trailers even when the plant is producing at 500,000 tons capacity, in order to make possible a smoother transition to one million tons production at a later date. (See Part III, Chapter 7-2 for reference.) The appropriate route location would be Route B for both the 500,000 tons scale and the one million tons scale, and the plans would be identical, and so the step-by-step approach would require no special considerations.

CHAPTER 8 CONCLUSION AND RECOMMENDATION

8-1 Feasibility

The technical, financial and economic evaluation in previous chapters suggests that this project may not be feasible unless some conditions and premises such as those mentioned below are satisfied:

(1) Production is generally maintained at the level of about one million tons and the output of such production obtains suitable market opportunities.

(2) The economical means of transportation is adopted by fully utilizing the existing port and railway facilities and by constructing a new road instead of a railway between Lake Natron and Arusha.

(3) Funds with which to finance the project's capital investments are obtained at an average rate of interest low enough to make the project financially viable, presumably 8 to 9% or less.

The emphasis of the future study should therefore be placed on the possibility of these conditions and premises being satisfied at a future date. Some other problems involved in the project planning are also pointed out in the following paragraphs.

8-2 Scale of World Market

The present world demand for soda ash is approximately 25 million tons, of which nearly 10% (2.5 million tons) is internationally marketed. Excluding 0.5 million tons traded among EC countries, the size of the world market into which Natron-ash is to be introduced is considerably smaller, only 2 million tons at present, and estimated to be 3 million tons in ten years. Natron-ash will constitute one-third thereof.

To acquire this large share in the international markets which are divided and scattered in relatively small areas will be a very difficult challenging task, mainly because of the necessity of maintaining a highly stabilized production system and the need for making inroads into the established worldwide sales channels.

It must be noted, however, that the production of synthetic soda ash by the advanced industrial nations is now facing the problem of environmental disruption and obsolescent plant facilities, which may in future attenuate the marketing problem of natural soda ash.

Any new developments and changes in the supply situation of synthetic soda ash must therefore be closely watched.

8-3 Trend of Soda Ash Price

Although the FOB price of refined soda ash at exporting port is estimated at $80 per ton in this report, considerable uncertainties are involved in this estimate.

While it is true that the export price of U.S. natural soda ash has sharply increased recently, one of the major reasons for this is relatively short-lived, because the fall of synthetic soda ash, and the recent sharp rise in the price may not continue. This possible slow-down of the increase in price and the fluctuating nature of soda ash demand which sensitively corresponds with the fluctuation of world business may be contributing factors to economically unstable plant operations.

8-4 Production Scale and Plant Cost

As economy of scale is obtained in this project, the project is promising economically, if a one million tons production level can be maintained constantly. But the unit cost of the product sharply increases as the production level goes down below this figure, making a 500,000 tons production economically unfeasible, much less a 250,000 tons production. It is noted here plant costs are at this time estimated at as high as 200 million dollars, far exceeding the cost of improvement and construction of the transport facilities which were estimated in the previous study of 1973 as being about equal to the plant costs.

This can not be helped in view of the worldwise hike of plant costs since the oil crisis. But it inevitably renders the smaller production scale more un-economical and also requires larger amount of funds, especially those from foreign sources. The difficulty of constantly maintaining the sales of one million tons is still ever-present. This is the biggest dilemma of this project.

8-5 Complexity of the Refining Process

The soda crust excavated from the Lake contains 1.37% by wt of sodium fluoride. Accordingly, need to remove fluoride makes the refining process complex, raising the equipment costs considerably. It also poses the problem of developing and putting to use the new technology of fluoride exclusion economically.

8-6 Full Utilization of Existing Railway Line

Operation of six trains consisting of 19 wagons per day utilizing the existing line is necessary for the annual production of one million tons. At the beginning of our survey, construction of the new line between Arusha and the Lake appeared promising but later it has been found un-economical for the following reasons:

(1) Initial construction cost of railway is large,

(2) Transportation of one million tons per year is not large enough to make the full utilization of new line possible,

3) Construction costs of a road are by far cheaper.

8-7 Locomotives and Wagons

In transporting the product using the existing line, a total investment cost of $37.5 million is needed, of which nearly two-thirds is required for providing locomotives and wagons, and the rest for the improvement of existing line.

8-8 Big Share of Storage Silo in Port Construction Cost

The total cost of port construction is $38.6 million, of which 70% is for storage silo. Of various alternatives, construction of another jetty near the existing fertilizer jetty is the most advantageous, but there is a possibility that another alternative will become feasible, if the existing pier in the inner harbor is extended for general cargoes prior to implementation of this project.

8-9 Multi-purpose Character of Roads

The total cost in the road sector including trucks, trans-shipment facilities as well as road construction amounts to $34.4 million for the transportation of one million tons per year. With this investment, road transport will be able to serve the purpose economically.

It must be noted however that the importance of roads lies in their multi-purpose character. Accordingly, construction of roads in advance is useful for implementing feasibility studies, transport of construction materials and other general uses and will not be totally wasted even if the implementation of the project is suspended or postponed.

8-10 Establishment of a Meteorological Observation Station

As in the case of road, the establishment of both a meteorological observation station and discharge gauging station in advance is essential. Because these stations supply necessary information and immense stimuli for the promotion of this project.

8-11 Other Related General Remarks

8-11-1 Comprehensive character of the project

Besides the above-mentioned major conclusions, there are many other related matters to be mentioned, because of the project's comprehensive and inter-disciplinary character. Some of them are indicated in the following.

8-11-2 Systematizing the approach to future study

As already indicated, at least ten years will be necessary before the operation of the purification plant can be started, and the feasibility study must precede that ten year period.

In carrying out the study, some systematicism of approach is necessary. There are some measures which must be taken as soon as possible, even before the feasibility study.

There are some other items of study which must be separated from the required feasibility study, such as for instance, the study of geo-thermal energy. The items to be included in the feasibility study should be properly scheduled, some sequentially and some others in parallel.

8-11-3 Utilization of accumulated economic resources in the Tanga–Moshi–Arusha Region

This project region is one of the most developed area in Tanzania. Population, agriculture, industry and an infra-structure are already present. These are the most important potential factors in promoting the project. As a result, there are advantages such as the possibility of utilizing the existing railway, and also the favorable spill-over effects of the project such as the benefits of the improvement of the existing railway for general cargoes and passengers. It is also pointed out that the project would give some favorable stimuli to the regional economy and the regional development plans should incorporate some measures to take advantage of such stimuli.

8-11-4 Magadi and Makgadikgadi Pans

From the view-point of world consumers of soda ash, there are many alternative suppliers, actual and potential. To be always kept well informed about any new developments about them is essential to the successful planning of the project.

Magadi has already seventy years' experience in the soda ash production close by. Even if the direct connection of railway service between Magadi and Natron is set aside from this project, close exchange of information at least appears most desirable.

On the contrary, Makgadikzadi in the Republic of Botsuwana is only a potential place of future soda ash production like Lake Natron. It is important that any developments there should be closely watched.

8-11-5 Industrialization policy

This projected enterprise will have a very different character from other industrial firms in this country. Some such characteristics are its large size, big fund requirements, multi-national participation, and the need of highly stabilized continued production and delicate quality control required in processing and transportating soda ash to avoid moisture absorption and congelation. It would be necessary to study effective government measures to encourage and foster the enterprise if this project is decided to be feasible.

8-12 Other Matters Related to the Plant

8-12-1 Geo-thermal energy

From the preliminary studies conducted so far, the possibility of utilizing the geo-thermal energy for this project appears somewhat remote. Because of the importance of geo-thermal energy in this country, however, it is advised that preliminary surveys be started prior to a full scale boring survey, conducted separately from this project. The surveys will require a considerable length of time and money.

8-12-2 Coal resources

The use of coal in the southern district of the country is a rather useful problem to consider. At an early stage of the future studies, the conclusion must be validated. In this report a tentative conclusion is that the coal could not be replaced by the fuel oil energy in the purification plant operation.

8-13 Other Matters Related to the Transportation Facilities

8-13-1 Musoma railway line

There is only a slight possibility that the future Musoma line will contribute to this project. Furthermore, economic feasibility of this line appears to require further careful study. It appears therefore desirable that the problem of the Musoma line should be studied separately and upon its own merit.

8-13-2 Endless ropeway and pipeline

In this study two other means of transport were considered. One is an endless ropeway to carry purified products from the plant to Arusha silo facilities. The other is a pipeline to convey the raw crust and brine in slurry from the Lake Natron to the Arusha alternative plant. Both are considered not feasible for the reasons stated in II-3-6 and III-7. Little possiblity is left for further studies on both means of transport.

CHAPTER 9 RECOMMENDATIONS ON FURTHER STUDY

Although it is considered that the project is well set out as described in the previous chapters, a considerable number of investigations and studies, namely 'a feasibility study' are still required before proceeding to the decision making on investment in the project. For the sake of reference, brief ideas on such investigations and studies are presented in this chapter.

For the feasibility study, the following work will be necessary:

A. Preparatory Works for Feasibility Study

- A–1 Establishment of Project Office
- A–2 Preparation of an access road to Lake Natron
- A–3 Preparation of temporary accommodation at Lake Natron

B. Investigation on Natural Soda Resources

C. Study on Soda Ash Mining and Processing

D. Study on Soda Ash Market and Marketing

E. Study on Utility

- E–1 Meteorology
- E–2 Water Sources
- E–3 Energy Sources
- E–4 Plant and Residential Quarters

F. Transportation Study

- F–1 Port
- F–2 Railway (mainly on the section between Tanga and Arusha)
- F–3 Road (mainly on the section between Arusha and Lake Natron)

G. Preparation of Feasibility Report

Since descriptions on the specific works, such as water resources study, transportation study, etc. are presented in a form of 'suggested terms of reference' separately in the Part II and Part III, brief descriptions on the above-mentioned works are given here-under.

A. Preparatory Works for Feasibility Study

A–1 Establishment of Project Office

As the Project involves many fields of engineering, a coordinating body will be required for the smooth execution of the feasibility study. It is desirable that such a body has qualified engineering and administration staff.

A–2 Preparation of an Access Road to Lake Natron

The existing road to Lake Natron is an earth road in extremely poor condition. For field works in the Lake Natron area, a reliable road is required, an engineered gravel road from Longido to the proposed plant site at Lake Natron via Gelai village should be prepared before the commencement of the field works in and around Lake Natron.

A–3 Preparation of temporary accommodations at Lake Natron

For the feasibility study, several persons will have to stay at Lake Natron for rather long periods. Therefore, it is desirable that temporary accommodation at Lake Natron is prepared.

B. Investigation on Natural Soda Resources

The surveys on the natural soda deposit in the Lake Natron area made currently and previously were carried out only by hand auger which could explore the existing crust and brine. However, there may be some possibility of deposits of natural soda beneath the bottom of the Lake or in other places other than the existing crust and brine. If such possibilities are confirmed, the plant location and mining method might be changed. Therefore, it is desirable to investigate the natural soda resources by test drilling and seismic exploration as well as by hand auger boring in advance of the commencement of the study on soda ash mining and processing.

In addition to the above, a periodical investigation on crust distribution and its thickness will be required to confirm the seasonal change of the crust distribution and the growth rate of crust.

C. Study on Soda Ash Mining and Processing

Although a considerable amount of study on soda ash mining and processing has been done in the present study, studies are still required, especially on the following points:

- Best method of mining
- Possibility of by-product recovery
- Process of reduction of NaF contents

After the above studies, the up-dating of construction, operation and maintenance costs will be required. In addition to the above, an institutional and managerial study on the plant operation will also be necessary.

D. Study on Soda Ash Market and Marketing

Although the market of soda ash has been growing at a strable rate, changes might occur during the period of feasibility study. Therefore, a comprehensive market study will be required to confirm potential export markets. The study should include the projection of export price as far as practicable.

E. Study on Utility

E–1 Meteorology
The meteorological conditions around Lake Natron will affect not only the growth of soda but also the selection of mining method and place and the design of living conditions. Therefore, it is recommended that a meteorological observation station be established at Lake Natron as soon as possible and that continuous observation of temperature, humidity, railfall, evaporation, etc. are carried out on the long-term basis.

E–2 Water Sources
According to the discharge measurements carried out on this occasion, it is estimated that the Peninj River has a run-off large enough to sustain the plant with a soda ash production capacity of one million tons per annum or more. However, it is necessary to establish a discharge gauging station with automatic measurement instruments at the mouth of the Peninj River and carry out measurements of continuous discharge to confirm the amount of run-off on a long-term basis.

E–3 Energy Sources
In the present study, petroleum is selected as the energy source. However, the possibilities of other sources such as locally producible coal should be more closely examined technically and economically. As this study affects the design of soda ash processing, it is necessary to perform the study on energy sources before the study of processing plant.

E–4 Plant and Residential Quarters
As the plant will be located at the coast of Lake Natron where no infrastructures exist, construction of residential quarters is required. The infra-structure required comprises water supply, sewage, roads, electricity supply, etc. The study on them will be carried out in close co-ordination with work on the Location of the plant.

F. Transportation Study

The transportation studies in this report were carried out on the basis of insufficient data. Therefore, in the feasibility study, further investigations will be required on topography, geology, soil, construction materials, oceanography, etc. for the preparation of a feasibility study, on general designs and cost estimates.

G. Preparation of Feasibility Report

On the basis of the results of study on the above-mentioned items, a Feasibility Report should be prepared. The report should contain not only the results of technical, economic and financial assessment but also the results of institutional and managerial assessment.

A tentative time schedule for the above works is as shown in the attached figure.

TENTATIVE TIME SCHEDULE FOR FURTHER STUDY

Items	Year				
		1st	2nd	3rd	4th
A. Preparatory Work					
B. Soda Ash Resources Investigation					
C. Study on Soda Ash Mining and Refining					
D. Study on Soda Ash Market and Marketing					
E. Utility Study					
1. Meteorology					
2. Water Sources					
3. Energy Sources					
4. Plant and Residential Quarters					
F. Transportation Study					
1. Road					
2. Railway					
3. Port					
G. Preparation of Feasibility Study					

Remarks

A P P E N D I X

CONTENTS

APPENDIX

1. Background

The Japan International Cooperation Agency selected four members from the Japanese Study Team amd sent them to Tanzania with the Draft Final Report for final discussions with the Government of Tanzania from June 1 through June 10, 1976. While appreciating the efforts of the Japanese Team which resulted in a voluminous and comprehensive study, the Government of Tanzania, represented by Principal Secretary Ndugu F. Lwegarulila of the Ministry of Water, Energy and Minerals, presented some questions and expressed some doubts about the premises and assumptions of the study and proposed certain modifications.

The Government of Tanzania was interested in whether a smaller scale of production, say 500,000 tons or less per year, could be made feasible through such means as reducing or even eliminating some costs of infrastructure and reducing the degree of purification of soda ash. The Japanese Team explained that there was not much room left for reducing the cost of infrastructure further and also that any substantial reduction in the degree of purification of soda ash would seriously hurt its competitiveness in the world market.

After the discussion during several meetings, the position of the Government of Tanzania was summarized in writing and presented to the Japanese Team, in the last meeting. This statement is reproduced in the following section. The Japanese Team, while not necessarily accepting all the points raised by the Tanzanians agreed to take into consideration all the points thus raised in completing their final report. The minutes of the last meeting are included as Attachment 1.

The Japanese Team conducted studies and anayses in accordance with the Tanzanian statement. While the results of such studies and analyses have led to some modification of the contents of the Draft Final Report, they did not alter its basic conclusion.

The studies and analyses thus conducted are summarized in the following sections 3. and 4.

2. Comments by the Government of Tanzania on the Draft Final Report

The objective of the Project is to produce soda ash by utilizing Lake Natron as a source and to market the produce. In this context, it is considered that all infrastructure not directly connected with the project should not be costed as an integral part of the project. Such infrastruture includes:

(a) The improvement of Tanga port facilities.

(b) The improvement of the existing railway.

Production

1. Location of Plant: The recommendation of the report that the plant should be located near Lake Natron is acceptable.

2. Access to the plant: It is felt that the most convinient access to the plant should be a railway line as a spur from the proposed Arusha – Musoma rail link whose firm alignment could take the soda ash project into consideration. It is proposed that the cost of this spur be borne by the East African Railways Tanzania Region.

3. Capacity of the Plant: Given the content of the project, review the most economical size of the plant as distinct from the one million tons capacity recommended in the report. We go further to suggest that we begin with a small plant to cover local and neighbouring countries demand.

4. Purification: It is agreed that purification plant is necessary in the long run but the most economical plant should be found so as to reduce the costs. The degree of purification required should depend on the quality the market demands.

5. Energy: In order to reduce drain of foreign exchange the use of coal or geothermal power is recommended. This implies acceleration of studies on these two items so that they do not retard the implementation of the project. These studies are being carried outside the project.

6. Housing: The costs for this item could be reduced by keeping to the Tanzania standards of equivalent status. For instance, for grade "A" houses, the cost estimate normally taken lies between shs. 1,200 to shs. 1,400 per square meter as against shs. 2,990/= per square meter applied in the report.

7. Water: Cost of the water project could be reduced taking into consideration of the results of the study to be executed with view to getting a cheaper source e.g. ground water.

8. Engineering Services: Taking into account the above cost reductions, engineering services could be reduced in so far as such services should not exceed 10% of the construction cost of the project.

9. Pilot Plant Cost: It is considered that this is a technological development study which could lead into patent of the method; hence it should be excluded as a cost item to the

project.

10. Rough cost estimate of the Project: Taking the above proposed measures of reducing costs, the rough cost estimate of the project works out to be US$150 m.

11. *Time Implementation:*. Due to the importance the Tanzania Government attaches to this project it is essential that it be implemented with least delay. Hence it is proposed that studies be completed within two years time and construction takes five years. On the assumption that the final report will be produced by August 1976 incorporating the comments by Tanzania party, the studies could be in full swing by January 1977.

12. Studies: Over and above the studies recommended in the report the following studies should be undertaken:

(a) Industries, consequential to the implementation of this project, to be established in Tanzania such as sheet glass, pulp and paper factory, sythetic textiles, pharmaceuticals, and detergents.

(b) Marketing of soda ash in Tanzania as well as in Africa in particular and outside Africa in general.

3. Costs of Infrastructure

In accordance with the above agreement, three alternative financial analyses fo the Project with and without infrastructure cost have been conducted.

The results of the analyses and the evaluation thereof are presented in this section. Economic analyses corresponding to the above have not been conducted because one can tell with certainty that the results of calculation and the evaluation thereof would be almost identical to those of the financial analyses. It is noted that the comments on the sub-section titled "Access to Plant" of the section 2 above are also included in the analysis of these three alternatives.

3-1 Analysis Including Costs of All Related Infrastructure

This has been adequately done in the analyses given in the Final Report and only one additional comment is needed. The analyses in the Final Report have been conducted with inclusion in the cost-benefit calculation of all the incremental costs to be required for the implementation of the Project which would not be required otherwise.

To give some examples, the costs of improving Tanga Port consist only of those of constructing a berth, silos, loading facilities and extension of railway sidings, all to be exclusively used for the transport handling of soda ash, and the cost of dredging required in excess of

10 meters depth which is the depth required by general cargo vessels. The costs of improving the existing railway include those of the addition of signal stations for the purpose of expanding the railway capacity in view of the large volume of soda ash transport, some improvements of gradient and track, some additional sidings for loading and the locomotives and wagons for hauling soda ash. No other cost of existing railway facilities is apportioned to the Project. All of the above are purely the additional or incremental costs required for the Project which would not be incurred if it were not for the Project. It is felt by the Study Team that no basic alterations to this incremental cost principle is needed, although the determination of the scope of such incremental cost is to some extent dependent on the judgement of the individual analyst and some modified figures of infrastructure costs such as those in section 3-3 below may also be considered equally valid.

3-2 Analysis Excluding All Infrastructure Costs

The soda ash produced under the Project would acquire real value only when it is transported to the market. Costs of any investment in infrastructure required solely for the purpose of transporting it to the market is an integral part of the project cost, and in no way different, for instance, from pipelines and conveyors provided within the plant for material handling. It is true that arrangements could be made so that the costs of construction and improvement of railways, roads and the port are borne by appropriate railway, highway and port authorities and not charged to the Project. Such arrangment would not, however, change the basic fact that the Tanzanian economy is burdened by the resource committments which would be required for infrastructure improvement because of the Project. Any economic feasibility analysis which disregards this basic principle would lead to misallocation of valuable national resources.

Overall financial analysis such as the one herein conducted is no different in this respect. If the additional cost of railway improvement necessitated by the Project is not borne by the Project itself, the railway authority will sustain a loss in that exact amount. No overall financial analysis can be conducted withou taking such loss into account. Therefore, neither economic analysis nor financial analysis excluding such infrastructure cost should be adopted.

Nevertheless, some results of calculations which exclude the cost of infrastructure altogether will be furnished hereunder in order to indicate the magnitude of the problem.

Conditions of calculation: No cost of constructing and improving new and existing transport facilities is included except the cost of new locomotives and wagons for rail transport of soda ash and that of constructing necessary siles and other loading-related facilities at Tanga Port. (It is assumed that the new railway line directly connecting Arusha and the Lake Natron plant site will be constructed as part of the future Arusha-Musoma Line with the alignment P_0 - P_5 shown in Attachment 2 and that no cost of such construction be charged to the Project). The scale of production of soda ash is 500,000 tons and the financial interest rates (discount rate) is is 8.5% and 10% respectively.

Result: Financial Cost per Ton of Soda Ash (500,000 tons case)

Unit: US$/ton

Rate of discount 8.5%				Rate of discount 10%			
Plant	Rail	Port	Total	Plant	Rail	Port	Total
68.2	11.4	5.6	85.2	73.1	11.8	6.3	91.2

Note: Details of this calculation are included in Attachments 4-1 and 4-2.

Reference is also to be made to Table 5-2, Part I, of the Final Report.

Comment: Even with these extremely favourable conditions, the case of 500,000 tons production is not financially feasible, because the total cost per ton of soda ash at Tanga Port exceeds its sales price FOB Tanga. In view of the proximity of the results of economic analyses to those of financial analyses under many varied conditions as described in the Final Report, calculation of economic analysis for this case is omitted as unnecessary.

3.3 Analysis Including Minimum Amount of Infrastructure Cost

As has been mentioned in 3-1. above, determination of the scope of the incremental cost of infrastructure chargeable to the Project is to some extent subject to the analyst's judgement and it is not claimed that the amount of incremental costs as used in the Final Report is the only correct figure. It will be useful, therefore, to try to find out the conceivable minimum (lower minimum) amount of such chargeable cost. As for the cost of improving Tanga Port, the minimum which is certain to be charged to the Project is that of constructing silos and loading facilities for soda ash, including a small office building and houses for the employees engaged in storing and loading soda ash. The cost of improving the existing railway facilities could be left out altogether as it may be deemed chargeable to the general operation of EAR if we can assume that the new Arusha-Musoma Line is constructed in time for and in such manner as it can be utilized for the Project. In that case, the passenger and cargo traffic on the existing Tanga-Arusha line may increase at a rate far exceeding the rate assumed in the Final Report and improvement and capacity expansion of the existing line might become necessary even without the Project.

As to the cost of construction of a new line between Arusha and Lake Natron, there are, generally speaking, two alternatives. One is to assume that the Route I in Fig. 8, Part III, which directly connects Arusha with the plant site, is constructed as part of the future Arusha-Musoma Line, as has been assumed in 3-2. above. In this case it is likely that its further extension westward will take the alignment indicated in the Attachment 2 and also as shown in

Fig. 1 below. (The alignment shown as the broken line between P_5 and P_3 is unlikely to be

Fig. 1. Assumed Alignment of Arusha-Musoma Line (Alternative 1)

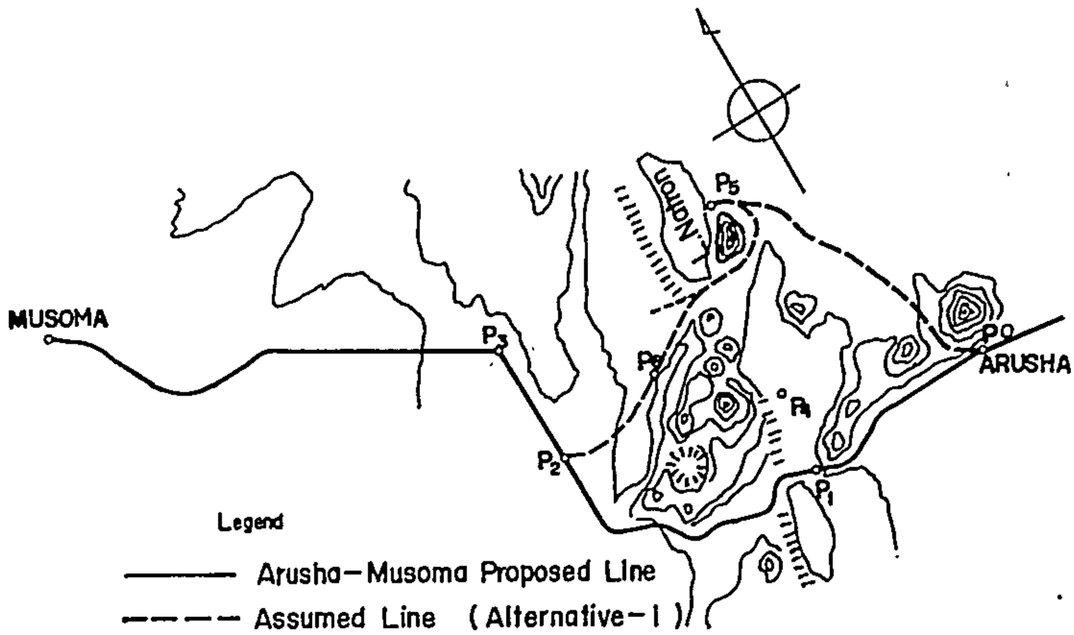
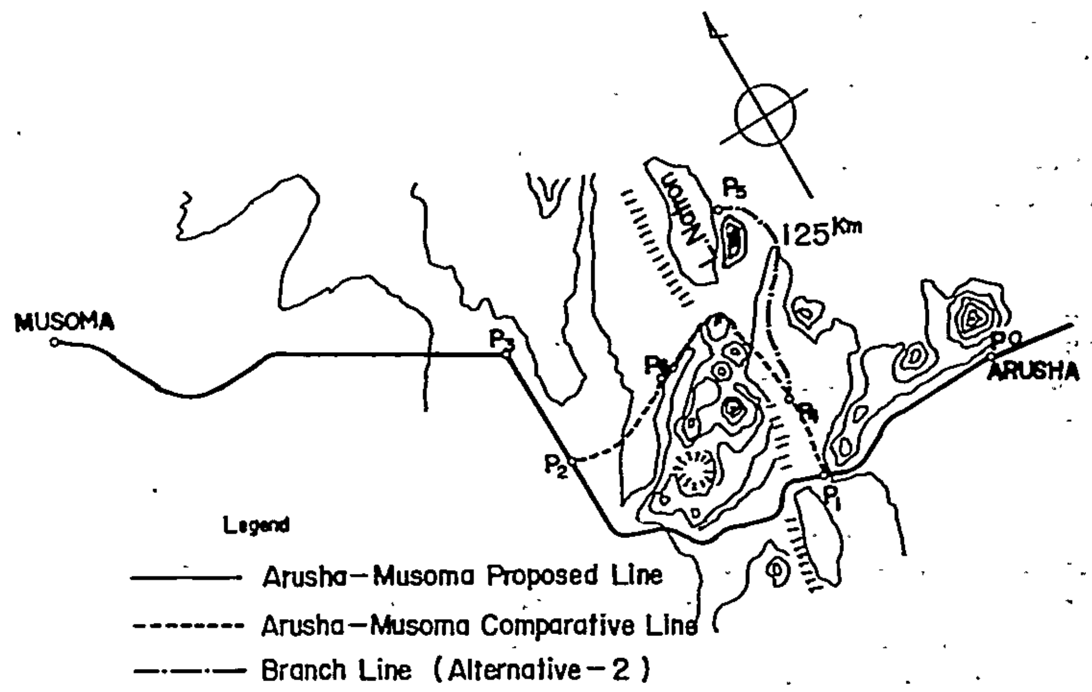


Fig. 2. Assumed Alignment of Arusha-Musoma Line and the Spur (Alternative 2)



adopted because the gradients are too steep.)

As a result of modifying the alignment in this manner, the route (P_0 - P_5 - P_6 - P_2) will be about 70 kilometers longer than the alignment originally proposed for Musoma Line, namely, P_0 - P_1 - P_2. Additional construction cost to be necessitated by selection of the alignment for the convenience of the Project is an incremental cost of the Project and should be charged to the Project. The amount of such incremental cost, though not yet identified, may be in the magnitude of US$60 million. This will make the total railway transportation cost per ton between Lake Natron and Tanga US$23.5 at the 8.5% discount rate and US$25.8 at the 10% discount rate.

Another alternative for the Arusha-Musoma Line is to use an alignment such as the one indicated in Fig. 2 below (see also Attachment 3) which follows the originally proposed route up to Lake Manyara, then sharply turns northward skirting Mt. 01 Donyo Lengai and then goes southwest up to Point 2.

This route is referred to as the Comparative Line. A spur could be branched out from the main line at Point 4, P_4 and P_5 is not so great as to create an unacceptable gradient. In this case, however, the length of the spur is 125 km and, although its construction cost is unknown, it may be in the magnitude of US$90 million and will have to be borne by the Project because the spur has no other use. In that case railway transportation cost from Lake Natron to Tanga will be US$31.9 at the 8.5% discount rate and US$35.4 at 10%.

In view of the above, it is fairly clear that neither of the two railway alternatives will produce any better results than the road and railway combination which the Final Report recommends. This will be shown in the following table.

Financial Cost per Ton of Soda Ash
(500,000 tons case)

Unit: US$/ton

	Discount rate of 8.5%					Discount rate of 10%				
	Plant	Rail	Road	Port	Total	Plant	Rail	Road	Port	Total
Alternative 1	68.2	23.5		5.6	97.3	73.1	25.8		6.3	105.2
Alternative 2	68.2	31.9		5.6	105.7	73.1	35.4		6.3	114.8
Road-Rail (case RR500)										
Final Report	68.2	9.2	13.1	7.5	98.0	73.1	9.9	14.5	8.5	106.0
Modified	68.2	6.8	13.1	5.6	93.7	73.1	7.1	14.5	6.3	101.0

Note: Details of this calculation are included in Attachments 4-1 and 4-2.

As is evident from the above table, the case of 500,000 tons will not be financially feasible even if the cost of infrastructure chargeable to the Project is kept at the minimum. Reduction of the infrastructure cost in this manner will not make the production scale of much less than a million tons financially feasible. At the most it would make the case of one million tons viable in the adverse situation wherein the operating rate of the plant goes down by, say, 10 to 20 percent. Although economic analysis has not been applied to the above cases, it will undoubtedly produce almost the same results and same conclusion.

4. Production

4-1 Location of Plant

The recommendation of the draft final report on the location of the plant was immediately accepted.

4-2 Access to the Plant

Please refer to section 3 above.

4-3 Capacity of the Plant

The optimum capacity of the purification plant should be decided, based on factors such as the size of the potential market for the product, the magnitude of the total investment, etc. The most important factor is whether the cost of the product is competitive in the international market.

As demonstrated in the report, study was made as to the feasibility of different capacities at the levels of 250,000 tons, 500,000 tons and 1,000,000 tons a year. As the result, the ex-factory price of $56.00 per ton was obtained at an annual capacity of a million tons and with the discount rate of 8.5%, while the FOB price at Tanga amounted to $77.70. This would mean that the product price is expected to be internationally competitive.

In case the capacity remains 250,000 tons to 500,000 tons, the FOB price would amount to $142.70 and $98.00 respectively at 8.5% as shown in Cases RR250 and R500. These prices are far above the internationally competitive level, making the project completely unfeasible.

Even the most favourable assumptions concerning infrastructure cost would not have the effect of substantially reducing the economical size of the plant. It would only have the effect of giving the plant of one million tons a more resisting power to adverse fluctuation of the rate of plant operation, as mentioned in 3-3 above.

In conclusion, with heavy reliance on export of the product, the Lake Natron Soda Ash Project will unavoidably involve a substantial scale of production capacity, through which the project can fully enjoy the advantage of scale. Thus, the annual capacity of the plant would become a million tons or a little less.

4-4 Purification

The realistic solution for the project will be a soda processing plant with purification facilities.

Suppose a process without purification is contemplated, it would consist of the mining process and calcination process only, with no further stages of production. This production scheme would bring about a product of lower grade similar to the soda ash manufactured at Lake Magadi in Kenya. This quality cannot be fully accepted in the international market due to its limited applications. Possible outlets for the product would therefore be drastically limited, and cannot but compete directly with the Magadi soda ash, which is being produced and transported more economically, as the plant and the transportation facilities for Magadi soda ash would have already been advantageously depreciated in comparison with the Lake Natron soda ash. This implies that a project lacking the purification process would not be price – competitive.

On the other hand, it must be noted that the process of purification of soda ash is an integrated series of chemical treatments which cannot be technically simplified or reduced in number.

In short there is no other alternative than the two, namely a project with purification process or the project without purification process. There is no possible compromise.

4-5 Energy

The fact that studies are being made in Tanzania as to the use of coal and geothermal energy is most encouraging and welcome, since the implementation of the Project will heavily depend on reliable and economical supply of energy for processing the product. Chapter 4, Part II of the Report has dealt with the scope of work relevant to the survey on the utilization of geothermal energy.

4-6 Housing

The average unit construction cost of Tsh. 2,990/m^2 for housing was determined taking into account the severe climatic conditions in the Lake Natron area and need for providing the following facilities and amenities in addition to the house buildings:

- land preparation,

- residential quarter roads with surface pavement,
- street lighting facilities,
- water and electricity supply apparatus,
- sewage system,
- planting of trees in the area of the residential quarters, and
- other essential community facilities.

The costs of the above facilities and amenities carry about the same weight as the house building and the average unit cost of Tsh. 2,990/m^2 is considered not be unreasonably expensive.

In addition, it should be noted that the housing cost is only a minor cost component when compared with the total construction cost of the Plant.

4-7 Water

It would be very convenient if ground water is available at a lower cost than the water from rivers. It must, however, be noted that the quality of the ground water has to be carefully checked to see whether it is suitable for use as process water. At the same time, any cost for treatment of the water must be considered .

4-8 Engineering Services

As mentioned in Table 5-1, Part II of the Report, the engineering service cost of US$25 million will have to cover not only the engineering for the equipment and machinery which are included within the battery limit of the process plant but a part of that cost for storage facilities such as silos, loading and unloading facilities etc. at Arusha and Tanga port the investment cost of which are classified as infrastructure costs for the sake of convenience in the Report.

In the case of RR1,000, for example, the items requiring the engineering services in the amount of US$ 25 million are shown as follows:

Case RR 1,000

	Million US Dollars
Process plant	183.6
Storage facilities at Arusha	5.0
Storage facilities at Tanga Port	26.1
Total	214.7

$$\frac{\text{25 million US dollars}}{\text{214.7 million US dollars}} = 11.6\%$$

If the above US$214.7 million can be considered as a construction cost which is directly related to the process plant, the amount of the engineering service fee will be only 11.6 percent of the construction cost. It is understandable that the engineering service cost for this project will be quite reasonably estimated.

4-9 Pilot Plant Cost

In the United States, there are now three natural soda ash producers, Stauffer Chemicals, Allied Chemicals and FMC. Magadi Soda is the only company producing natural soda ash in Africa. Three companies in the United States are producing soda ash equivalent to synthetic soda ash by purifying the trona soda.

The soda crust in Lake Natron is considerably different from the trona at Green River, Wyoming (USA) in the following ways;

(1) Formation processes of the ore
(2) Existing conditions of the ore
(3) Nature and content of impurities, especially organic matters and fluoride, contained in the ore

Please refer to Table 4-3 and 4-2-3-(3), Part II, of the Report.

It will be difficult, therefore, for the purification processes which are being used by the companies in the United States to be introduced for the purpose of purifying the soda crust in Lake Natron. It can be mentioned that apart from some petrochemical processes, there will be no purification process of natural soda ash which will be broadly applicable to almost any type of raw materials. It will be necessary that the purification process for the soda crust in Lake Natron be developed and brought up to commercial production scale level, by means of a pilot plant test.

As shown in Table 5-1-1-(8), Part II, of the Report, it will cost at least US$5 million to carry out the test with a pilot plant having a capacity of 1 ton/day and will take about 2 years including construction and operation.

The pilot plant test has to be performed consequently by the investors who will be interested in developing the Lake Natron soda ash project. It is quite natural that the expenses necessary for the pilot plant test have to be allocated to the project itself due to the fact that there will be no other proper entity in a position to bear such expenses, because of nature of the project.

4-10 Rough Cost Estimate of the Project

The suggested figure of US$150 million for the rough cost estimate can never be attained. Considering all the factors in this Appendix, the total amount of the project, US$318 million, may be reduced by only about 7%, at most, by reduction of infrastructure cost.

4-11 Time Schedule

The time schedule presented in the Report might be shortened to a certain extent, provided that the optimum cooperation and coordination are realized by and among the parties concerned. The feasibility study may be completed within two and a half years, if the necessary data on meteorology and hydrology are available.

The implementation period of the project after the completion of the feasibility study would be shortened by some three years, making the period only seven years, if and when the following conditions are fulfilled:

(1) The process development with a pilot plant is financed and carried out by the pilot company created by the project promotor(s), during the period of the feasibility study.

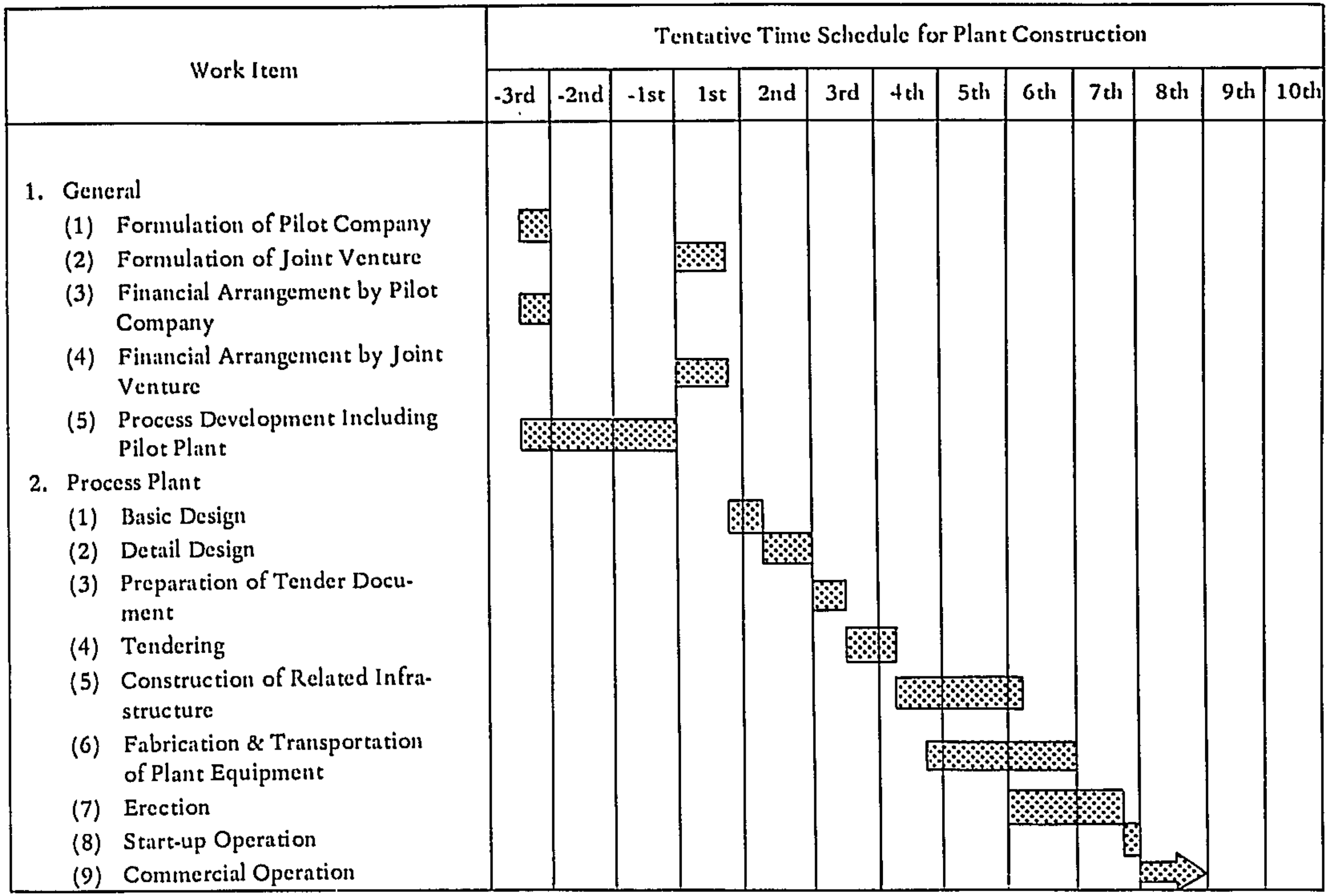
(2) Preparatory work is done for the formulation of the joint-venture which acts as project administrator in the stage of the feasibility study, and all necessary financial and marketing arrangements can be accomplished within six up to nine months' time after the positive decision is taken for the implementation of the project.

4-12 Market Studies

(a) The Tanzanian demand for soda ash is expected to amount to approximately 16,000 tons a year in the early 1980's. This figure is based upon the following reasoning. Tanzanian soda ash import has been recorded as shown below (source: Department of Mines, Feb. 1976).

1970	3,678 tons
1971	2,927
1972	3,948
1973	4,390
1974	6,527

Although the future projection of demand for soda ash in Tanzania is not available, the future forecast for "Caustic Soda" demand has been made as follows, showing that the demand will be doubled in ten years (source: Department of Mines, Feb. 1976)


Work Item
Tentative Time Schedule for Plant Construction
-3rd
-2nd
-1st
1st
2nd
3rd
4th
5th
6th
7th
8th
9th
10th
1. General
(1) Formulation of Pilot Company
(2) Formulation of Joint Venture
(3) Financial Arrangement by Pilot Company
(4) Financial Arrangement by Joint Venture
(5) Process Development Including Pilot Plant
2. Process Plant
(1) Basic Design
(2) Detail Design
(3) Preparation of Tender Document
(4) Tendering
(5) Construction of Related Infrastructure
(6) Fabrication & Transportation of Plant Equipment
(7) Erection
(8) Start-up Operation
(9) Commercial Operation

1975	5,732 tons
1976	6,057
1977	6,853
1978	7,503
1979	7,789
1980	8,944
–	–
1985	10,847

Based on a degree of similarity as chemicals between the two products, the estimated growth rate of caustic soda could be applied to that of soda ash with reasonable confidence for the purpose of making a rough estimate of soda ash demand. Upon this assumption, the demand for soda ash will double from 6,527 tons of 1974 to some 13,000 tons a year in 1985. This quantity, however, should be recognized as the result of natural increase of the demand in the already existing application fields.

In addition, the demand for soda ash in the industries emerging in the near future in Tanzania should also be considered. Those are primarily sheet-glass manufacturing and detergent production. The demand from these sources:

Sheet glass 1,400 tons/year	(capacity 7,000 tons x 0.2)
Detergent 1,560 tons/year	(capacity 7,200 tons x 0.22)
Total approx. 3,000 tons/year	

With the addition of this demand, it is estimated that the total demand for soda ash in Tanzania will reach 16,000 tons a year in the middle of the 1980's.

Pulp and paper as well as synthetic textiles and pharmaceuticals are known to be new fields which are planned to be established in Tanzania. Due to unavailability of the details on such plans, such as production capacity, etc., however, these specific industries cannot be taken into account at the moment in relation to the demand forecast of soda ash.

(b) Other African countries have demand for soda ash, but such demand has not reached a significant level. Kenya's exports to African countries are recorded as follows:

1972	23,000 tons
1973	23,000
1974	22,000

Exports to African countries by others are as shown below.

Unit: tons

	U.S.A.	France	W. Germany	U.S.S.R.	Japan	Total
1972	1,000	27,000	3,000	5,000	–	36,000
1973	7,000	38,000	6,000	4,000	–	55,000
1974	2,000	29,000	9,000	4,000 *	29,000	73,000

* estimated

These figures combined with those of Kenya make the total exports to African countries as listed below.

1972	59,000 tons
1973	78,000
1974	95,000

The current level of imports, around 100,000 tons, includes the markets in North and West Africa situated relatively far from East Africa. As to the market trends in the other continents of the world, observation and analysis have been made in the Report.

Attachment 1. Minutes

MINUTES OF THE FINAL MEETING HELD IN THE PRINCIPAL SECRETARY'S OFFICE MINISTRY OF WATER, ENERGY AND MINERALS TO DISCUSS JAPANESE DRAFT FINAL PRE-FEASIBILITY REPORT ON THE LAKE NATRON SODA ASH PROJECT – 9TH JUNE, 1976.

Present:

Ndugu F. Lwegarulila	Principal Secretary MWEM (Chairman)
Ndugu S.M. Mbilinyi	State House (Economic Affairs)
Ndugu F.S. Issa	Treasury
Ndugu S.L. Lwakatare	Stamico
Ndugu S.L. Bugaisa	Stamico
Ndugu A.E. Mboya	Communication
Ndugu M.S. Mujaya	Foreign Affairs
Ndugu A.J. Zidikheri	MWEM
Mr. J. Kano	Japanese Team Leader
Mr. F. Takeda	Japanese Team Leader of Infrastructure
Mr. K. Kawaguchi	Member of the Japanese Team from TOYO MENKA KAISHA LTD. NAIROBI
Mr. T. Takasu	Member of the Japanese Team
Mr. H. Kojima	Japanese Team Coordinator
Mr. M. Hashimoto	Representative of the Japanese Embassy Dar es Salaam
Mr. J.W. Adams	Representative from World Bank

Introduction:

The meeting was opened by the Chairman at 11:30 a.m. after his short introductory talk to inform the members the purpose of this meeting. He thanked the visiting Japanese Experts and Tanzanians from various institutions for their contributions made in the previous discussions on the Draft Final Report on Lake Natron Soda Ash. Further the Chairman reviewed and elaborated the final comments prepared by Tanzanian side on the said report. The comments as presented are in the attached appendix. [See paragraph 2 of this Report]

Conclusion:

After the discussion it was agreed that:

(a) the Japanese Experts will take into consideration all comments finally submitted by the Tanzania side while preparing the final report.

(b) the final report should come as an appendix to the already submitted Draft Final Report in order to save time in re-writing the report.

(c) In the preparation of the final report, the financial and economic analysis will give three alternatives as follows:

(i) Analysis of the project including infrastructure (This is what has been proposed as per present report)

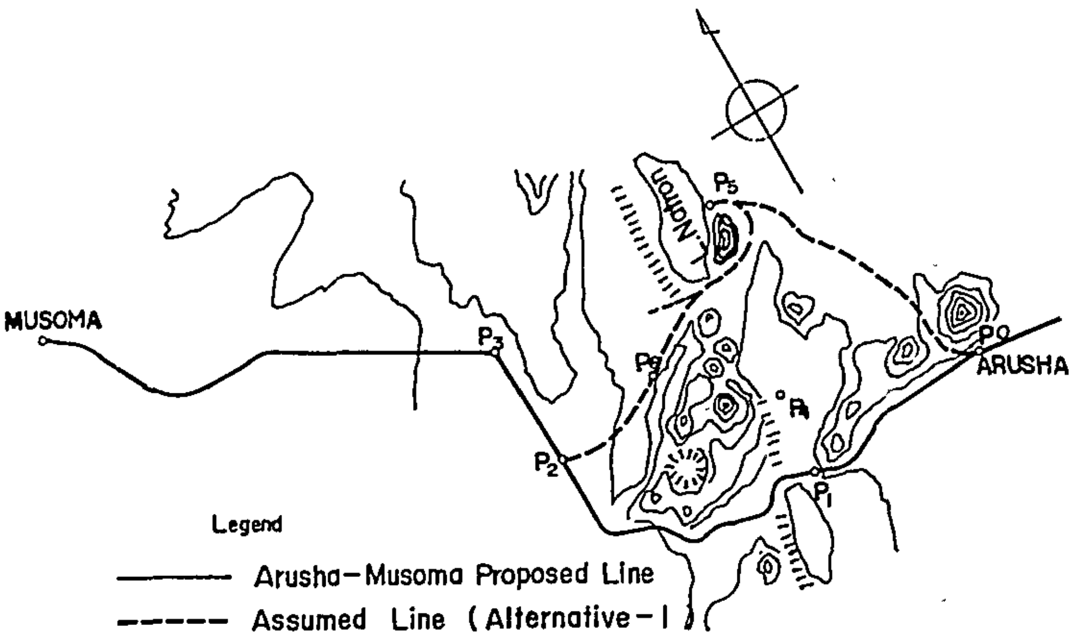
(ii) Analysis of the project excluding infrastructure (taking all the Tanzania side comments)

(iii) Analysis of the project taking a small portion of infrastrucure which is integral part of the Soda Ash Project.

The meeting closed at 2:00 p.m. after the Chairman's words of gratitude to the Japanese Team for the good work done to produce such self-contained big report in a such short period. Lastly he assured them of Tanzanian's willingness to co-operate with the Government of Japan for the betterment of the two peoples.

Attachment 2. Alternative - 1

This alignment is assumed for the benefit of Lake Natron project.



Distance

$P_0 \sim P_1 \sim P_2$	280 km
$P_0 \sim P_5 \sim P_6 \sim P_2$	350 km

Therefore, the length of the Assumed Line is 70 km longer than the Arusha-Musoma Proposed Line.

Calculation of Construction Cost

$$6{,}582^{\times 10^3 Tsh} \times 70\,km = 460{,}000^{\times 10^3 Tsh}$$

The estimation of construction cost per km is made as in the case of Route - 1 because of its similar location.

Engineering Fee (same as Route - 1)

$$54{,}056^{\times 10^3 Tsh} \times 70/150\,km = 25{,}000^{\times 10^3 Tsh}$$

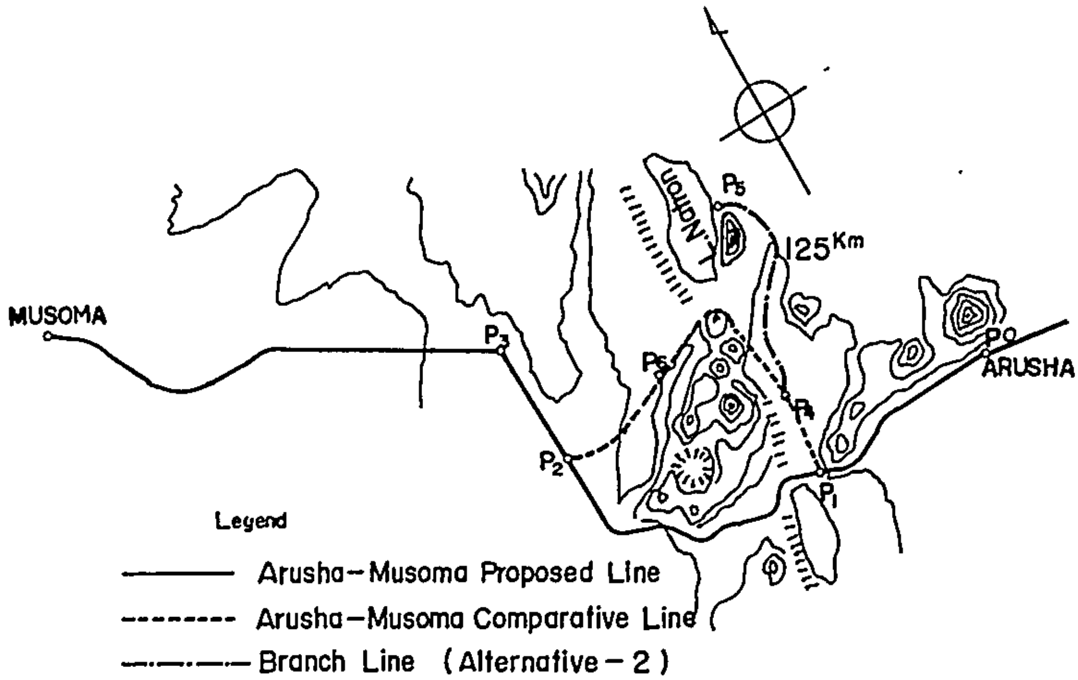
Investment Program

(x 10^3 Tsh)

Year	Engineering Fee	Construction Cost
-5	10,000	
-4	15,000	
-3		92,000
-2		230,000
-1		138,000

Attachment 3.   Alternative - 2

Arusha-Musoma Comparative Line is assumed and it is also assumed that a apur is constructed between P_4 and P_5.



The elevation of Arusha-Musoma Comparative Line and the Branch Line are the same at Point P_4.

Distance

$P_0 \sim P_1 \sim P_4$	150 km
$P_0 \sim P_1 \sim P_4 \sim P_5$	275 km

Therefore, the length of $P_4 \sim P_5$ is 125 km

Calculation of Construction Cost (assumed to be same as Route 2)

$5{,}504^{\times 10^3 Tsh} \times 125 \text{ km} = 688{,}000^{\times 10^3 Tsh}$

Engineering Fee (same as Route 2)

$54{,}772^{\times 10^3 Tsh} \times 125/181 \text{ km} = 38{,}000^{\times 10^3 Tsh}$

Investment Program

(x 10^3 Tsh)

Year	Engineering Fee	Construction Cost
-6	15,200	
-5	22,800	
-4		68,800
-3		206,400
-2		309,600
-1		103,200

Attachment 4-1. Calculation – Railway

Detailed Calculation of Modified Financial Cost of Soda Ash – Railway Transportation (500,000 tons)

(x 10^3 Tsh)

	Excluding Infrastructure Cost						Assumed Line (Alternative - 1)						Branch Line (Alternative - 2)						Combination of Rail and Road					
	Engineering & capital cost	Operting cost	Maintenance cost	Total	Present worth 8.5%	Present worth 10.0%	Engineering & capital cost	Operting cost	Maintenance cost	Total	Present worth 8.5%	Present worth 10.0%	Engineering & capital cost	Operating cost	Maintenance cost	Total	Present worth 8.5%	Present worth 10.0%	Engineering & capital cost	Operating cost	Maintenance cost	Total	Present worth 8.5%	Present worth 10.0%
-6													15200			15200	24791	26934						
-5							10000			10000	15040	16110	22800			22800	34291	36731						
-4							15000			15000	20790	21960	68800			68800	95367	100723						
-3							92000			92000	117484	122452	206400			206400	263573	274718						
-2							230000			230000	270710	278300	309600			309600	364399	374616						
-1	120072			120072	130278	132079	258072			258072	280008	283879	239370			239370	259716	263307	98156			98156	106499	107972
1		12524	21563	34087	34087	34087		12524	21563	34087	34087	34087		15133	23795	38928	38928	38928		9108	8309	17417	17417	17417
2		12524	21563	34087	31428	30985		12524	21563	34087	31428	30985		15133	23795	38928	35892	35386		9108	8309	17417	16058	15830
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10					277230	248562					277230	248562					316601	283863					141652	127005
11																								
12																								
13																								
14																								
15																								
16																								
17																								
18																								
19																								
20	120072	12524	21563	154159	32682	25282	120072	12524	21563	154159	32682	25282	136170	15133	23795	175098	37121	28716	98156	9108	8309	115573	24501	18954
21	-6004	12524	21563	28083	5504	4184	-6004	12524	21563	28083	5504	4184	-6809	15133	23795	32119	6295	4786	-4908	9108	8309	12509	2452	1864
22																								
23																								
24																								
25																								
26					37598	27031					37598	27031					42938	30871					19211	13812
27																								
28																								
29																								
30	-60036	12524	21563	-25949	-2439	-1635	-60036	12524	21563	-25949	-2439	-1635	-68085	15133	23795	-29157	-2741	-1837	-4908	9108	8309	31661	-2976	-1995
Total					546368	500575					1120122	1091197					1517171	1497742					324814	300861

Financial Cost per Ton	Excluding Infrastructure Cost		Assumed Line (Alternative - 1)		Branch Line (Alternative - 2)		Combination of Rail and Road	
	8.5%	10%	8.5%	10%	8.5%	10%	8.5%	10%
Tsh.	93.71	96.55	192.12	210.46	260.22	288.87	55.71	58.03
US$	11.48	11.83	23.54	25.79	31.89	35.40	6.83	7.11

Attachment 4-2. Calculation – Port

Detailed Modified Calculation – Port Transportation Cost

Year	Costs Tshs	Discount Factor at 8.5%	PV discounted at 8.5%	Discount Factor at 10%	PV discounted at 10%
-10		2.260983		2.593742	
-9		2.083856		2.357948	
-8		1.920604		2.143589	
-7		1.770142		1.948717	
-6		1.631468		1.771561	
-5		1.503657		1.61051	
-4		1.385859		1,4641	
-3	4,473,700	1.277289	5,714,208	1.331	5,954,495
-2	61,587,000	1.177225	72,501,756	1.210	74,520,270
-1	120,868,400	1.085	131,142,214	1.100	132,955,240
1	7,386,000	1.000	7,386,000	1.000	7,386,000
2	7,386,000	0.921659	6,807,373	0.9090	6,714,539
3	4,452,000	0.849455	3,781,774	0.826446	3,679,338
4	4,452,000	0.782908	3,485,506	0.751315	3,344,854
5	4,452,000	0.721574	3,212,447	0.683013	3,040,774
6	4,452,000	0.665045	2,960,780	0.020921	2,764,340
7	4,452,000	0.612945	2,768899	0.564474	2,513,038
8	4,452,000	0.564926	2,515,051	0.513158	2,284,579
9	4,452,000	0.520670	2,318,023	0.466507	2,076,889
10	4,452,000	0.479880	2,136,426	0.424098	1,888,084
11	4,452,000	0.442286	1,969,057	0.385543	1,716,437
12	4,452,000	0.407636	1,814,795	0.350494	1,560,399
13	4,452,000	0.357702	1,592,489	0.318631	1,418,545
14	4,452,000	0.346269	1,541,590	0.239664	1,289,584
15	4,452,000	0.319142	1,420,820	0.263331	1,172,350
16	4,452,000	0.294140	1,309,511	0.239392	1,065,773
17	4,452,000	0.271097	1,206,924	0.217629	968,884
18	4,452,000	0.249859	1,112,372	0.197845	880,806
19	4,452,000	0.230284	1,025,224	0.179859	800,732
20	4,452,000	0.212244	944,910	0.163508	727,938
21	4,452,000	0.195616	870,882	0.148644	661,763
22	4,452,000	0.180292	802,660	0.135131	601,603
23	4,452,000	0.166167	739,775	0.122846	546,910
24	4,452,000	0.153150	681,824	0.111678	497,190
25	4,452,000	0.141152	628,409	0.101526	451,994
26	4,452,000	0.130094	579,178	0.092296	410,902
27	4,452,000	0.119902	533,804	0.083905	373,545
28	4,452,000	0.110509	491,986	0.076278	339,590
29	4,452,000	0.101851	453,441	0.069343	308,715
30	4,452,000	0.093872	417,918	0.063039	280,650
Total			266,868,026		265,196,750

Cost per ton (annualized at 8.5%)

$$\frac{266.868,026}{500,000 \times 1.085 \times 10.747} = 45.773 \text{ Tshs/ton}$$

$$= 5.609 \text{ US\$/ton}$$

Cost per ton (annualized at 10%)

$$\frac{265,196,750}{500,000 \times 1.10 \times 9.427} = 51.148 \text{ Tshs/ton}$$

$$= 6.268 \text{ US\$/ton}$$

(1 US$ = 8.16 Tshs)