Chapter 13 Construction Costs

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13–1 Chemical Engineering Industry in Zimbabwe

Zimbabwe has had a considerable amount of experience in civil construction and building construction and the capability of designing and construction in this field has been well proven. However, construction of chemical plants in Zimbabwe is different from ordinary construction. Since the market is not large enough, there is no chemical engineering firm in Zimbabwe that specializes in the design and construction of chemical plants. For the construction of chemical plants in Zimbabwe, in most cases consultant and engineering firms that specialize in architecture and civil construction become the main contractors and they, in turn, subcontract to equipment makers for each unit of the process by individual contracts.

13–2 Construction Work

13–2–1 Procurement of Equipment and Materials

(1) Outline of equipment

Specifications of the equipment required for this plant and the demarcation of import or domestic purchase are shown in Table 13–2 "Equipment List". Citric acid production processes for this study are divided into the following four areas:

- Area 100 : Fermentation process
- Area 200 : Separation process
- Area 300 : Utilities facilities
- Area 400 : Environmental protection facilities

The equipment for areas 200, 300 and 400 is the same as that used widely for ordinary chemical processes and consists of centrifuges, evaporators, crystallizers, dryers and so on. On the other hand, the fermentation process (area 100) is one which utilizes biochemical reactions of microorganisms and consists of so-called biotechnology equipment. The equipment required for the fermentation process such as the fermenters, the air filters, the continuous sterilizers are designed and manufactured based on biochemical engineering know-how. All of the equipment used for the fermentation process is made of stainless steel to prevent contamination by bacteria and to avoid corrosion by citric acid.

(2) Procurement of equipment and materials

For this study, products made in Zimbabwe have been considered as much as possible. Procurement methods for the equipment and materials are summarized as follows:

(a) Steel

Zimbabwe produces ordinary steels but does not produce special steels such as thick steel plates, large rolled steel sections, and seamless steel pipes. Stainless steel used for the equipment in the fermentation process is not manufactured in Zimbabwe and has to be imported from the Republic of South Africa or other countries. Zimbabwean fabricators of stainless steel equipment are not always satisfied with the quality of the stainless steel material made in the Republic of South Africa and they hope to import better quality material from Europe or Japan. However, due to the constraints of foreign currency allocations, stainless steels from Europe or Japan are not imported. For construction of this plant, equipment made of high quality stainless steel is essential, and therefore most of the stainless steel equipment and materials will have to be imported.

(b) Cement and concrete

Storage ponds for process water and various ponds for the waste water treatment facilities are made of reinforced concrete. Cement is produced in Zimbabwe but it is always in short supply. The construction schedule of this plant should not be interrupted by a shortage of cement. Domestic cement will be used for this plant and it will be necessary to secure sufficient cement beforehand.

(c) Pumps

A number of pumps are required for transferring liquid and slurry in this plant. Centrifugal pumps made of carbon steel and stainless steel (stainless steel impellers are imported) are manufactured in Zimbabwe. All pumps used for this plant will be made in Zimbabwe. It is necessary to select good quality pumps, especially for use with slurry.

(d) Filters

For this process, filters are required to eliminate bacteria from the air and a vacuum filter is required for the separation process. It is considered that these filters will have to be imported.

(e) Continuous steam sterilizer

The continuous steam sterilizer consists of plate type heat exchangers. This equipment will be imported.

(f) Fermenters

The fermenters used in this process are aerated and agitated fermentation equipment operated under sterilized conditions. However, they are quite different from the fermentation equipment used for brewing beer and wine. For manufacturing this equipment, advanced techniques are necessary to satisfy the following requirements:

- High precision welding to withstand the heavy agitation load and advanced techniques in the construction of the agitator.
- Design and fabrication techniques for medium and large size stainless steel pressure vessels (the fermenters are operated under pressure).
- Fabricating and finishing techniques for the inside of the vessels to prevent contamination by bacteria.
- Appropriate design, welding and heat treatment techniques for anti-corrosion purposes (the fermenters are subjected to high temperatures during sterilization and to corrosive conditions due to the citric acid produced in the process).

The main fermenters used in this process have volumes as large as 240 cubic meters. They are approximately 5.3 meters in diameter and 15 meters in height and weigh about 65 tons. Stainless steel vessel fabricators in Zimbabwe have not manufactured this kind of large vessel. Therefore, for this study, it is considered that the main fermenters (240 kℓ in volume) will be imported. The first seed tank (1.7 kℓ in volume) and the second seed tank (20 kℓ in volume), both relatively small in size, can be manufactured in Zimbabwe by giving appropriate guidance to local stainless steel vessel fabricators.

(g) Evaporator

The evaporator consists of a shell and tube heat exchanger, evaporating chamber, circulating pump and vacuum generating equipment. In view of the supply of stainless steel and the design and fabrication capability of the local fabricators, the evaporator will be imported.

(h) Centrifuges

Centrifuges are required in various parts of the process for the separation of liquids and solids. Special techniques are required for the design and fabrication of this equipment and a small number of makers monopolise the market. It is considered that these centrifuges should be imported.

(i) Air compressors

One process air compressor and one instrument air compressor are required. In order to prevent oil carry-over, oil free type compressors are needed. The compressors must be equipped with a dryer. It is desirable to import compressors manufactured by a well-known international vendor.

(j) Atmospheric vessels

In the citric acid production process, a number of unpressurized carbon steel vessels and stainless steel vessels are used. It is possible to use locally manufactured vessels.

(3) Transportation of equipment

Importation of equipment to Zimbabwe is usually either through the port of Beira in Mozambique or the port of Durban in the Republic of South Africa. The transportation distance to the planned plant site in Harare is shorter from Beira than from Durban. However, unloading facilities for heavy equipment are readily available in the port of Durban, and therefore heavy pieces of equipment are usually imported through Durban. For this project, it is planned that the equipment and materials required for the construction of this plant will be imported through the port of Durban. Inland transportation is either by truck or by railway. For the railways, dimensions are restricted to 3 meters in width, 2.95 meters in height above the deck, 11.3 meters in length and 10 tons in weight (the weight can be increased by negotiation with the authorities) and so transportation by rail is not recommendable for large size equipment. The normal restrictions for road transportation by truck are 3.85 meters in width, 4.5 meters in height above the road surface, 18.2 meters in length and 28 tons in weight. In special cases, if the permission of the road authorities is granted, larger equipment exceeding these dimensions can be transported provided the route is surveyed beforehand to make sure it is safe. In view of the above, it is planned that the large equipment will be transported by road. The largest pieces of equipment for this plant are the main fermenters and the broth tank and their volumes are all 240 kℓ. The diameter of the cylindrical portion is 5.3 meters. A number of nozzles are installed and project from the cylindrical portion so that when laid down horizontally for transportation, the maximum height will be about 5.6 meters. The main fermenters are manufactured by an advanced fabricating technique and it is not practical to fabricate them by field welding at the construction site. Therefore, the main fermenters will be imported, unloaded at the port of Durban and transported to the construction site by large trailer trucks.

13-2-2 Installation and Pipe Work

(1) Installation of equipment

The largest piece of equipment used for the citric acid plant is about 5.3 meters in diameter, 15 meters in length and 65 tons in weight. In the light of the actual construction experience of large thermal power plants and various heavy and chemical industries in Zimbabwe, installation of the equipment required for this plant should not present any serious problems. The equipment installed inside the buildings has to be moved in and installed in place during the construction phase of the buildings, so that careful schedule coordination is required.

(2) Procurement of piping materials

Since piping materials are in short supply in Zimbabwe, it is necessary to make good preparations beforehand and to secure a sufficient quantity of piping materials, so that the construction schedule is not delayed for this reason.

(3) Pipework

For the fermentation process, a unique design and construction know-how is required to avoid contamination by unwanted bacteria or fungi. The detailed contents cannot be illustrated on drawings so the supervision of experienced engineers is required at the construction site. If irregularities are produced on the inner surface of the pipe by welding distortions, these uneven parts can become contaminated by bacteria. Therefore, it is very important to hire highly skilled welders for the pipework.

(4) Insulation work

Weather in Zimbabwe is mild in general. Hot and cold insulation work are relatively easy. This plant produces food additives, so insulating materials which include asbestos will not be used.

(5) Painting work

The specification for painting is, in principle, the usual requirement for general painting. However, the portions which may be corroded by citric acid will be painted with anti-corrosive paint.

13–2–3 Electrical and Instrument Work

Recently, many chemical plants have adopted computer control systems. However, a highly sophisticated electronic instrumentation system is not required for this plant. Conventional control systems have been adopted in view of easy maintenance and local availability of replacement parts. Using conventional instruments will have the advantage that experience of instrument work done for the existing factories in Zimbabwe can be used.

13–2–4 Construction and Civil Work

(1) Soil conditions around Harare

Soil around the city of Harare is very strong and there are no earthquakes. The Mukuvisi district, where it is planned to locate the plant, is on firm ground consisting of gravel and coarse sand and piling is not required for the construction of the plant buildings.

(2) Outline of building and procurement of materials

Large size rolled steel sections are imported in Zimbabwe and in this study the buildings and structures are all made of reinforced concrete, to avoid the use of steel sections. Domestic bricks are to be used for the walls. Since Zimbabwe is not a seismic country, the reinforced concrete structure will be adequate. Materials containing asbestos will not be used for the walls and roof because the plant produces food additives. Shortage of cement is a problem in Zimbabwe. The supply of cement should be well planned and also should the supply of stainless steel materials. Plate glass is also reported to be in short supply. Therefore, procurement and logistics for these construction materials should be well planned beforehand. Piperacks will be made of steel, because it is difficult to attach a reinforced concrete piperack to the building structure.

(3) Design, administration and execution of construction work

There are a number of architect consultants and engineering firms who design, administrate and execute the construction of large buildings and factories and they are proud of their distinguished records. These firms are performing the engineering functions of chemical plant construction. There are also a number of contractors who are subcontracted to carry out various tasks under the supervision of these architect consultant firms. There is no problem regarding the capabilities of these consulting firms and contractors.

13-2-5 Procurement of Laboratory Equipment

Analysis equipment is required for this plant as for any other chemical plant. This includes equipment for acceptance inspection of raw materials, control of the production process, quality inspection of intermediate products, quality inspection of final product and packaging materials, and miscellaneous analyses for environmental control. Most of the laboratory equipment will be imported.

13-2-6 Construction Schedule

The construction period for this kind of plant is generally about two years after signing a construction contract. It is possible to construct this plant in two years if there is no shortage of materials and funds. The overall construction schedule is shown in Figure 13-1.

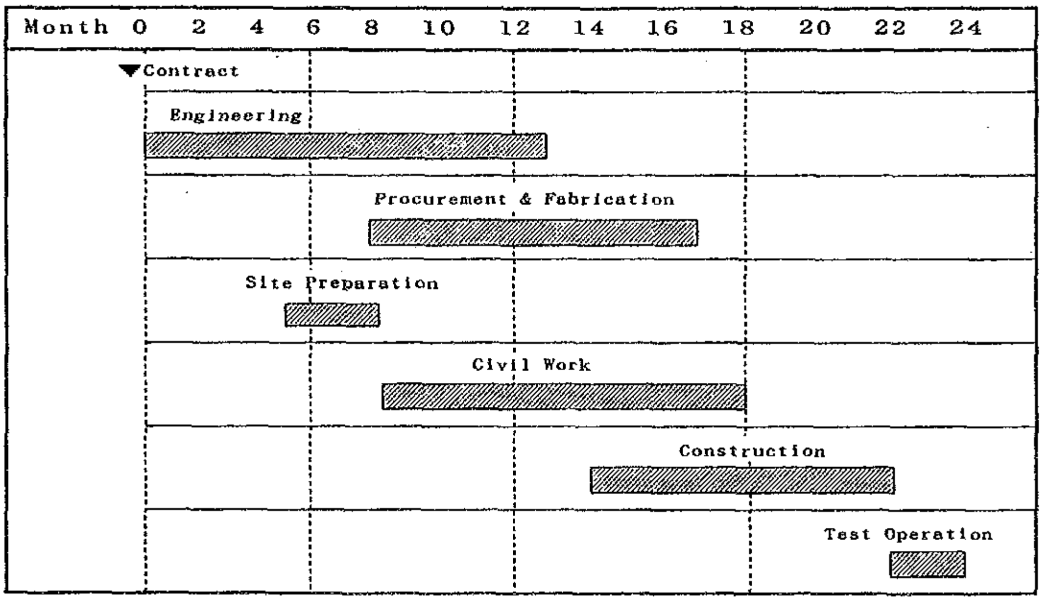

Figure 13-1 Master Schedule

13–3 Estimation of Construction Costs

13–3–1 Assumptions for Cost Estimation

The estimation of the construction cost is based on the cost information obtained during the field survey conducted in 1991. The estimation of the Zimbabwe local currency portion is based on local data and information as far as possible. There are some items for which local data and information were not available due to insufficient statistical data, price fluctuations due to inflation and the devaluation of the local currency, extreme price differences due to difference of distribution routes and so on. The cost of those items for which local data were not available have been estimated based on Japanese price data and information. Imported items are estimated based on procurement in Japan, ocean freight to Durban, and road transport by truck from Durban to Harare. The construction work is estimated assuming that local consultant engineering firms will do the building and civil construction work under supervision of specialists dispatched from a process licenser.

The local currency portion is estimated in Zimbabwean dollars (Z$) and the foreign portion is estimated in Japanese Yen and converted to U.S. dollars using the following conversion rates:

- US$1 = 3.15 Z$
- US$1 = 132 Yen

13–3–2 Estimation of Construction Costs

(1) Cost of land and preparation costs

The cost of the land for this plant is based on the unit price of 61.7 Z$/$m^2$, calculated for the total required area of 27,250 square meters and the unit cost of land preparation is assumed to be 12.5 Z$/$m^2$. The cost of acquiring the required area and the preparatory work are calculated by multiplying by these unit costs.

(2) License fee

For the design and construction of the citric acid plant, it is necessary to acquire technology (supply of fungus, conservation methods for the fungus, fermentation conditions, and other various know-how) from a licenser. Production technology for citric acid is not generally sold and the price cannot be estimated from actual contract records. For this study, a license fee of one million U.S. dollars is estimated, by referring to an actual example for the sale of technology for amino acid production and other cases.

(3) Engineering fees

It is assumed that a Japanese engineering firm will prepare the basic design package based on the information and data from the licenser and Zimbabwean consulting and engineering firms will carry out the detailed design. The cost for the basic engineering and the detailed engineering are estimated at US$ 727,000 and US$ 644,000, respectively.

The cost for the detailed engineering includes US$ 390,000 which is required for dispatching engineers from the firm which carried out the basic engineering and is broken down as follows:

- Air tickets : US$ 165,000
- Living expenses : US$ 45,000
- Personnel costs : US$ 180,000

Total : US$ 390,000

The foreign currency portion is the cost for the basic engineering, air travel and salaries.

(4) Cost of equipment

The cost of all imported equipment is estimated based on purchase in Japan and ocean freight to Durban. CIF costs at Durban (including the design costs of the equipment) and the costs of the locally procured equipment, delivered to the plant site, are summarized in Table 13–1. Also lists for major equipment are shown in Table 13–2.

Table 13–1 Summary of Machinery and Equipment Costs, US$

	Foreign	Local	Total
Fermentation	3,677,000	549,000	4,226,000
Separation	2,412,000	1,747,000	4,159,000
Utilities	202,000	833,000	1,035,000
Environmental Control	0	743,000	743,000
Laboratory Equipment	78,000	15,000	93,000
Total	6,369,000	3,887,000	10,256,000

Table 13–2 List for Major Equipment (1/7)

Process Area : 100
Process Name : Fermentation

Equip. No.	Service	Quantity	Specification	Material	Import/ Domestic
101	Starch Make-up Tank	1	Vertical Cylinder Vessel with Agitator, 100 m^3	CS	D
102	Starch Milk Pump	1	10 $m^3/h \times 30$ mH	CI	D
103	Jet Cooker	1	Steam Injector, 10 m^3/h	SS304	D
104	Reaction Tank	2	Vertical Cylinder Vessel with Agitator, 120 m^3	SS304	D
105	Liquified Solution Pump	1	10 $m^3/h \times 20$ mH	SS304	D
106	Medium Make-up Tank	1	Vertical Cylinder Vessel with Agitator, 10 m^3	SS304	D
107	Sterilizing Pump	2	10 $m^3/h \times 50$ mH	SS304	D
108	Medium Pump	1	5 $m^3/h \times 30$ mH	SS304	D
109	Continuous Sterilizer	1	Plate Heat Exchanger Unit, 10 $m^3/h \times 4$ kg/cm^2G	SS304	I
110	First Seed Tank	1	Vertical Cylinder Vessel with Jaket & Agitator, 1.7 m^3	SS304, Jct: CS	D
111	First Air Filter	1	Depth Type Filter, 0.07 m^3	CS	D
112	Second Seed Tank	1	Vertical Cylinder Vessel with Jaket & Agitator, 20 m^3	SS304, Jct: CS	D
113	Second Air Filter	1	Depth Type Filter, 0.4 m^3	CS	D
114	Main Fermenter	3	Vertical Cylinder Vessel with Cooling Coil & Agitator, 240 m^3	SS304/316	I
115	Main Fermenter Air Filter	3	Depth Type Filter, 4 m^3	CS	D
116	Broth-out Pump	1	50 $m^3/h \times 20$ mH	SS304	D
117	Process Air Compressor	1	Oil-free Compressor with Instruments, 10,000 $Nm^3/h \times 2.3$ kg/cm^2G	---	I
118	Hot Water Tank	1	Vertical Cylinder Vessel, 50 m^3	CS	D
119	Hot Water Pump	1	50 $m^3/h \times 20$ mH	CI	D
120	Fork Lift	2	Engine Drive, 1,000 kg	---	D
121	Hoist	1	1,000 kg × 10 mH	---	D
122	Balance	1	Full Scale 100 kg	---	D
123	Balance	1	Full Scale 10 kg	---	D

Material CS : Carbon Steel, CI : Cast Iron, SS : Stainless Steel
RL : Rubber Lining, RC : Reinforced Concrete

Table 13–2 List for Major Equipment (2/7)

Process Area : 200
Process Name : Separation (1/3)

Equip. No.	Service	Quantity	Specification	Material	Import/ Domestic
201	Broth Tank	1	Vertical Cylinder Vessel with Air Spurger, 240 m^3	SS304	D
202	Broth Pump	1	10 $m^3/h \times 20$ mH	SS304	D
203	Mycelium Filter	1	Rotary Vaccum Precoat Filter with Vaccum Pump, 10 m^3/h, 8 m^2	SS304	I
204	Precoat Tank	1	Vertical Cylinder Vessel with Agitator, 1 m^3	SS304	D
205	Precoat Pump	1	2 $m^3/h \times 10$ mH	SS304	D
206	First Filtrate Tank	1	Vertical Cylinder Vessel, 50 m^3	SS304	D
207	First Filtrate Pump	1	10 $m^3/h \times 30$ mH	SS304	D
208	Filter Press	1	20 m^2	CI + RL	D
209	Second Filtrate Tank	1	Vertical Cylinder Vessel, 50 m^3	SS304	D
210	Second Filtrate Pump	1	10 $m^3/h \times 30$ mH	SS304	D
211	Slaked Lime Slurry Tank	1	Vertical Cylinder Vessel with Agitator, 30 m^3	CS	D
212	Slaked Lime Pump	1	3 $m^3/h \times 10$ mH	CI	D
213	Neutralization Tank	3	Vertical Cylinder Vessel with Agitator, 25 m^3	SS304	D
214	Neutralized Slurry Pump	1	10 $m^3/h \times 20$ mH	SS304	D
215	Calcium Citrate Filter	3	Nutch Type Filter with Vaccum Pump, Turn-over Discharge, 5 m^2	SS304	D
216	Conveyor	3	Screw Conveyor, 3 ton/h × 8 mL	SS304	D
217	Incline Conveyor	1	Incline Screw Conveyor, 3 ton/h × 8mL	SS304	D
218	Sulfuric Acid Tank	1	Vertical Cylinder Vessel, 25 m^3	CS	D
219	Sulfuric Acid Pump	1	1 $m^3/h \times 20$ mH	CI	D
220	Acidification Tank	3	Vertical Cylinder Vessel with Agitator, 12 m^3	SS304	D
221	Acidified Slurry Pump	1	5 $m^3/h \times 20$ mH	SS304	D
222	Centrifuge	3	Basket Type Centrifuge, Bottom Discharge, 48 inches ø	SS304	I
223	Conveyor	1	Screw Conveyor, 2 ton/h × 8 mL	SS304	D

Material CS : Carbon Steel, CI : Cast Iron, SS : Stainless Steel
RL : Rubber Lining, RC : Reinforced Concrete

Table 13–2 List for Major Equipment (3/7)

Process Area : 200
Process Name : Separation (2/3)

Equip. No.	Service	Quantity	Specification	Material	Import/ Domestic
224	Incline Conveyor	1	Incline Screw Conveyor, 2 ton/h × 8 mL	SS304	D
225	Citric Acid Solution Tank	1	Vertical Cylinder Vessel, 20 m^3	SS304	D
226	Citric Acid Solution Pump	1	10 m^3/h × 30 mH	SS304	D
227	Filter Press	1	20 m^2	CI + RL	I
228	Filtrate Tank	2	Vertical Cylinder Vessel with Agitator, 20 m^3	SS304	D
229	Filtrate Pump	1	5 m^3/h × 20 mH	SS304	D
230	First Evaporator	1 set	Vaccum Evaporator with Steam Heater, Steam Ejector, Barometric Condensor, Pumps & CIP System. Evaporation 2 ton/h	SS316L	I
231	First Crystallizer	2	Vertical Cylinder Vessel with Jacket & Agitator, 10 m^3	SS316L, Jct: CS	D
232	First Crystallizer Pump	1	2 m^3/h × 20 mH	SS316	D
233	First Centrifuge	2	Basket Type Centrifuge, Bottom Discharge, 48 inches ø	SS304	I
234	First Mother Liquor Tank	1	Vertical Cylinder Vessel with Agitator, 20 m^3	SS304	D
235	First Mother Liquor Pump	1	5 m^3/h × 20 mH	SS304	D
236	Second Evaporator	1 set	Batch Vaccum Evaporator with Steam Heater, Steam Ejector & Barometric Condenser. Evaporation 0.5 ton/h	SS316L	I
237	Second Crystallizer	1	Vertical Cylinder Vessel with Jacket & Agitator, 10 m^3	SS316L, Jct: CS	D
238	Second Crystallizer Pump	1	2 m^3/h × 20 mH	SS316	D
239	Second Centrifuge	1	Basket Type Centrifuge, Bottom Discharge, 48 inches ø	SS304	I
240	Second Mother Liquor Tank	1	Vertical Cylinder Vessel with Agitator, 10 m^3	SS304	D
241	Second Mother Liquor Pump	1	5 m^3/h × 20 mH	SS304	D
242	Decolorization Tank	3	Vertical Cylinder Vessel with Jacket & Agitator, 20 m^3	SS304, Jct: CS	D
243	Decolorization Pump	1	5 m^3/h × 30 mH	SS304	D
244	Carbon Filter	1	Leaf Type Filter, 10 m^2	SS304	I

Material CS : Carbon Steel, CI : Cast Iron, SS : Stainless Steel
RL : Rubber Lining, RC : Reinforced Concrete

Table 13–2 List for Major Equipment (4/7)

Process Area : 200
Process Name : Separation (3/3)

Equip. No.	Service	Quantity	Specification	Material	Import/ Domestic
245	Precoat Tank	1	Vertical Cylinder Vessel with Agitator, 500 ℓ	SS304	D
246	Precoat Pump	1	2 $m^3/h \times 10$ mH	SS304	D
247	Polish Filter	1	Sparkler Filter, 1 m^2	SS304	I
248	Final Crystalizer	2	Vertical Cylinder Vessel with Jacket & Agitator, 10 m^3	SS316L, Jct: CS	D
249	Final Crystalizer Pump	2	2 $m^3/h \times 20$ mH	SS316	D
250	Final Centrifuge	2	Basket Type Centrifuge, Bottom Discharge, 48 inches ø	SS316	I
251	Final Mother Liquor Tank	1	Vertical Cylinder Vessel with Agitator, 20 m^3	SS304	D
252	Final Mother Liquor Pump	1	5 $m^3/h \times 20$ mH	SS304	D
253	Conveyor	1	Screw Conveyor with 2 Wet Hoppers, 500 kg/h (wet crystal) × 6 mL	SS304	D
254	Dryer Unit	1	Rotary Dryer with Air Heater unit, Fan, Dust Collecter & Rotary Valves, 500 kg/h	SS316	I
255	Lifter	1	Pneumatic Lifter with Blower, Cyclone, Dust Collecter & Rotary Valves, 500 kg/h (dry crystal)	SS304	I
256	Storage Hopper	1	Vertical Cylinder Vessel, 30 m^3	SS304	D
257	Sifter	1	Vibrating Screen Sifter, 1,500 kg/h	SS304	I
258	Balance	1	Industrial Balance with Hopper, Range: 0 ~ 50 kg, Mnimum Leading: 20 g	---	I
259	Heat Sealer	1	Industrial Heat Sealer	---	I
260	Sewing Machine	1	Industrial Sewing Machine	---	I
261	Chiller	1 set	Turbo Compressor Type, 350,000 kcal/h, Outlet Water Temp. 10°C	---	I
262	Chiller Pump	1	50 $m^3/h \times 20$ mH	CI	D
263	Fork Lift	2	Engine Drive, 1,000 kg	---	D
264	Hoist	2	1,000 kg × 10 mH	---	D
265	Waste Solid Carrier	6	Steel Box with Wheels, Hand Push Carry. Capacity: 2 m^3	CS	D

Material CS : Carbon Steel, CI : Cast Iron, SS : Stainless Steel
RL : Rubber Lining, RC : Reinforced Concrete

Table 13–2 List for Major Equipment (5/7)

Process Area : 300
Process Name : Utilities

Equip. No.	Service	Quantity	Specification	Material	Import/ Domestic
301	Raw Water Pit	1	200 m^3	RC	D
302	Raw Water Pump	2	100 $m^3/h \times 30$ mH	CI	D
303	First Water Pit	1	500 m^3	RC	D
304	First Water Pump	2	300 $m^3/h \times 30$ mH	CI	D
305	Second Water Pit	1	500 m^3	RC	D
306	Second Water Pump	2	300 $m^3/h \times 30$ mH	CI	D
307	Cooling Tower	1	Forced Ventilation Type Cooling Tower with Fan, 200 m^3/h, Water Outlet Temperature: 22°C max.	---	D
308	Cooling Tower	1	Forced Ventilation Type Cooling Tower with Fan, 150 m^3/h, Water Outlet Temperature: 22°C max.	---	D
309	Cooling Tower Pump	2	150 $m^3/h \times 30$ mH	CI	D
310	Cooling Tower	1	Forced Ventilation Type Cooling Tower with Fan, 150 m^3/h, Water Outlet Temperature: 22°C max.	---	D
311	Cooling Tower Pump	2	150 $m^3/h \times 10$ mH	CI	D
312	Evaporator Feed Pump	2	150 $m^3/h \times 10$ mH	CI	D
321	Boiler	1 set	Fire Tube Boiler with Water Treatment System & Attachments. Steam Generation: 10 ton/h × 10 g/cm^2G	---	D
331	Instrument Air Compressor	1	Oil Free Air Compressor with After Cooler, Dehumidifier & Instruments, 500 $Nm^3/h \times 5$ kg/cm^2G	---	I

Material CS : Carbon Steel, CI : Cast Iron, SS : Stainless Steel
RL : Rubber Lining, RC : Reinforced Concrete

Table 13-2 List for Major Equipment (6/7)

Process Area : 400
Process Name : Environmental Control

Equip. No.	Service	Quantity	Specification	Material	Import/ Domestic
401	Boiler Exhaust Dust Collector	1 set	Multi-cyclone Dust Collector Exhaust Gas : 6,900 $Nm^3/h \times 17$ g/ℓ Yield : 90% up	CS	D
402	Exhaust Fan	1	Sirocco Type Fan 200 $Nm^3/h \times 300$ mmAq.	CS	D
403	Stack	1	Steel Stack with Inside Insulation Exhaust Gas : 6,900 Nm^3/h Size : 1 mø × 20 mH (above ground)	CS	D
411	Waste Water Storage Tank	1	Reinforced Concreat Tank with Resin Coating Inside, pH Controller & Agitator. Volume : 40 m^3	RC	D
412	Screen	1	Vertical Stainless Steel Screen Capacity : 40 m^3/h Space : 0.5 mm	SS304	D
413	Lagoon Tank	1 set	Reinforced Concreat Tank with Asphalt Sheet Lining, Agitator, Air Blower, Pump etc. Volume : 5,000 m^3 BOD Load : 1,354 kg/d, Capacity : 400 m^3/d	RC	D
414	Sludge Storage Tank	1	Reinforced Concreat Tank with Asphalt Sheet Lining, Ejector & Pump. Volume : 160 m^3	RC	D
421	Incinerator	2 sets	Incinerator with Burner, Stack & Control Panel Capacity : 300 kg/h × 24 h/d = 7.2 ton/d Fuel Consumption : 419 ℓ/h Material Burnt : Solid Wastes	---	D

Material CS : Carbon Steel, CI : Cast Iron, SS : Stainless Steel
RL : Rubber Lining, RC : Reinforced Concrete

Table 13–2 List for Major Equipment (7/7)

Process Name : Laboratory

No.	Equipment Name	Quantity	Specification	Import/ Domestic
1	Autoclave	1	Inside 300 mmø × 630 mmH, SS	I
2	Rotary Shaker	1	15 ~ 60°C, 500 m ℓ × 24/2 ℓ × 6,30 ~ 250 rpm	I
3	Clean Bench	1	Biological Cabinet, 840 mmW × 1,050 mmD × 1,710 mmH, SS	I
4	Dry Heat Oven	1	600 mmW × 720 mmD × 1,500 mmH, SS	I
5	Incubator	1	10 ~ 50°C, 720 mmW × 665 mmD × 1,500 mmH, SS	I
6	Spectrophotometer	1	395 ~ 900 nm, Tungsten Lamp	I
7	pH Meter	2	0 ~ 14 pH, Direct Reading	I
8	Chemical Balance	1	Full Scale 200 g	I
9	Balance	2	Full Scale 1,200 g	D
10	Microscope	1	Single Eye Type, × 900 Max.	I
11	Centrifuge	1	4,000 rpm, 2,800 G	I
12	Refrigerator	1	100 ℓ, –3 ~ 8°C	D
13	Draft Chamber	1	900 mmW × 750 mmD × 2,350 mmH	I
14	Water Bath	1	Inside 350 mmW × 235 mmD × 80 mmH	D
15	Water Purifier	1	1 ℓ /min	I
16	Muffle Furnace	1	440 mmW × 625 mmD × 640 mmH, 1,150°C Max.	I
17	Magnetic Stirrer	2	30 ~ 1,500 rpm, 0.1 ~ 10 ℓ	I
18	Sieve Set	1 set	10 mmø × 45 mmH, SS	D
19	Storage Shelf	4	1,800 mmW × 400 mmD × 1,800 mmH	D
20	Balance Table	1	1,350 mmW × 750 mmD × 750 mmH	D
21	Labo. Table	2	3,000 mmW × 1,200 mmD × 800 mmH	D

(5) Spare parts and spare pumps

The cost for the spare parts required for two years' operation and the spare pumps has been estimated. For the imported parts, CIF Durban cost and for locally procured spare parts and spare pumps, cost delivered at the plant site have been estimated.

(6) Inland transportation

The inland transportation costs from the port of Durban to the plant site near Harare have been estimated to be US$ 203,000. To establish the border price the inland transportation cost from Durban to Beitbridge at the border is estimated to be US$ 131,000, considering the distance from Durban to Beitbridge is 1,050 km and from Beitbridge to Harare is 580 km.

(7) Import duty

In Zimbabwe, 20% of the CIF cost is charged as import duty for all imported goods and 20% of CIF is also charged as surtax on imported goods. The import duty is refunded after the completion of the construction of the plant, but the surtax is not refundable. Therefore, for this study, CIF Beitbridge cost is calculated by adding the inland transportation cost from Durban to Beitbridge to the foreign currency portion of (4) and (5) above and 20% of this CIF Beitbridge cost is calculated and included as the surcharge in the plant cost.

(8) Installation and pipework

The cost for installation of the equipment and pipework are estimated in the local currency.

(9) Electrical and instrument work

The cost for the electrical and instrument work is estimated in the local currency.

(10) Building and civil works

The Mukuvisi district has firm soil and piling work is not needed to strengthen the foundations. The cost is estimated without piling work. All costs required for the buildings and civil works are in the local currency.

(11) Insulation and painting work

All work for insulation and painting are to be carried out by local contractors using local construction materials.

(12) Supervisors fees

Supervisors fees are estimated based on the construction schedule shown in Figure 13–1. Three supervisors (one supervisor for civil and building work for 13 months and two supervisors for mechanical installation for 10 months) are thought to be dispatched from Japan. The costs for these supervisors are estimated as follows:

• Air ticket	: US$ 11,000	×	3 trips	= US$	33,000
• Living allowance	: US$ 3,000	×	33 man-months	= US$	99,000
• Personnel cost	: US$ 12,000	×	33 man-months	= US$	396,000
Total				US$	528,000

(13) Contingency

The plant cost is based on the conceptual design of the plant so it contains some unknown elements. As mentioned above, there are some items for which cost data and information were not available during the field survey. Therefore, it is necessary to provide a contingency in the estimate. In view of the accuracy of the cost estimation, 3 percent of the foreign currency costs excluding the license fee, the engineering fee and supervisors fees and 5 percent of the local currency costs excluding the engineering fee, the surtax, the inland transportation cost, and supervisors fees are estimated as the contingency.

13–3–3 Summary

The results of the above study are summarized in Table 13–3. In the costs of this plant, the following have been excluded: the cost for connecting roads, the charges for extending water and electricity supply from outside the plant. The training fee for operators and the test operation costs are separately estimated in Chapter 15 "Total Capital Requirement".

Table 13-3 Total Plant Costs, US$

Item	Foreign Scope	Local Scope	Total
Land Aquisition & Site Preparation Cost	0	641,889	641,889
License Fee	1,000,000	0	1,000,000
Engineering Fee	1,072,000	299,000	1,371,000
Machinery & Equipment	6,369,000	3,887,000	10,256,000
Spare Parts and Spare Pumps	191,000	154,000	345,000
Inland Transportation Cost (Durban to Beitbridge)	0	131,000	131,000
Surtax	0	1,338,200	1,338,200
Inland Transportation Cost (Beitbridge to Harare)	0	72,000	72,000
Installation & Piping Costs	0	2,739,000	2,739,000
Electrical & Instrument Costs	0	1,430,000	1,430,000
Civil & Building Costs	0	3,342,000	3,342,000
Insulation & Painting Costs	0	318,000	318,000
Supervision	429,000	99,000	528,000
Contingency	196,800	625,594	822,394
TOTAL	9,257,800	15,076,683	24,334,483

Chapter 14 Implementation of the Project

Chapter 14 Implementation of the Project

In this Chapter, the construction, education and training, and operation schedule which are important for the implementation of the project are described.

14–1 Design and Construction of the Plant

It is planned that the design and construction of the plant should be carried out by Zimbabwean contractors as far as possible. Since the design and construction of a citric acid plant require specific technical expertise, unique to biotechnology, all of the work cannot be done completely by Zimbabwean contractors. The work required to complete the plant consists of:

(1) Supply of process technology

(2) Basic design

(3) Detailed design

(4) Manufacture of equipment

(5) Construction work at site

The work (1) and (2) will be carried out in the country which supplies the technology. As for item (4), manufacture of the major equipment will be taken care of by the foreign suppliers. For item (5) construction work at site, it will be advantageous to use Zimbabwean contractors in view of their technical level and labor costs. For item (3) detailed design, the following two cases were considered:

Case 1 : Detailed design work is to be done by the foreign engineering firm which carried out the basic design.

Case 2 : Detailed design work is to be done by Zimbabwean companies under the supervision of the foreign engineering firm which carried out the basic design.

In Case 1, the transition from the basic design to the detailed design will be carried out smoothly, but the cost of the design work will be expensive.

On the other hand, the transition from the basic design to the detailed design may present some difficulties for Case 2, but the cost of the detailed design can definitely be reduced. Further, the transition from the detailed design to construction activities such as equipment installation, piping, electrical and instrument works can be carried out smoothly. Technology transfer can be achieved by using Zimbabwean companies for the design work.

It is planned to implement this project using Case 2 and the estimates for the construction of the plant described in Chapter 13 are based on this assumption.

14–2 Operation Plan

14–2–1 Number of Operation Days

Much of the equipment in this plant will be operated on a batch cycle. However the plant is designed to operate continuously for 333 days per year and the operation is basically by 3 shifts using 4 groups of operators. 32 non-operating days per year have been assumed and these days are for maintenance work during normal operation, the annual maintenance period (usually about 2 weeks) and the start-up period after the annual maintenance work.

14–2–2 Operating Ratio and Plant Production

It would be desirable to operate the plant at its designed capacity from the initial start-up of the plant. However, due to initial problems with equipment and lack of experience on the part of the operators, the palnt cannot be operated as designed during the initial start-up period. Also, it will be very difficult to sell all of the 3,000 tons of the product from the first year. Therefore, the operating ratio and the production have been assumed as follows for this project:

First year of operation	:	76.2%,	2,286 tons
Second year of operation	:	97.2%,	2,916 tons
Third and subsequent years	:	100.0%,	3,000 tons

The number of fermentation batches will be 109 for the first year, 139 for the second year and 143 for the third and later years. Therefore, the fermentation batches will be prepared once every three days for the first year, and 3 batches every seven days for the second year and thereafter.

14–3 Organization and Staff

14–3–1 Organization and Duties

The organization required for the management and operation of the citric acid plant is shown in Figure 14–1 and the role of each department is described below:

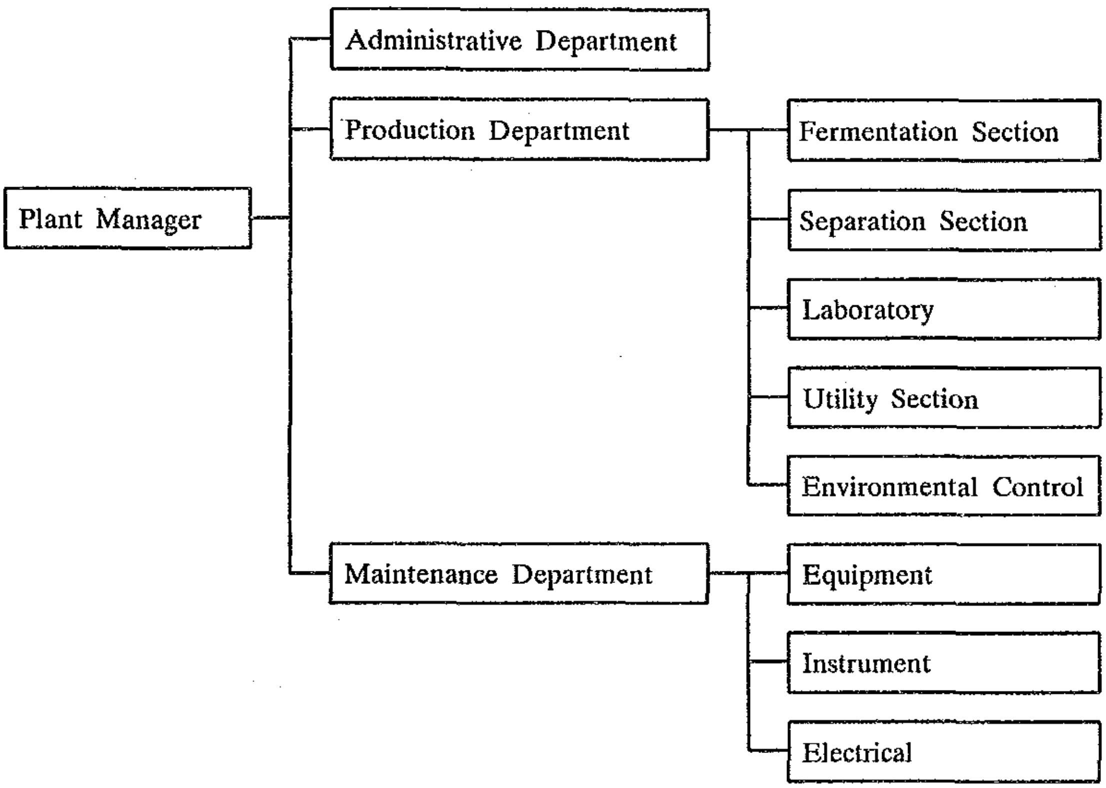

Figure 14–1 Organization Chart of a Citric Acid Production Plant

(1) Production department

The production department consists of the following 5 sections: fermentation, separation, analysis, utilities and environmental control sections. The fermentation seciton is in charge of the preparation of the raw materials and the production of the citric acid. The separation section is in charge of the separation process of the citric acid plant, packaging work and inventory control of the product. The analysis section is in charge of the inspection of the raw materials, the analyses for process control, the inspection of the product, the seed fermentation by flask and the control of fungus.

The utilities section is in charge of the generation and distribution of steam, and distribution of water, and electricity. The boiler operators operate the boiler flue gas treatment facility in addition to the boiler. The environmental protection section is in charge of the biological treatment of the waste water, the incineration of the wastes and the disposal of the wastes.

(2) Maintenance department

The maintenance department is in charge of the inspection, maintenance and control of the equipment, the instrument and electrical system. Most of the equipment in this plant operates in highly acid conditions, and therefore daily maintenance and control of the equipment are essential to achieve steady production of citric acid and to prolong the life of the plant. It is planned that the maintenance of the large pieces of equipment and the specialised equipment should be subcontracted to outside specialist companies.

(3) Administration department

The administration department is in charge of accounting, personnel and general affairs in addition to the control of inflow and outflow of the raw materials and products through the main gate.

14–3–2 Personnel Plan

The number of people required for the operation of the plant is 115 persons including the plant manager. These people are the staff directly required for operation of the plant and the number does not include staff for the welfare and management.

(1) Production department

The number of staff required for the production department totals 91 persons, consisting of 1 manager, 23 operators for the fermentation process, 29 for the separation process, 7 for the laboratory, 19 for utilities, and 12 for environmental control.

(a) Fermentation Process

The breakdown of the 23 people employed in the fermentation process is as follows: 4 groups of 5 persons (1 foreman, 1 technical operator and 3 operators) on a 3 shift rate. The chief engineer works only during days and the foreman is responsible for operations during the evening and midnight shifts. Because the foreman is responsible for taking action in the case of an emergency such as a power failure, he is required to have a good understanding of the plant, the process technology and operations. The day shift operators are in charge of the work done mainly during day time such as preparation of the feed materials.

• engineer	:	1	person
• foreman (responsible for shift)	:	4	persons
• technician (shift)	:	4	persons
• operators (shift)	:	12	persons
• operators (day shift only)	:	2	persons
		23	persons

(b) Separation process

29 operators are required for the separation process and the number of operators per shift is 6.

• engineer	:	1	person
• foreman (responsible for shift)	:	4	persons
• technician (shift)	:	4	persons
• operators (shift)	:	16	persons
• operators (day shift only)	:	4	persons
		29	persons

(c) Laboratory

The number of operators required for the laboratory totals 7 persons: one engineer and 6 analysts (4 on shift and 2 on days). The control of the fungus is a particularly important function of the laboratory. A pure strain of fungus for citric acid should always be maintained and cultured, otherwise the production capability will gradually deteriorate. Good control of the fungus will influence to a great extent the performance of citric acid production. Therefore, the responsibility of the engineer in charge of the laboratory is very great.

(d) Utility section

The number of operators required for the utility facilities is 19 and consists of:

• engineer	:	1 person
• foreman (responsible for shift)	:	4 persons
• technician (shift)	:	4 persons
• operators (shift)	:	8 persons
• operators (day shift only)	:	2 persons
		19 persons

(e) Environmental protection section

The operating staff required for the environmental protection section are shown below. The working time for this section is different from other sections. The waste water treatment facilities are operated 24 hours daily, but are not attended at night. The operating time for the small incinerator for solid wastes is 16 hours per day and it is attended by 2 shifts.

•engineer	:	1 person
•technician (shift)	:	1 person
•operators (shift)	:	6 persons
•operators (day shift only)	:	4 persons
		12 persons

Therefore, the operators will work in a 3 shift operation mode and it will be necessary to prepare the

(2) Maintenance department

All staff working for the maintenance department work only on day time. 10 people are required, consisting of 1 manager, 3 engineers (one each for mechanical equipment, instruments and electrical), 4 technicians (2 for mechanical equipment, 1 each for instruments and electrical) and 2 workers.

(3) Administration department

13 persons are required for the administration department, consisting of 1 manager, 7 clerks and 5 guards.

14–4 Operating Guidance and Training Program

In Zimbabwe, there is no plant similar to this citric acid production plant and it will be extremely difficult to hire experienced operators from other factories. Therefore, the education and training of employees are very important. For this project, it is planned to conduct education and training in operation technology for a period of three and half months starting half a month prior to commencement of the start-up operation by sending technical experts from the process owner. The team of technical experts will consist of 4 persons (one for the fermentation process, one for the separation process, one for the laboratory, and one for utililties and environmental control). The education and training program conducted by the technical experts will be carried out in 4 different classes, one class for each of the specialties mentioned above. Staff for the maintenance department will be educated and trained in appropriate classes. The training program will be divided into three phases; (1) at the end of mechanical installation, (2) test period using water only and (3) actual start up test period. After completion of the start up tests using actual solutions, a proving test will be carried out by the team of technical experts to confirm the plant is operating correctly and then the operation technology and technical know-how will be transferred. The contents of the education and training program for each phase are as follows:

14–4–1 Education and Training at the End of Mechanical Completion

At this stage of the construction, most of the equipment will be installed and the pipework, instrument and electrical work will be almost complete. The education and training program during this period consists of (1) desk education and training and (2) education and training in situ by showing the equipment during installation. The program will last about 15 days and the contents of the program are as follows:

(1) Desk education and training

The contents of the education and training program for the production operators are as follows:

(a) Detailed technical information about the citric acid production process.

(b) Detailed knowledge about the construction, performance and method of handling the production equipment.

(c) Detailed information about the material characteristics and handling of the main raw materials, the subsidiary materials, the citric acid product, the utilities and the wastes.

(d) Basic knowledge about the safety and environmental control of the production process.

The contents of the education and training program for the laboratory staff are as follows:

(a) Knowledge regarding the main raw materials, the subsidiary materials, the citric acid product and waste materials.

(b) Detailed information regarding the analyzing work and the analysis equipment.

(c) Detailed information regarding fungus control and fungus handling.

(d) Basic knowledge about the safety and environmental control of the work in the laboratory.

(e) Basic information regarding the process and equipment for producing citric acid.

The contents of the education and training for the utility operators are shown below.

The technical experts are only in charge of (d) mentioned below.

(a) Detailed information regarding the utilities and the properties and handling of coal.

(b) Detailed information about the construction, performance and methods of operating the utility facilities.

(c) Basic information about safety and environmental protection in relation to the operation of the utility facilities.

(d) Basic information about the process and equipment for producing citric acid.

The contents of the education and training for the environmental protection staff are as follows:

(a) Detailed information about the environmental protection process and facilities.

(b) Detailed information regarding the construction, performance and methods of operating the environmental protection facilities.

(c) Basic information about safety and environmental protection.

(d) Basic information about the process and the facilities for producing citric acid.

(2) Education and training program in situ

During this stage, the operators learn and confirm the contents of the desk education and training by studying in the plant. The preparations for the water test run will be done as a training exercise for the next step. The staff of the maintenance department will receive detailed information about the production facilities in addition to basic knowledge about the citric acid production process.

14–4–2 Education and Training Program during the Water Test Run

The purposes of the water test run are to confirm the operating characteristics of each piece of equipment and to clean process equipment and piping by flushing with water. The purpose of the education and training during the water test run is to provide opportunities for the operators to learn the fundamentals of the production of citric acid and also to learn about the operator's duties and the laboratory work. The period of the training is about 15 days. The main contents of the education and training during this period are as follows:

- Production operator : Training in the operation of the production facilities
- Laboratory staff : Training for fungus control and the analysis work
- Utilities operator : Training in the operation of the utilities facilities (to supply utilities as required by the production section, the laboratory section and the environmental protection section during the water test run)
- Environmental protection operators : Training in operating the environmental protection facilities

14–4–3 Start-up Operation using Actual Solutions

Subsequent to the water test run, a start-up operation using actual solutions of the raw material and the subsidiary materials used in actual production will be carried out. The purpose of the education and training during this start-up operation is to polish the skills acquired during the water test run and to get ready for the continuous operation of the plant.

The start-up operation using actual solutions is to be carried out in the continuous operation mode. Therefore, the operators will work in a 3 shift operation mode and it will be necessary to prepare the raw materials, the utilities and the packaging materials on a continuous basis and also to operate the waste water and the waste material treatment facilities on a normal basis. The operational schedule of the start-up run using actual solutions is shown in Figure 14–2. The operational schedule shown in this figure is for one batch every 3 days in consideration of the operators' technical level in the initial stage (the normal operation will be 3 batches every 7 days). The start-up operation period using actual solutions is planned for 45 days.

14–4–4 Proving Test

After the completion of the start-up operation using actual solutions, and at a time when the operation becomes steady, the proving test will be carried out. The purpose of the proving test is to confirm the guaranteed production quantity and quality of citric acid. The proving test will be completed when the yield of 3 batches of the fermented broth is confirmed to exceed 63 tons of citric acid which satisfies the BP standard specification. During this period, the operators will endeavour to improve the technical skills which they acquired during the course of the start-up operation using actual solutions. Technological transfer of the various kinds of operation know-how will be carried out by the expert engineers. If any emergency situation such as stoppage of utilities occurs during plant operation, this will not only affect the production of citric acid, but also may damage the equipment. In the case of an emergency, the first priority should be placed on protection of the operators and the equipment and facilities, and then to minimize the damage to the process operation. Necessary steps must be taken to avoid secondary or tertiary damage to the plant by exercising the appropriate judgement. In the last stage of the education and training program, guidance and training for emergencies will be provided.

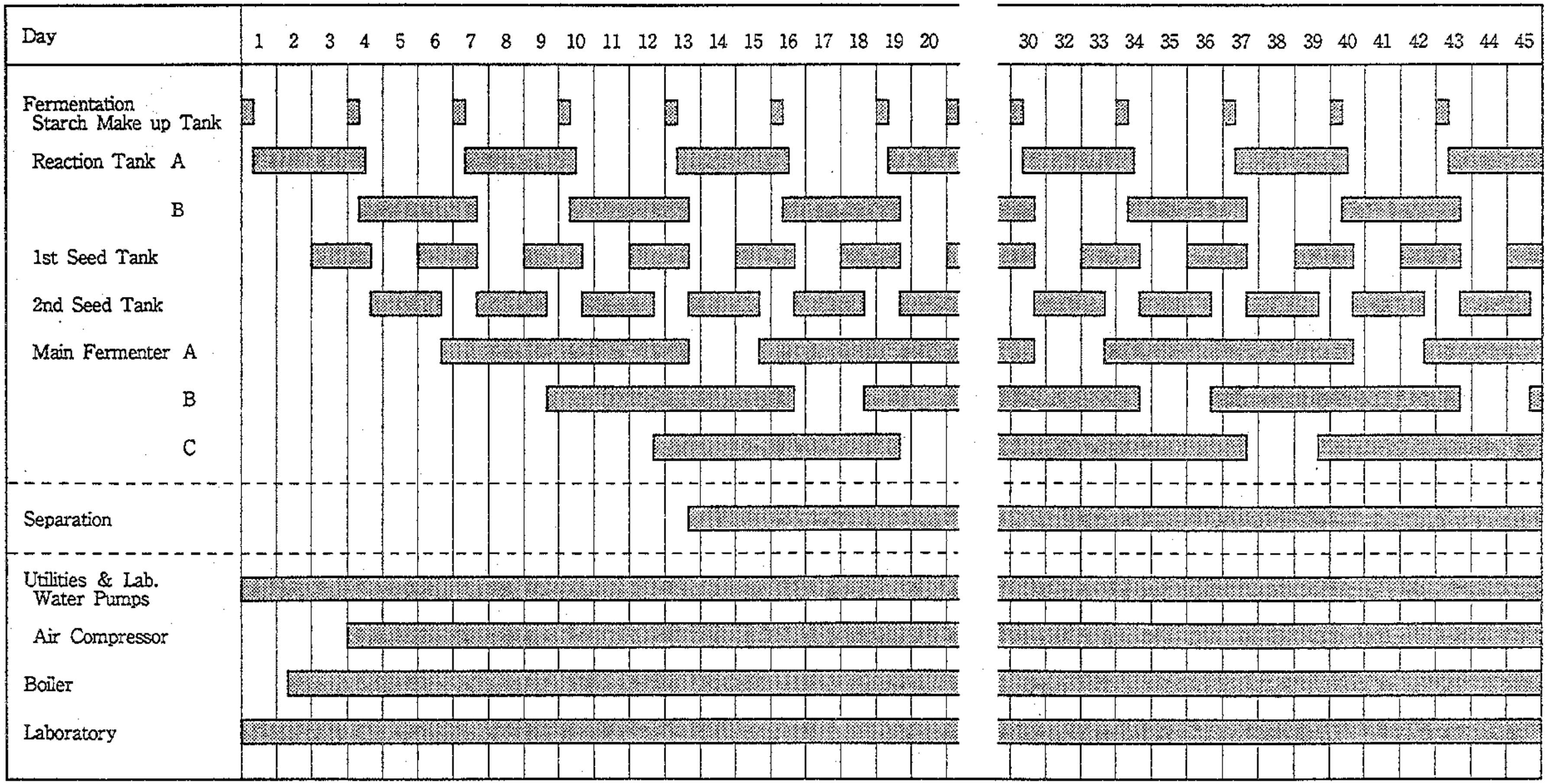

Figure 14–2 Trial Operation Schedule

Chapter 15 Total Capital Requirements

Chapter 15 Total Capital Requirements

15–1 General

In this chapter, the total capital requirements for this project are calculated by adding the pre-operation cost, the initial working capital and the interest during construction to the estimates of the plant costs described in Chapter 13. In calculating the total capital requirements, the following conditions are assumed:

(1) Exchange rates

In calculating the capital requirements, the following currency exchange rates for 1991 are applied as it is difficult to predict future currency rates.

US$ 1.0 = Z$ 3.15 = 132 Yen

(2) Price

All costs and prices are calculated in 1991 prices.

(3) Taxes

For this project, it is assumed that all taxes are exempted, except the surtax levied on imported equipment and materials.

(4) Source of funds

Of the required funds for implementation of this project, it is assumed that one third is raised by the owner's equity, the foreign currency portion is financed by a long term loan from foreign countries and the balance is financed by a long term loan from the domestic banks in Zimbabwe. The interest during the construction period is added to the principle of the loan. The terms and conditions of the long term loan from the foreign country cannot be defined because the lending organization is not decided. For this study, two cases are assumed, namely, Case 1 for an interest rate of 10.75% per year and Case 2 for an interest rate of 4.5% per year for the purpose of calculating the financial analysis. The loan conditions for Zimbabwe domestic banks are set at an interest rate of 20% per year according to information provided during discussions with IDC. As this interest rate is based on Zimbabwe dollar, it must be converted to the rate based on U.S. dollar. The details are described in Chapter 16.

15–2 Plant Construction Costs

In order to calculate the total capital requirements including the interest during the construction period, it is necessary to define the expenditure schedule for plant construction costs. It can be considered that the construction costs of the plant will be paid based on the construction schedule, but the final payment terms will be decided by the agreement between the owner and the contractors. At this point in time, the contractors responsible for the manufacture and installation of the equipment are not yet decided and the type of contract is also not yet decided. Therefore, the expenditure schedule is taken to be as shown in Table 15–1, by referring to the construction schedule.

Table 15–1 Expenditure Schedule

Project Year	–2		–1		Total
	I	II	I	II	
Foreign Currency Portion	15%	30%	45%	10%	100%
Local Currency Portion	10%	25%	45%	20%	100%

15–3 Pre-operation Costs

Various costs and fees are required prior to the commencement of operation of the plant. The following are estimated to be the pre-operation costs:

(1) Personnel training costs and start-up costs

As described in Chapter 14, the education and training of the operators and the test run will be carried out starting 3.5 months prior to the mechanical completion of the plant. These costs are divided into 3 parts, namely, the cost paid for dispatching the technical experts from the process licenser, the cost of the raw materials required for the test run and start-up operation of the plant and the salaries and expenses of the operators receiving the education and training. The education and training will be carried out by four (4) expert engineers dispatched from the licenser. For this project, the costs of the engineers required for the education, training and start-up operation are estimated as shown below. Of the total cost of US$ 254,000, the living expenses in Zimbabwe are in domestic currency and all other costs are in foreign currency.

• Traveling	: US$ 11,000 × 4 persons	=	44,000
• Living expenses	: US$ 3,000 × 4P × 3.5 months	=	42,000
• Personnel costs	: US$ 12,000/month × 4P × 3.5 months	=	168,000
Total		US$	254,000

For the test run and start-up operation, raw material, electricity and water are required. The costs for these items are balanced against the income from the product produced during the start-up operation. Therefore, the costs for the raw materials required for the start-up operation are considered to be zero. The salaries and expenses of the operators during the education, training and the start up operation are included in the miscellaneous costs mentioned below and are not included in this item.

(2) Miscellaneous costs

Included in these miscellaneous costs are the costs of the staff hired by the employer during the construction period and the indirect costs. The costs of personnel are calculated based on the manning schedule shown in Table 15–2 and the indirect cost is calculated at 25% of the personnel costs.

The personnel costs for each class are taken to be as follows and these costs are all in local currency:

• Plant manager	: 100,000 Z$ per year
• Department manager	: 60,000
• Chief engineer	: 55,000
• Foreman	: 35,000
• Analysis engineer	: 30,000
• Technician	: 25,000
• Operator and clerk	: 10,000
• Guard	: 5,000

Table 15–2 Manning Schedule, persons

Project Year	-2				-1			
	1-Qtr.	2-Qtr.	3-Qtr.	4-Qtr.	1-Qtr.	2-Qtr.	3-Qtr.	4-Qtr.
Plant Manager	1	1	1	1	1	1	1	1
Manager	1	1	1	1	1	1	3	3
Chief Engineer	0	0	0	0	0	0	5	8
Foreman	0	0	0	0	0	0	8	12
Analyst	0	0	0	0	0	0	6	6
Skilled Operator	0	0	0	0	0	0	12	17
Operator	0	0	0	0	0	0	0	56
Office Clerk	2	2	2	2	2	3	4	7
Guard	0	0	0	0	4	4	4	5
Total	4	4	4	4	8	9	43	115

(3) Summary

The pre-operation costs based on the above are summarized in Table 15–3.

Table 15–3 Summary of Pre-operation Costs, US$

Project Year	-2		-1		Total
	I	II	I	II	
Training & Trial Operation					
Foreign Currency Portion	0	0	0	212,000	212,000
Local Currency Portion	0	0	0	0	42,000
Administration Cost					
Foreign Currency Portion	0	0	0	0	0
Local Currency Portion	35,714	35,714	40,674	374,504	486,607
Total					
Foreign Currency Portion	0	0	0	212,000	212,000
Local Currency Portion	35,714	35,714	40,674	416,504	528,607

15–4 Initial Working Capital

At the commencement of the operation, in order to carry out the plant operation smoothly, it is necessary to build up an inventory of raw materials, spare parts and cash. The cost of these items is called the initial working capital. For this project, the following is estimated to be the initial working capital. The cost for the spare parts are not included in the initial working capital because it is included in the plant construction costs.

(1) Cash

For the operation and management of the company, cash is required for various purposes. The income from sales may not be recovered for sometime and this may cause difficulties in the cash flow of the company. The cash required for this will be financed by a short term loan but some cash is still needed. For this project, cash equal to one month's labor cost, namely, Z$ 200,000 (US$ 63,492) is always assumed to be in the current account of the company.

(2) Inventory of the raw materials

For this project, the inventory of the raw materials to be kept in stock is as shown in Table 15–4. Some of the raw materials are imported items but these items are not necessarily imported by the citric acid company, so all the costs required for the inventory are considered as local currency. The unit price for each raw material is given in Chapter 16 "Financial Analysis".

Table 15–4 Summary of Inventory

	Required Amount		Source	Unit Price	Required Cost
	tons	days of operation		(Z$/ton)	(Z$)
Cornstarch	61.155	5	Local	562	34,369
Sulfuric Acid	45.0	5	Local	610	27,450
Slaked Lime	94.5	14	Import	308	29,106
Activated Carbon	1.26	14	Import	880	1,109
Filter Aid	13.86	14	Import	920	12,751
Ammonium Nitrate	1.305	5	Local	430	561
Potassium Phosphate	4.284	28	Import	700	2,999
Other Nutrients	0.9324	28	Import	—	600
Amylase	0.3528	28	Import	22,000	7,762
Bags for Packing	900 bags	5	Local	2Z$/each	1,800
Coal	54.0	5	Local	133.32	7,199
Total	274.6692	—	—	—	125,706

15–5 Interest During Construction and the Total Capital Requirements

The interest during the construction of the plant is calculated in accordance with the capital expenditure schedule for the plant construction and the financing schedule. The total capital requirement which consists of the plant construction cost, the pre-operation cost, the initial working capital and the interest during the construction period is summarized in Table 15–5 (Case 1) and Table

15–6 (Case 2). For Case 1, the interest of the long term loan from the foreign banks is set at 10.75% per annum and for Case 2, it is set at 4.5% per annum.

Table 15–5 Total Capital Requirements (Case–1)

(Unit: US$ in Thousand)

Project Year	–2		–1		Total
	I	II	I	II	
Application of Funds					
Foreign Currency Portion					
Plant Construction Cost	1,388.7	2,777.3	4,166.0	925.8	9,257.8
Pre-operation Cost	0.0	0.0	0.0	212.0	212.0
Initial Working Capital	0.0	0.0	0.0	0.0	0.0
Interest during Const.	37.3	151.3	346.0	507.2	1,041.8
Sub-total	1,426.0	2,928.6	4,512.0	1.644.9	10.511.6
Local Currency Portion					
Plant Construction Cost	1,507.7	3,769.2	6,784.5	3,015.3	15,076.7
Pre-operation Cost	35.7	35.7	40.7	416.5	528.6
Initial Working Capital	0.0	0.0	0.0	103.4	103.4
Interest during Const.	6.5	31.7	87.3	148.4	273.9
Sub-total	1,549.9	3,936.6	6,912.5	3,683.6	15,982.6
Total Application	2,975.9	6,765.2	11,424.5	5,328.6	26,494.2
Source of Funds					
Equity	977.4	2,194.1	3,663.7	1,557.7	8,392.8
Foreign Loans	1,426.0	2,928.6	4,512.0	1,644.9	10,511.6
Local Loans	572.5	1,642.5	3,248.8	2,126.0	7,589.8
Total	2975.9	6,765.2	11,424.5	5,328.6	26,494.2

Table 15-6 Total Capital Requirements (Case-2)

(Unit: US$ in Thousand)

Project Year	-2		-1		Total
	I	II	I	II	
Application of Funds					
Foreign Currency Portion					
Plant Construction Cost	1,388.7	2,777.3	4,166.0	925.8	9,257.8
Pre-operation Cost	0.0	0.0	0.0	212.0	212.0
Initial Working Capital	0.0	0.0	0.0	0.0	0.0
Interest during Const.	15.6	62.8	142.4	205.2	426.1
Sub-total	1,404.3	2,840.2	4,308.4	1,343.0	9,895.9
Local Currency Portion					
Plant Construction Cost	1,507.7	3,769.2	6,784.5	3,015.3	15,076.7
Pre-operation Cost	35.7	35.7	40.7	416.5	528.6
Initial Working Capital	0.0	0.0	0.0	103.4	103.4
Interest during Const.	6.5	31.7	87.3	148.4	273.9
Sub-total	1,549.9	3,836.6	6,912.5	3,683.6	15,982.6
Total Application	2,954.2	6,676.8	11,220.9	5,026.7	25,878.5
Source of Funds					
Equity	977.4	2,194.1	3,663.7	1,557.7	8,392.8
Foreign Loans	1404.3	2,840.2	4,308.4	1,343.0	9,895.9
Local Loans	572.5	1,642.5	3,248.8	2,126.0	7,589.8
Total	2954.2	6,676.8	11,220.9	5,026.7	25,878.5

Chapter 16 Financial Analysis

Chapter 16 Financial Analysis

16–1 Financial Analysis

In this Chapter, the viability of the citric acid plant project producing 3,000 tons per year by the submerged culture fermentation process using cornstarch is financially analyzed and reviewed. In evaluating the profitability of the project, the following financial statements are prepared based on the estimated plant construction cost, operation cost and sales revenue of the product, and the financial situation of the project such as ordinary profit (loss) and cash surplus (deficit) are studied. In addition, a cash flow table is prepared and the internal rate of return by the Discounted Cash Flow (DCF) method is calculated.

- Production Cost Accounting Table
- Profit and Loss Statement
- Fund Flow Table
- Balance Sheet

16–2 Major Premises

The major premises necessary for conducting the financial analysis of this project are summarized below:

(1) Project life

- Construction period : 2 years
- Operating period : 20 years

(2) Cost and price

The construction cost, the production cost, the product price and so on used for the financial analysis are in constant 1991 prices and inflation is not included. All calculations are carried out in U.S. dollars. Any cost estimated in local Zimbabwean dollars or in Japanese Yen are converted to U.S. dollars at the following exchange rates:

US$ 1 = Z$ 3.15 = 132 Japanese Yen

(3) *Sales and production plan*

The sales plan prepared in accordance with the results of the market study is shown in Table 16–1. The production plan is based on the sales plan and is as follows. The difference between the production volume and the sales volume is the product inventory.

- – Initial operation year : 2,286 tons (76.2%)
- – *Second operation year* : 2,916 tons (97.2%)
- – Third operation year and later : 3,000 tons (100%)

Table 16–1 Sales Plan, tons/year

Year	Zimbabwe	Zambia	Malawi	RSA/SACU	Mozambique	Madagascar	Total
1	703	105	53	1,267	48	105	2,281
2	809	108	55	1,776	49	108	2,905
3	862	111	57	1,971	0	0	3,000
4	917	113	58	1,911	0	0	3,000
5	977	116	60	1,847	0	0	3,000
6	1,020	119	62	1,799	0	0	3,000
7	1,065	122	63	1,749	0	0	3,000
8	1,113	126	65	1,697	0	0	3,000
9	1,162	129	67	1,642	0	0	3,000
10	1,213	132	69	1,585	0	0	3,000
11	1,267	136	71	1,526	0	0	3,000
12	1,324	139	73	1,464	0	0	3,000
13	1,383	143	75	1,399	0	0	3,000
14	1,444	147	77	1,331	0	0	3,000
15	1,509	150	80	1,261	0	0	3,000
16	1,577	154	82	1,187	0	0	3,000
17	1,647	158	84	1,110	0	0	3,000
18	1,721	162	87	1,029	0	0	3,000
19	1,799	167	89	945	0	0	3,000
20	1,880	171	92	873	0	0	3,016

Note: RSA/SACU means the Republic of South Africa & South African Customs Union

It is planed that the product from this plant should be sold in the southern African countries as a replacement for the product from Europe and other countries. Therefore, the sales price at the factory is set by deducting the transportation cost from the average purchase price in each of the southern African countries. The price at the factory for each area in the market is shown below.

– Domestic market in Zimbabwe	: 2.26 US$/kg
– Zambia and Malawi	: 1.54 US$/kg
– The Republic of South Africa and South African Customs Union	: 1.47 US$/kg
– Mozambique and Madagascar	: 1.40 US$/kg

(4) Corporate tax

In accordance with the taxation rule set forth in July, 1991 which will be effective from April 1992, the corporate tax rate will be 42.5% of the profit before tax deduction. In case that a loss is encountered, the loss can be carried over.

(5) Depreciation

All assets are depreciated by the straight line method as follows:

– Plant and machinery	: 5%, salvage value 5%
– Buildings	: 5%, salvage value 10%
– Interest during construction	: 5%, salvage value 5%
– Preoperation cost	: 100%, salvage value 0%

(6) Working capital

The working capital is the fund necessary for sustaining the operation of the plant. In this study, the working capital is defined as the amount remaining after deducting the current liabilities from the current assets as shown below. The following cash and raw materials inventories are considered during the construction period as the initial working capital, and the others are considered after the commencement of commercial operation as the running working capital.

(a) Current assets

- Cash : Cash equivalent to one month of the labor cost is retained.
- Accounts receivable : Assuming the allowance for receiving cash for sales of the product is one month, one month sales revenue is assumed.
- Raw material inventories : Amounts equivalent to 5 days operation for the domestic raw materials and 14 days or 28 days for the imported materials.
- Product inventory : The difference between the production amount and the expected sales amount is defined as the product inventory.

(b) Current liabilities

- Accounts payable : Assuming the allowance for payment for the raw materials and the utilities is one month, the equivalent of one month's cost is assumed.

(7) Financing plan

The financing plan for this project is not finalized yet at this point in time. As explained in Chapter 15 "Total Capital Requirement", it is planned that one third of the total cost excluding the interest during construction will be covered by equity, the foreign currency portion by a long term loan from foreign countries and the balance by a long term loan from Zimbabwean banks. The interest during the construction period will be capitalized into the principle of each loan. Two cases for loan conditions from foreign lending institutions were assumed as follows:

	Case 1	Case 2
– Interest	10.75% p.a.	4.50% p.a.
– Repayment	15 years, 30 installments	15 years, 30 installments
– Grace period	3 years from commencement of operation	5 years from commencement of operation

The loan conditions for the local currency will be as follows according to discussions with IDC:

- Interest : 20%
- Repayment : 7 years, 14 installments
- Grace period : Zero

The interest rate mentioned above is the interest rate based on Zimbabwean dollars and it is not appropriate to apply this interest rate to a financial analysis based on U.S. dollars. The reason for this theory is as follows.

- The inflation rate of Zimbabwean dollars is higher than the inflation rate of U.S. dollars.
- The high interest rate mentioned above is the interest rate applicable to the high inflation rate assumed for Zimbabwean dollars.
- Coupled with the high inflation rate, the Zimbabwean dollar will be devalued against the U.S. dollar.
- In line with the devaluation of the Zimbabwean dollar, the foreign currency exchange rate will become weaker.
- If the repayment amount for the principle and the interest calculated in Zimbabwean dollars is converted to U.S. dollars at the future exchange rate, that amount will be lower than the amount calculated by the present exchange rate.

In order to avoid these kinds of discrepancies, it is necessary to adopt an interest rate suitable for calculations in U.S. dollars, taking the variation of the future foreign exchange rates into consideration. It is extremely difficult to forecast future foreign exchange rates, however it is possible to predict the future from past records. The exchange rate for the Zimbabwean dollar against the U.S.dollar from 1980 to 1990 has declined at an annual rate of 15.4% on the average. If this figure is deducted from the abovementioned interest rate, the interest rate for the domestic loan will be 4.6% p.a. From the above, by deducting 15.4% p.a. as the allowance for variation in foreign currency exchange rates from the interest rate set for the local currency loan, the interest rate of 4.6% p.a. will be applied for the financial analysis of this project.

In case that a shortage of funds occurs after commencement of operation, a short term loan at 18% p.a. will be required. Since this interest rate is for Zimbabwean dollars, 15.4% p.a. is deducted in the same way as the long term loan and 2.6% p.a. interest rate is applied for the short term loan.

16–3 Total Capital Requirement

The total capital requirement, rearranged for the purpose of conducting the financial analysis, is shown in Table 16–2. In this table, the plant construction costs are divided into three categories for calculating the depreciation.

Table 16–2 Total Capital Requirement, US$

	Case–1	Case–2
Plant Construction Cost		
Land Acquisition & Site Preparation	673,983	673,983
Plant	20,151,400	20,151,400
Civil Work & Buildings	3,509,100	3,509,100
Pre–operation Cost	740,606	740,606
Initial Working Capital	103,399	103,399
IDC(Foreign Loan)	1,041,791	426,072
IDC(Local Loan)	273,914	273,914
Total	26,494,193	25,878,474

16–4 Operating Costs

The costs necessary for the production of citric acid are summarized below:

(1) Raw materials costs

(a) Cornstarch

The amount of cornstarch required for producing one ton of citric acid is 1.359 tons. For the cost of the cornstarch, 20 Z$ per ton for transportation was added to the cornstarch price of 542 Z$/ton which is assumed in Chapter 7 "Raw Materials" to give 562 Z$/ton (178 US$/ton) as the purchase price of the cornstarch for this project.

(b) Sulfuric acid

The price of the sulfuric acid produced by Zimphos Company, which is planned to be used for this project, is 610 Z$/ton (194US$/ton). The amount of sulfuric acid required for producing one ton of citric acid is also one ton.

(c) Slaked lime

For this project, it is planned to purchase slaked lime produced in Zambia at 308 Z$/ton (98 US$/ton). The consumption of slaked lime is 750kg per ton of citric acid.

(d) Activated carbon

It is planned to use activated carbon made in the Republic of South Africa. The price of this activated carbon is 880 Z$/ton (279 US$/ton). The amount of activated carbon required for producing one ton of citric acid is 10kg.

(e) Filter aid

Since the diatomaceous earth used as the filter aid is not produced in Zimbabwe, the filter aid must be imported. The price of the filter aid is set at 920 Z$/ton (292 US$/ton), by referring to the filter aid price in the U.S.A. and other countries. The amount of filter aid required for producing one ton of citric acid is 110kg.

(f) Ammonium nitrate

29kg of ammonium nitrate is required as a nutrient for producing one ton of citric acid. The price of the ammonium nitrate produced by the Zimphos Company which it is planned to use for this project is 430 Z$/ton (137 US$/ton).

(g) Potassium phosphate

The potassium phosphate used as a nutrient is imported. The imported price of 700 Z$/ton (222 US$/ton) is assumed for this project. The amount of the potassium phosphate required for producing one ton of citric acid is 17kg.

(h) Other nutrients

A small amount of various nutrients such as copper, zinc and magnesium is required for the production of citric acid in addition to the nutrients mentioned above. In Chapter 12 "Conceptual Design of the Plant", the total consumption of 3.7kg of the various nutrients is assumed for producing one ton of citric acid. However, the kind of elements required and the precise amounts are not finalized. Since the amount of the various nutrients is small, 20% of the cost of the potassium phosphate is assumed for this project. Chemical products used as the nutrients are imported.

(i) Enzyme amylase

The amylase required for liquefying the cornstarch is to be imported. Considering the price of the amylase sold in the U.S.A. and Japan, the price of the amylase is assumed to be 22,000 Z$/ton (6,984 US$/ton). The amount of the amylase required for producing one ton of citric acid is 1.4kg.

(j) Packaging material

The citric acid product is packed in 50kg bags (4 layers of paper and 1 layer of polyethylene). The price of this specification is 2Z$ per bag.

(2) By-product credit

Gypsum is produced as a by-product from this plant at the rate of 1.86 times the weight of citric acid. It is planned to sell the gypsum and the operating cost is credited with the sales of the gypsum. The price of the gypsum is 25 Z$/ton. In addition to the gypsum, waste mycelium and the ash after incinerating the waste activated carbon are produced as by-products. These by-products have some commercial value, but do not contribute financially to the project, after deducting the transportation cost of these by-products from the factory to the place of use. Therefore, only the by-product credit of the gypsum is considered for this project.

(3) Costs of utilities

The amount of the utilities required for producing one ton of citric acid and their unit costs are as follows:

- Electricity : 4,000kWh, 5.97 Z¢/kWh (1.90 US¢/kWh)
- Water : 145 tons, 50 Z¢/ton (15.87 US¢/ton)
- Coal : 1.2 tons, 133.32 Z$/ton (42.32 US$/ton)

(4) Labor cost

The labor cost required for this project is summarized in Table 16–3.

Table 16-3 Labor Cost, Z$/year

Plant Manager	(1 person)	100,000
Manager	(3 persons)	180,000
Chief Engineer	(8 persons)	440,000
Foreman	(12 persons)	420,000
Analyst	(6 persons)	180,000
Skilled Operator	(17 persons)	425,000
Operator	(56 persons)	560,000
Office Clerk	(7 persons)	70,000
Guards	(5 persons)	25,000
Total	(115 persons)	2,400,000

During the initial year of operation, one foreign engineer will be employed as the operating supervisor and the cost is estimated and included as follows:

– Traveling cost	:	US\$11,000 × 1 person	= US\$ 11,000
– Living expenses	:	US\$3,000 × 1 p × 12 months	= US\$ 36,000
– Personnel charge	:	US\$12,000 × 1 p × 12 m	= US\$ 144,000
		Total	US\$ 191,000

(5) Administration charge

The administration charge is set at 25% of the labor cost, excluding the cost of the foreign supervisor.

(6) Maintenance costs

The annual maintenance cost is set at 2% of the plant construction cost, excluding the cost of the land and site preparation.

(7) Insurance premium

The annual insurance premium is set at 0.35% of the plant construction cost, excluding the cost of the land and site preparation.

16–5 Results of the Financial Analysis

16–5–1 Financial Statements

Based on the premises mentioned above, the following financial statements are prepared and attached at the end of this chapter.

- Production Cost Accounting Table : Table 16–4 (Case 1), Table 16–10 (Case 2)
- Profit and Loss Statement : Table 16–5 (Case 1), Table 16–11 (Case 2)
- Fund Flow Table : Table 16–6 (Case 1), Table 16–12 (Case 2)
- Balance Sheet : Table 16–7 (Case 1), Table 16–13 (Case 2)

The contents of these financial tables are summarized below:

(1) Production Cost Accounting Table

In this study, the production cost is defined as the total of the operating cost, depreciation, and the interest (excluding the interest for the short term loan). The average production cost of citric acid over the period of 20 years is 1.87 US$/kg for Case 1 (for the initial year: 2.93 US$/kg, for the last operating year: 1.60 US$/kg) and 1.75 US$/kg for Case 2 (for the initial year: 2.62 US$/kg, for the last operating year: 1.60US$/kg). The breakdown of the production costs for Case 2 is shown in Figure 16–1. As the average unit sales price of citric acid is 1.81 US$/kg, a large profit cannot be expected from the operation.

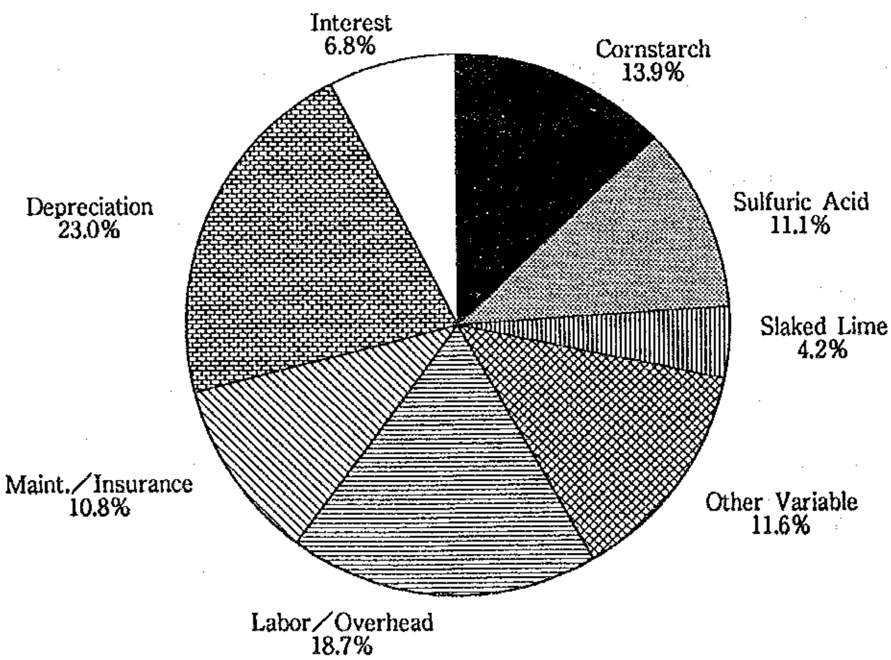

Figure 16–1 Breakdown of the Production Costs

(2) Profit and Loss Statement

For Case 1, a profit is obtained from year 13 and the accumulated profit before tax is minus US$ 6.55 million. For Case 2, a profit is obtained from year 8 and the accumulated profit before tax becomes positive and the payment of corporate tax begins from year 17. The accumulated profit after tax is about US$1.98 million.

(3) Fund Flow Table

For Case 1, a cash shortage will occur and continue until the last year of operation. For Case 2, a short term loan will not be required from the year 13 onwards.

(4) Balance Sheet

For Case 1, a debt of US$ 0.26 million is left at the end of the operation. For Case 2, about US$ 8.30 million in cash will remain at the end of the project.

(5) Summary

For Case 1, the cash position at the end of the project will be negative and the financial position is bad. For Case 2, it is possible to sustain the operation of the plant by using the short-term loan, but an adequate profit cannot be expected.

16–5–2 Internal Rate of Return

For this project, as indicators of financial profitability of the project, Internal Rate of Return on Investment (IRROI) and Internal Rate of Return on Equity (IRROE) are computed for both cases of "before tax" and "after tax". IRROI is the rate of return for the case in which the total capital required for the execution of the project is financed 100% by the company's own equity and this shows the inherent profitability of the project without the effect of the loan conditions or the ratio of equity and debt. On the other hand, IRROE shows the profitability for the company's equity under a particular set of the loan conditions. Therefore, if it is assumed that the surplus cash generated by the execution of the project is distributed to shareholders as a dividend according to their shares, IRROE is the rate of return to the share holders. The internal rate of return is the rate at which the cash flow for each year would have to be discounted to result in the accumulated cash flow generated becoming equal to the funds required for implementing the project. The calculation method for the cash flow is as shown in the attached cash flow tables (Tables 16–8, 9, 14 and 15). IRROI before tax is 2.9% and 1.5% after tax. IRROE cannot be calculated for Case 1 because the cash flow is minus for all the years. For Case 2, IRROE is 0.9% before tax and –0.1% after tax.

16–6 Sensitivity Analysis

By making Case 2 as the base case, assuming a soft loan can be borrowed from foreign countries, the sensitivity was evaluated by changing the assumptions used in the base case.

(1) Change of the product price

For this project, the sales price for each designated market is set based on the current market price. The price of chemical products including citric acid changes greatly according to the supply and demand balance and there is a possibility that the price of citric acid will change according to the market situation in future. There is also a possibility that the demand for citric acid in Zimbabwe will increase more than anticipated and the domestic sales amount, which is priced higher than the sales price for export, may increase. Furthermore, it can be assumed that an export incentive subsidy may be introduced as an export promotion policy in the future. In view of these possibilities, the project profitability is evaluated, assuming a sales price increase of 20%.

(2) Operating cost (variable cost and fixed cost)

Most of the industries in Zimbabwe are either monopolistic or oligopolistic and, therefore, the prices of industrial products in Zimbabwe are much higher than international prices due to this local industrial structure. Compared to the international price, only electricity is cheaper and all other costs are equal or higher. Taking sulfuric acid and slaked lime as examples, the price of sulfuric acid in the U.S.A. is 75 US$ per ton versus the local Zimbabwean price of 194 US$/ton which is 2.59 times higher, and the price of slaked lime is 48 US$/ton in the U.S.A. and 98 US$/ton in Zimbabwe which is 2.04 times higher. The price of coal is 9.5 US$/ton in the Republic of South Africa and 42.32 US$/ton in Zimbabwe, which is 4.4 times higher. The reason for the high prices of the industrial products is not necessarily due to monopoly or oligopoly, but by rationalizing the profits of producers and distributors in Zimbabwe, a considerable price reduction could be achieved. Considering these situations, a sensitivity analysis is carried out by reducing the operation cost by 20%.

(3) Plant construction cost

There may be a possibility to reduce the plant cost to some extent below the figure estimated in Chapter 13 for the reasons described below: The profitability of the project is analyzed assuming a plant cost reduction of 30%.

- In this study, the plant cost is estimated based on the conceptual design and adding a contingency to provide for a budget overrun. The accuracy of the plant cost estimates is plus minus 20%.
- Surtax levied on the plant cost may be exempted.
- For this study, the cost of the major pieces of equipment is estimated assuming Japanese supply. It may be possible to procure less expensive equipment in the European market.
- The cost of the construction supervisors can be reduced by hiring a European engineering firm in the Republic of South Africa or a Japanese contractor in Zambia.

16–6–2 Results of the Sensitivity Analysis

The results of the sensitivity analysis are summarized in Table 16–16 and the essential points are explained below.

(1) Change of the product price

If the sales price of the product is raised by 20%, IRROI and IRROE, both before tax, are 7.9% and 10.8% respectively. In the profit and loss statement, a profit is obtained from two years after commencement of the operation. The cash flow becomes positive from year 3 and it becomes negative again in years 6 and 7 when the repayment for the long term loan starts. However, after year 8, a cash surplus is available for allocation of dividends. The accumulated cash surplus at the end of the project life is about US$ 21.1 million.

(2) Operating costs (variable cost and fixed cost)

If the operating cost is reduced by 20%, the average production cost for the period of 20 years is 1.50 US$/kg. A profit is obtained from year 2 and no shortage of cash occur after year 8. The accumulated cash surplus at the end of the project life is approximately US$ 17.16 million. IRROI and IRROE, both before tax, are 6.5% and 8.2%, respectively.

(3) Plant construction cost

If the plant construction cost is reduced by 30%, the average production cost for 20 years is 1.54 US$/kg. A profit can be expected from year 2 on the profit and loss statement. The accumulated cash surplus at the end of the project is about US$ 14 million. IRROI and IRROE, both before tax, are 7.2% and 9.5%, respectively.

Table 16–16 Summary of the Sensitivity Analysis

	Base Case	Product Price 20% up	Operation Cost 20% down	Plant Cost 30% down
IRROI(b/tax)	2.9%	7.9%	6.5%	7.2%
IRROI(a/tax)	1.5%	4.9%	3.9%	4.5%
IRROE(b/tax)	0.9%	10.8%	8.2%	9.5%
IRROE(a/tax)	–0.1%	7.0%	5.1%	6.2%
Production Cost	1.75US$/kg	1.75US$/kg	1.50US$/kg	1.54US$/kg
Total Profit after Tax	2.0MMUS$	14.8MMUS$	10.8MMUS$	9.5MMUS$
Cum. Cash Surplus at 20th year	8.3MMUS$	21.1MMUS$	17.2MMUS$	14.0MMUS$

16–7 Summary of the Financial Analysis

The citric acid business in the world is in a severely competitive situation and a restructuring of the producers is currently under way. The plants which generate profits are those which are all already depreciated and their production capacities are as large as several tens of thousand tons per year of citric acid or those plants in regions where the raw materials, the subsidiary materials, the chemicals and the labor costs are extremely cheap and competitive, internationally. The producers, the new comers to the citric acid business, are the grain majors such as ADM and Cargil who are able to supply the main raw-material for production of citric acid by the fermentation process at a very competitive price. Since the raw material costs and the labor costs in Zimbabwe are not so competitive, it is not easy to enter into the citric acid business as a newcomer by constructing a citric acid plant with a size of 3,000 tons per year. The results of the financial analysis show that the project is not feasible.

Table 16-4 Production Cost Accounting Table (Case-1)

(1/2)

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Production Vol. (tons)	-/-	-/-	2,286	2,916	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Operation Cost												
Variable Operation Cost												
Cornstarch	-/-	-/-	554.3	707.0	727.4	727.4	727.4	727.4	727.4	727.4	727.4	727.4
Sulfuric Acid	-/-	-/-	442.7	564.7	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
Slaked Lime	-/-	-/-	167.6	213.8	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0
Filter Aid	-/-	-/-	73.4	93.7	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4
Activated Carbon	-/-	-/-	6.4	8.1	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
Ammonium Nitrate	-/-	-/-	9.0	11.5	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
Potassium Diphosphate	-/-	-/-	8.6	11.0	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Other Nutrients	-/-	-/-	1.7	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Amylase	-/-	-/-	22.4	28.5	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
Bag	-/-	-/-	29.0	37.0	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1
Electricity	-/-	-/-	173.3	221.1	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4
Water	-/-	-/-	52.6	67.1	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0
Coal	-/-	-/-	116.1	148.1	152.4	152.4	152.4	152.4	152.4	152.4	152.4	152.4
Sub-total	-/-	-/-	1,657.2	2,114.0	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8
Fixed Operation Cost												
Labour	-/-	-/-	952.9	761.9	761.9	761.9	761.9	761.9	761.9	761.9	761.9	761.9
Overhead	-/-	-/-	190.5	190.5	190.5	190.5	190.5	190.5	190.5	190.5	190.5	190.5
Maintenance	-/-	-/-	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2
Insurance	-/-	-/-	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8
Sub-total	-/-	-/-	1,699.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4
By-product Credit	-/-	-/-	-33.7	-43.0	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3
Total Operation Cost	-/-	-/-	3,322.9	3,579.3	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0
Depreciation												
Plant	-/-	-/-	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2
Building	-/-	-/-	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9
Pre-operation Cost	-/-	-/-	740.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest during Const.	-/-	-/-	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5
Total	-/-	-/-	1,918.2	1,177.6	1,177.6	1,177.6	1,177.6	1,177.6	1,177.6	1,177.6	1,177.6	1,177.6
Interest												
Foreign Loan	-/-	-/-	1,130.0	1,130.0	1,130.0	1,111.2	1,035.8	960.5	885.2	809.8	734.5	659.2
Local Loan	-/-	-/-	336.7	286.8	236.9	187.0	137.2	87.3	37.4	0.0	0.0	0.0
Total	-/-	-/-	1,466.7	1,416.8	1,366.9	1,298.2	1,173.0	1,047.8	922.6	809.8	734.5	659.2
Total Production Cost	-/-	-/-	6,707.8	6,173.7	6,183.5	6,114.8	5,989.6	5,864.3	5,739.1	5,626.4	5,551.1	5,475.7
Unit Prod. Cost (US$/kg)	-/-	-/-	2.93	2.12	2.06	2.04	2.00	1.95	1.91	1.88	1.85	1.83

Table 16－4 Production Cost Accounting Table (Case－1)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Average
Production Vol. (tons)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	2,960
Operation Cost											
Variable Operation Cost											
Cornstarch	727.4	727.4	727.4	727.4	727.4	727.4	727.4	727.4	727.4	727.4	717.7
Sulfuric Acid	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0	573.2
Slaked Lime	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	217.1
Filter Aid	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	95.1
Activated Carbon	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.3
Ammonium Nitrate	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.7
Potassium Diphosphate	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.2
Other Nutrients	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.2
Amylase	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	28.9
Bag	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	37.6
Electricity	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4	224.4
Water	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	68.1
Coal	152.4	152.4	152.4	152.4	152.4	152.4	152.4	152.4	152.4	152.4	150.3
Sub-total	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,145.9
Fixed Operation Cost											
Labour	761.9	761.9	761.9	761.9	761.9	761.9	761.9	761.9	761.9	760.3	771.4
Overhead	190.5	190.5	190.5	190.5	190.5	190.5	190.5	190.5	190.5	190.1	190.5
Maintenance	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2
Insurance	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8
Sub-total	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,506.4	1,517.9
By-product Credit	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-43.7
Total Operation Cost	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,637.0	3,620.1
Depreciation											
Plant	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2
Building	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9
Pre-operation Cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.0
Interest during Const.	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5
Total	1,177.6	1,177.6	1,177.6	1,177.6	1,177.6	1,177.6	1,177.6	1,177.6	1,177.6	1,177.6	1,214.6
Interest											
Foreign Loan	583.8	508.5	433.2	357.8	282.5	207.2	131.8	56.5	0.0	0.0	607.4
Local Loan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.5
Total	583.8	508.5	433.2	357.8	282.5	207.2	131.8	56.5	0.0	0.0	672.8
Total Production Cost	5,400.4	5,325.1	5,249.7	5,174.4	5,099.1	5,023.7	4,948.4	4,873.1	4,816.6	4,814.6	5,507.5
Unit Prod. Cost(US$/kg)	1.80	1.78	1.75	1.72	1.70	1.67	1.65	1.62	1.61	1.60	1.87

Table 16−5 Profit and Loss Statement (Case−1)

(1/2)

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Sales Revenue												
for Domestic Market	-/-	-/-	1,589	1,828	1,948	2,072	2,208	2,305	2,407	2,515	2,626	2,741
for Zambia	-/-	-/-	162	166	171	174	179	183	188	194	199	203
for Malawi	-/-	-/-	82	85	88	89	92	95	97	100	103	106
for RSA/SACU	-/-	-/-	1,862	2,611	2,897	2,809	2,715	2,645	2,571	2,495	2,414	2,330
for Mozambique	-/-	-/-	67	69	0	0	0	0	0	0	0	0
for Madagascar	-/-	-/-	147	151	0	0	0	0	0	0	0	0
Total	-/-	-/-	3,909	4,910	5,104	5,145	5,194	5,228	5,263	5,304	5,342	5,381
Cost of Sales	-/-	-/-	3,316	3,567	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639
Initial Product Inventory	-/-	-/-	0	7	20	19	19	19	19	19	19	19
Operation Cost	-/-	-/-	3,323	3,579	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639
Final Product Inventory	-/-	-/-	7	20	19	19	19	19	19	19	19	19
Depreciation	-/-	-/-	1,918	1,178	1,178	1,178	1,178	1,178	1,178	1,178	1,178	1,178
Interest												
Foreign Loan	-/-	-/-	1,130	1,130	1,130	1,111	1,036	960	885	810	734	659
Local Loan	-/-	-/-	337	287	237	187	137	87	37	0	0	0
Short-term Loan	-/-	-/-	0	56	89	117	161	202	240	274	278	278
Total	-/-	-/-	1,467	1,473	1,456	1,415	1,334	1,250	1,162	1,084	1,012	937
Profit bofore Tax	-/-	-/-	-2,792	-1,307	-1,169	-1,087	-957	-838	-716	-597	-487	-373
Taxable Income	-/-	-/-	0	0	0	0	0	0	0	0	0	0
Income Tax	-/-	-/-	0	0	0	0	0	0	0	0	0	0
Profit after Tax	-/-	-/-	-2,792	-1,307	-1,169	-1,087	-957	-838	-716	-597	-487	-373

Table 16-5 Profit and Loss Statement (Case-1)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Total
for Domestic Market	2,863	2,992	3,126	3,263	3,410	3,564	3,722	3,889	4,066	4,249	57,386
for Zambia	209	214	220	226	231	237	243	249	257	263	4,170
for Malawi	109	112	116	119	123	126	129	134	137	142	2,185
for RSA/SACU	2,243	2,152	2,057	1,957	1,854	1,745	1,632	1,513	1,389	1,283	43,172
for Mozambique	0	0	0	0	0	0	0	0	0	0	136
for Madagascar	0	0	0	0	0	0	0	0	0	0	298
Total	5,425	5,471	5,518	5,565	5,618	5,672	5,727	5,786	5,849	5,937	107,348
Cost of Sales	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,656	72,402
Initial Product Inventory	19	19	19	19	19	19	19	19	19	19	-/-
Operation Cost	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,637	72,402
Final Product Inventory	19	19	19	19	19	19	19	19	19	0	-/-
Depreciation	1,178	1,178	1,178	1,178	1,178	1,178	1,178	1,178	1,178	1,178	24,293
Interest											
Foreign Loan	584	508	433	358	282	207	132	56	0	0	12,147
Local Loan	0	0	0	0	0	0	0	0	0	0	1,309
Short-term Loan	275	269	260	248	232	212	189	161	129	75	3,746
Total	859	778	694	606	514	419	320	217	129	75	17,203
Profit before Tax	-250	-124	8	143	287	436	590	752	903	1,028	-6,549
Taxable Income	0	0	0	0	0	0	0	0	0	0	0
Income Tax	0	0	0	0	0	0	0	0	0	0	0
Profit after Tax	-250	-124	8	143	287	436	590	752	903	1,028	-6,549

Table 16-6 Fund Flow Table (Case-1)

(1/2)

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Source of Funds												
Profit after Tax	0	0	-2,792	-1,307	-1,169	-1,087	-957	-838	-716	-597	-487	-373
Depreciation	0	0	1,918	1,178	1,178	1,178	1,178	1,178	1,178	1,178	1,178	1,178
Equity	3,171	5,221	0	0	0	0	0	0	0	0	0	0
Foreign Loan	4,355	6,157	0	0	0	0	0	0	0	0	0	0
Local Loan	2,215	5,375	0	0	0	0	0	0	0	0	0	0
Short-term Loan	0	0	2,153	3,424	4,511	6,208	7,777	9,225	10,552	10,675	10,688	10,587
Account Payable Move.	0	0	138	38	5	0	0	0	0	0	0	0
Total	9,741	16,753	1,417	3,333	4,525	6,299	7,998	9,565	11,013	11,256	11,379	11,392
Application of Funds												
Plant Investment	9,443	14,892	0	0	0	0	0	0	0	0	0	0
Pre-operation Cost	71	669	0	0	0	0	0	0	0	0	0	0
Interest during Const.												
Foreign Loan	189	853	0	0	0	0	0	0	0	0	0	0
Local Loan	38	236	0	0	0	0	0	0	0	0	0	0
Working Capital Move.												
Cash on Hand	0	63	0	0	0	0	0	0	0	0	0	0
Raw Material Inventory	0	40	0	0	0	0	0	0	0	0	0	0
Product Inventory	0	0	7	12	0	0	0	0	0	0	0	0
Account Receivable	0	0	326	83	16	3	4	3	3	3	3	3
Repayment												
Foreign Loan	0	0	0	0	0	701	701	701	701	701	701	701
Local Loan	0	0	1,084	1,084	1,084	1,084	1,084	1,084	1,084	0	0	0
Short-term Loan	0	0	0	2,153	3,424	4,511	6,208	7,777	9,225	10,552	10,675	10,688
Total	9,741	16,753	1,417	3,333	4,525	6,299	7,998	9,565	11,013	11,256	11,379	11,392
Cash Surplus	0	0	0	0	0	0	0	0	0	0	0	0

Table 16-6 Fund Flow Table (Case-1)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Total
Source of Funds											
Profit after Tax	-250	-124	8	143	287	436	590	752	903	1,028	-6,549
Depreciation	1,178	1,178	1,178	1,178	1,178	1,178	1,178	1,178	1,178	1,178	24,293
Equity	0	0	0	0	0	0	0	0	0	0	8,393
Foreign Loan	0	0	0	0	0	0	0	0	0	0	10,512
Local Loan	0	0	0	0	0	0	0	0	0	0	7,590
Short-term Loan	10,364	10,015	9,534	8,919	8,159	7,250	6,188	4,965	2,889	0	144,085
Account Payable Move.	0	0	0	0	0	0	0	0	0	-181	0
Total	11,292	11,069	10,720	10,239	9,624	8,865	7,956	6,894	4,970	2,024	188,322
Application of Funds											
Plant Investment	0	0	0	0	0	0	0	0	0	0	24,334
Pre-operation Cost	0	0	0	0	0	0	0	0	0	0	741
Interest during Const.											
Foreign Loan	0	0	0	0	0	0	0	0	0	0	1,042
Local Loan	0	0	0	0	0	0	0	0	0	0	274
Working Capital Move.											
Cash on Hand	0	0	0	0	0	0	0	0	0	0	63
Raw Material Inventory	0	0	0	0	0	0	0	0	0	-40	0
Product Inventory	0	0	0	0	0	0	0	0	0	-19	0
Account Receivable	4	4	4	4	4	5	5	5	5	-487	0
Repayment											
Foreign Loan	701	701	701	701	701	701	701	701	0	0	10,512
Local Loan	0	0	0	0	0	0	0	0	0	0	7,590
Short-term Loan	10,587	10,364	10,015	9,534	8,919	8,159	7,250	6,188	4,965	2,889	144,085
Total	11,292	11,069	10,720	10,239	9,624	8,865	7,956	6,894	4,970	2,342	188,640
Cash Surplus	0	0	0	0	0	0	0	0	0	-318	-318

Table 16－7 Projected Balance Sheet (Case－1)

(1/2)

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Current Asset												
Cash on Hand & Bank	0	63	63	63	63	63	63	63	63	63	63	63
Raw Material Inventory	0	40	40	40	40	40	40	40	40	40	40	40
Product Inventory	0	0	7	20	19	19	19	19	19	19	19	19
Account Receivable	0	0	326	409	425	429	433	436	439	442	445	448
Total	0	103	436	532	548	552	556	559	561	565	568	571
Fixed Asset												
Land	674	674	674	674	674	674	674	674	674	674	674	674
Plant & Building	8,769	23,661	22,545	21,430	20,315	19,200	18,085	16,970	15,855	14,740	13,625	12,509
Pre-operation Cost	71	741	0	0	0	0	0	0	0	0	0	0
Interest during Const.	227	1,316	1,253	1,191	1,128	1,066	1,003	941	878	816	753	691
Total	9,741	26,391	24,473	23,295	22,117	20,940	19,762	18,585	17,407	16,229	15,052	13,874
Total Asset	9,741	26,494	24,909	23,827	22,666	21,491	20,318	19,143	17,968	16,794	15,620	14,445
Current Liability												
Short-term Loan	0	0	2,153	3,424	4,511	6,208	7,777	9,225	10,552	10,675	10,688	10,587
Account Payable	0	0	138	176	181	181	181	181	181	181	181	181
Total	0	0	2,291	3,601	4,692	6,390	7,958	9,406	10,733	10,856	10,869	10,768
Long-term Liability												
Foreign Loan	4,355	10,512	10,512	10,512	10,512	9,811	9,110	8,409	7,709	7,008	6,307	5,606
Local Loan	2,215	7,590	6,506	5,421	4,337	3,253	2,169	1,084	0	0	0	0
Total	6,570	18,101	17,017	15,933	14,849	13,064	11,279	9,494	7,709	7,008	6,307	5,606
Shareholders' Equity												
Capital	3,171	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393
Retained Earning	0	0	-2,792	-4,099	-5,268	-6,355	-7,312	-8,150	-8,866	-9,462	-9,949	-10,322
Total	3,171	8,393	5,601	4,294	3,125	2,038	1,081	243	-473	-1,070	-1,556	-1,929
Total Equity & Liability	9,741	26,494	24,909	23,827	22,666	21,491	20,318	19,143	17,968	16,794	15,620	14,445

Table 16-7 Projected Balance Sheet (Case-1)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20
Current Asset										
Cash on Hand	63	63	63	63	63	63	63	63	63	-255
Raw Material Inventory	40	40	40	40	40	40	40	40	40	0
Product Inventory	19	19	19	19	19	19	19	19	19	0
Account Receivable	452	456	460	464	468	473	477	482	487	0
Total	575	579	583	587	591	596	600	605	610	-255
Fixed Asset										
Land	674	674	674	674	674	674	674	674	674	674
Plant & Building	11,394	10,279	9,164	8,049	6,934	5,819	4,704	3,589	2,474	1,358
Pre-operation Cost	0	0	0	0	0	0	0	0	0	0
Interest during Const.	628	566	503	441	378	316	253	191	128	66
Total	12,697	11,519	10,341	9,164	7,986	6,809	5,631	4,453	3,276	2,098
Total Asset	13,272	12,098	10,924	9,750	8,577	7,404	6,231	5,058	3,886	1,844
Current Liability										
Short-term Loan	10,364	10,015	9,534	8,919	8,159	7,250	6,188	4,965	2,889	0
Account Payable	181	181	181	181	181	181	181	181	181	0
Total	10,546	10,196	9,716	9,100	8,340	7,432	6,370	5,146	3,070	0
Long-term Liability										
Foreign Loan	4,905	4,205	3,504	2,803	2,102	1,402	701	0	0	0
Local Loan	0	0	0	0	0	0	0	0	0	0
Total	4,905	4,205	3,504	2,803	2,102	1,402	701	0	0	0
Shareholders' Equity										
Capital	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393
Retained Earning	-10,572	-10,696	-10,688	-10,546	-10,258	-9,822	-9,232	-8,481	-7,577	-6,549
Total	-2,179	-2,303	-2,295	-2,153	-1,866	-1,429	-839	-88	816	1,844
Total Equity & Liability	13,272	12,098	10,924	9,750	8,577	7,404	6,231	5,058	3,886	1,844

Table 16－8 Ungeared Cash Flow Table (Case－1)

(1/2)

ROI(b/tax)= 2.9%　　ROI(a/tax)= 1.5%

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Cash Inflow												
Sales Revenue	0	0	3,909	4,910	5,104	5,145	5,194	5,228	5,263	5,304	5,342	5.381
Account Payable Move.	0	0	138	38	5	0	0	0	0	0	0	0
Total	0	0	4.047	4,948	5,109	5,145	5,194	5,228	5,263	5,304	5,342	5.381
Cash Outflow												
Cost of Sales	0	0	3.316	3,567	3,639	3,639	3,639	3,639	3.639	3,639	3,639	3.639
Plant Investment	9,443	14,892	0	0	0	0	0	0	0	0	0	0
Pre-operation Cost	71	669	0	0	0	0	0	0	0	0	0	0
Working Capital Move.												
Cash on Hand	0	63	0	0	0	0	0	0	0	0	0	0
Raw Material Inventory	0	40	0	0	0	0	0	0	0	0	0	0
Product Inventory	0	0	7	12	0	0	0	0	0	0	0	0
Account Receivable	0	0	326	83	16	3	4	3	3	3	3	3
Income Tax	0	0	0	0	0	0	62	202	216	234	250	266
Total	9,514	15,564	3,649	3,663	3,655	3,642	3,705	3,843	3,858	3,876	3,892	3.909
Cash Flow(before/tax)	-9,514	-15,664	398	1,285	1,454	1,503	1,551	1,587	1,621	1,662	1,700	1.739
Cash Flow(after/tax)	-9,514	-15,664	398	1,285	1,454	1,503	1,489	1,385	1,405	1,428	1,450	1.472

Table 16－8 Ungeared Cash Flow Table (Case－1)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Total
Cash Inflow											
Sales Revenue	5,425	5,471	5,518	5,565	5,618	5,672	5,727	5,786	5,849	5,937	107,348
Account Payable Move.	0	0	0	0	0	0	0	0	0	-181	0
Total	5,425	5,471	5,518	5,565	5,618	5,672	5,727	5,786	5,849	5,756	107,348
Cash Outflow											
Cost of Sales	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,656	72,402
Plant Investment	0	0	0	0	0	0	0	0	0	0	24,334
Pre-operation Cost	0	0	0	0	0	0	0	0	0	0	741
Working Capital Move.											
Cash on Hand	0	0	0	0	0	0	0	0	0	-63	0
Raw Material Inventory	0	0	0	0	0	0	0	0	0	-40	0
Product Inventory	0	0	0	0	0	0	0	0	0	-19	0
Account Receivable	4	4	4	4	4	5	5	5	5	-487	0
Income Tax	285	305	325	345	367	390	413	438	465	495	5,059
Total	3,928	3,947	3,967	3,988	4,011	4,034	4,057	4,082	4,110	3,542	102,536
Cash Flow(before/tax)	1,783	1,828	1,875	1,922	1,975	2,029	2,083	2,142	2,205	2,710	9,871
Cash Flow(after/tax)	1,497	1,523	1,550	1,577	1,608	1,639	1,670	1,703	1,739	2,214	4,812

Table 16-9 Geared Cash Flow Table (Case-1)

(1/2)

ROE(b/tax)= #DIV/0! ROE(a/tax)= #DIV/0!

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Cash Inflow												
Sales Revenue	0	0	3,909	4,910	5,104	5,145	5,194	5,228	5,263	5,304	5,342	5,381
Foreign Loan	4,355	6,157	0	0	0	0	0	0	0	0	0	0
Local Loan	2,215	5,375	0	0	0	0	0	0	0	0	0	0
Short-term Loan	0	0	2,153	3,424	4,511	6,208	7,777	9,225	10,552	10,675	10,688	10,587
Account Payable Move.	0	0	138	38	5	0	0	0	0	0	0	0
Total	6,570	11,532	6,200	8,372	9,620	11,353	12,971	14,454	15,814	15,979	16,030	15,968
Cash Outflow												
Cost of Sales	0	0	3,316	3,567	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639
Plant Investment	9,443	14,892	0	0	0	0	0	0	0	0	0	0
Pre-operation Cost	71	669	0	0	0	0	0	0	0	0	0	0
Interest during Const.	227	1,089	0	0	0	0	0	0	0	0	0	0
Working Capital Move.												
Cash on Hand	0	63	0	0	0	0	0	0	0	0	0	0
Raw Material Inventory	0	40	0	0	0	0	0	0	0	0	0	0
Product Inventory	0	0	7	12	0	0	0	0	0	0	0	0
Account Receivable	0	0	326	83	16	3	4	3	3	3	3	3
Interest												
Foreign Loan	0	0	1,130	1,130	1,130	1,111	1,036	960	885	810	734	659
Local Loan	0	0	337	287	237	187	137	87	37	0	0	0
Short-term Loan	0	0	0	56	89	117	161	202	240	274	278	278
Repayment												
Foreign Loan	0	0	0	0	0	701	701	701	701	701	701	701
Local Loan	0	0	1,084	1,084	1,084	1,084	1,084	1,084	1,084	0	0	0
Short-term Loan	0	0	0	2,153	3,424	4,511	6,208	7,777	9,225	10,552	10,675	10,688
Income Tax	0	0	0	0	0	0	0	0	0	0	0	0
Total	9,741	16,753	6,200	8,372	9,620	11,353	12,971	14,454	15,814	15,979	16,030	15,968
Cash Flow(before/tax)	-3,171	-5,221	0	0	0	0	0	0	0	0	0	0
Cash Flow(after/tax)	-3,171	-5,221	0	0	0	0	0	0	0	0	0	0

Table 16-9 Geared Cash Flow Table (Case-1)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Total
Cash Inflow											
Sales Revenue	5,425	5,471	5,518	5,565	5,618	5,672	5,727	5,786	5,849	5,937	107,348
Foreign Loan	0	0	0	0	0	0	0	0	0	0	10,512
Local Loan	0	0	0	0	0	0	0	0	0	0	7,590
Short-term Loan	10,364	10,015	9,534	8,919	8,159	7,250	6,188	4,965	2,889	0	144,085
Account Payable Move.	0	0	0	0	0	0	0	0	0	-181	0
Total	15,790	15,486	15,052	14,484	13,777	12,923	11,915	10,750	8,738	5,756	269,534
Cash Outflow											
Cost of Sales	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,656	72,402
Plant Investment	0	0	0	0	0	0	0	0	0	0	24,334
Pre-operation Cost	0	0	0	0	0	0	0	0	0	0	741
Interest during Const.	0	0	0	0	0	0	0	0	0	0	1,316
Working Capital Move.											
Cash on Hand	0	0	0	0	0	0	0	0	0	-63	0
Raw Material Inventory	0	0	0	0	0	0	0	0	0	-40	0
Product Inventory	0	0	0	0	0	0	0	0	0	-19	0
Account Receivable	4	4	4	4	4	5	5	5	5	-487	0
Interest											
Foreign Loan	584	508	433	358	282	207	132	56	0	0	12,147
Local Loan	0	0	0	0	0	0	0	0	0	0	1,309
Short-term Loan	275	269	260	248	232	212	189	161	129	75	3,746
Repayment											
Foreign Loan	701	701	701	701	701	701	701	701	0	0	10,512
Local Loan	0	0	0	0	0	0	0	0	0	0	7,590
Short-term Loan	10,587	10,364	10,015	9,534	8,919	8,159	7,250	6,188	4,965	2,889	144,085
Income Tax	0	0	0	0	0	0	0	0	0	0	0
Total	15,790	15,486	15,052	14,484	13,777	12,923	11,915	10,750	8,738	6,010	278,181
Cash Flow(before/tax)	0	0	0	0	0	0	0	0	0	-255	-8,647
Cash Flow(after/tax)	0	0	0	0	0	0	0	0	0	-255	-8,647

Table 16－10 Production Cost Accounting Table (Case－2)

(1/2)

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Production Vol. (tons)	-/-	-/-	2,286	2,916	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Operation Cost												
Variable Operation Cost												
Cornstarch	-/-	-/-	554.3	707.0	727.4	727.4	727.4	727.4	727.4	727.4	727.4	727.4
Sulfuric Acid	-/-	-/-	442.7	564.7	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
Slaked Lime	-/-	-/-	167.6	213.8	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0
Filter Aid	-/-	-/-	73.4	93.7	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4
Activated Carbon	-/-	-/-	6.4	8.1	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
Ammonium Nitrate	-/-	-/-	9.0	11.5	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
Potassium Diphosphate	-/-	-/-	8.6	11.0	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Other Nutrients	-/-	-/-	1.7	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Amylase	-/-	-/-	22.4	28.5	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
Bag	-/-	-/-	29.0	37.0	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1
Electricity	-/-	-/-	173.3	221.1	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4
Water	-/-	-/-	52.6	67.1	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0
Coal	-/-	-/-	116.1	148.1	152.4	152.4	152.4	152.4	152.4	152.4	152.4	152.4
Sub-total	-/-	-/-	1,657.2	2,114.0	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8
Fixed Operation Cost												
Labour	-/-	-/-	952.9	761.9	761.9	761.9	761.9	761.9	761.9	761.9	761.9	761.9
Overhead	-/-	-/-	190.5	190.5	190.5	190.5	190.5	190.5	190.5	190.5	190.5	190.5
Maintenance	-/-	-/-	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2
Insurance	-/-	-/-	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8
Sub-total	-/-	-/-	1,699.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4
By-product Credit	-/-	-/-	-33.7	-43.0	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3
Total Operation Cost	-/-	-/-	3,322.9	3,579.3	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0
Depreciation												
Plant	-/-	-/-	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2
Building	-/-	-/-	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9
Pre-operation Cost	-/-	-/-	740.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest during Const.	-/-	-/-	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2
Total	-/-	-/-	1,889.0	1,148.4	1,148.4	1,148.4	1,148.4	1,148.4	1,148.4	1,148.4	1,148.4	1,148.4
Interest												
Foreign Loan	-/-	-/-	445.3	445.3	445.3	445.3	445.3	437.9	408.2	378.5	348.8	319.1
Local Loan	-/-	-/-	336.7	286.8	236.9	187.0	137.2	87.3	37.4	0.0	0.0	0.0
Total	-/-	-/-	782.0	732.1	682.2	632.3	582.5	525.2	445.6	378.5	348.8	319.1
Total Production Cost	-/-	-/-	5,993.8	5,459.8	5,469.5	5,419.7	5,369.8	5,312.5	5,232.9	5,165.8	5,136.1	5,106.5
Unit Prod. Cost(US$/kg)	-/-	-/-	2.62	1.87	1.82	1.81	1.79	1.77	1.74	1.72	1.71	1.70

Table 16-10 Production Cost Accounting Table (Case-2)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Average
Production Vol. (tons)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	2,960
Operation Cost											
Variable Operation Cost											
Cornstarch	727.4	727.4	727.4	727.4	727.4	727.4	727.4	727.4	727.4	727.4	717.7
Sulfuric Acid	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0	573.2
Slaked Lime	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	217.1
Filter Aid	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	95.1
Activated Carbon	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.3
Ammonium Nitrate	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.7
Potassium Diphosphate	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.2
Other Nutrients	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.2
Amylase	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	28.9
Bag	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	37.6
Electricity	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4	224.4
Water	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	68.1
Coal	152.4	152.4	152.4	152.4	152.4	152.4	152.4	152.4	152.4	152.4	150.3
Sub-total	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,174.8	2,145.9
Fixed Operation Cost											
Labour	761.9	761.9	761.9	761.9	761.9	761.9	761.9	761.9	761.9	760.3	771.4
Overhead	190.5	190.5	190.5	190.5	190.5	190.5	190.5	190.5	190.5	190.1	190.5
Maintenance	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2	473.2
Insurance	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8
Sub-total	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,508.4	1,506.4	1,517.9
By-product Credit	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-44.3	-43.7
Total Operation Cost	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,639.0	3,637.0	3,620.1
Depreciation											
Plant	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2	957.2
Building	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9	157.9
Pre-operation Cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.0
Interest during Const.	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2
Total	1,148.4	1,148.4	1,148.4	1,148.4	1,148.4	1,148.4	1,148.4	1,148.4	1,148.4	1,148.4	1,185.4
Interest											
Foreign Loan	289.5	259.8	230.1	200.4	170.7	141.0	111.3	81.6	52.0	22.3	283.9
Local Loan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.5
Total	289.5	259.8	230.1	200.4	170.7	141.0	111.3	81.6	52.0	22.3	349.3
Total Production Cost	5,076.8	5,047.1	5,017.4	4,987.7	4,958.0	4,928.3	4,898.6	4,869.0	4,839.3	4,807.6	5,154.8
Unit Prod. Cost(US$/kg)	1.69	1.68	1.67	1.66	1.65	1.64	1.63	1.62	1.61	1.60	1.75

Table 16－11 Profit and Loss Statement (Case－2)

(1/2)

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Sales Revenue												
for Domestic Market	-/-	-/-	1,589	1,828	1,948	2,072	2,208	2,305	2,407	2,515	2,626	2,741
for Zambia	-/-	-/-	162	166	171	174	179	183	188	194	199	203
for Malawi	-/-	-/-	82	85	88	89	92	95	97	100	103	106
for RSA/SACU	-/-	-/-	1,862	2,611	2,897	2,809	2,715	2,645	2,571	2,495	2,414	2,330
for Mozambique	-/-	-/-	67	69	0	0	0	0	0	0	0	0
for Madagascar	-/-	-/-	147	151	0	0	0	0	0	0	0	0
Total	-/-	-/-	3,909	4,910	5,104	5,145	5,194	5,228	5,263	5,304	5,342	5,381
Cost of Sales	-/-	-/-	3,316	3,567	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639
Initial Product Inventory	-/-	-/-	0	7	20	19	19	19	19	19	19	19
Operation Cost	-/-	-/-	3,323	3,579	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639
Final Product Inventory	-/-	-/-	7	20	19	19	19	19	19	19	19	19
Depreciation	-/-	-/-	1,889	1,148	1,148	1,148	1,148	1,148	1,148	1,148	1,148	1,148
Interest												
Foreign Loan	-/-	-/-	445	445	445	445	445	438	408	379	349	319
Local Loan	-/-	-/-	337	287	237	187	137	87	37	0	0	0
Short-term Loan	-/-	-/-	0	38	53	62	70	74	94	111	98	83
Total	-/-	-/-	782	770	735	695	652	600	540	490	447	402
Profit bofore Tax	-/-	-/-	-2,078	-576	-419	-337	-245	-158	-64	27	107	192
Taxable Income	-/-	-/-	0	0	0	0	0	0	0	0	0	0
Income Tax	-/-	-/-	0	0	0	0	0	0	0	0	0	0
Profit after Tax	-/-	-/-	-2,078	-576	-419	-337	-245	-158	-64	27	107	192

Table 16-11 Profit and Loss Statement (Case-2)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Total
for Domestic Market	2,863	2,992	3,126	3,263	3,410	3,564	3,722	3,889	4,066	4,249	57,386
for Zambia	209	214	220	226	231	237	243	249	257	263	4,170
for Malawi	109	112	116	119	123	126	129	134	137	142	2,185
for RSA/SACU	2,243	2,152	2,057	1,957	1,854	1,745	1,632	1,513	1,389	1,283	43,172
for Mozambique	0	0	0	0	0	0	0	0	0	0	136
for Madagascar	0	0	0	0	0	0	0	0	0	0	298
Total	5,425	5,471	5,518	5,565	5,618	5,672	5,727	5,786	5,849	5,937	107,348
Cost of Sales	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,656	72,402
Initial Product Inventory	19	19	19	19	19	19	19	19	19	19	-/-
Operation Cost	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,637	72,402
Final Product Inventory	19	19	19	19	19	19	19	19	19	0	-/-
Depreciation	1,148	1,148	1,148	1,148	1,148	1,148	1,148	1,148	1,148	1,148	23,708
Interest											
Foreign Loan	289	260	230	200	171	141	111	82	52	22	5,678
Local Loan	0	0	0	0	0	0	0	0	0	0	1,309
Short-term Loan	65	45	23	0	0	0	0	0	0	0	817
Total	355	305	253	200	171	141	111	82	52	22	7,804
Profit before Tax	284	379	478	577	660	744	828	917	1,010	1,110	3,435
Taxable Income	0	0	0	0	0	0	398	917	1,010	1,110	3,435
Income Tax	0	0	0	0	0	0	169	390	429	472	1,460
Profit after Tax	284	379	478	577	660	744	659	527	581	638	1,975

Table 16－12 Fund Flow Table (Case－2)

(1/2)

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Source of Funds												
Profit after Tax	0	0	-2,078	-576	-419	-337	-245	-158	-64	27	107	192
Depreciation	0	0	1,889	1,148	1,148	1,148	1,148	1,148	1,148	1,148	1,148	1,148
Equity	3,171	5,221	0	0	0	0	0	0	0	0	0	0
Foreign Loan	4,244	5,651	0	0	0	0	0	0	0	0	0	0
Local Loan	2,215	5,375	0	0	0	0	0	0	0	0	0	0
Short-term Loan	0	0	1,468	2,037	2,403	2,679	2,864	3,621	4,284	3,772	3,179	2,502
Account Payable Move.	0	0	138	38	5	0	0	0	0	0	0	0
Total	9,631	16,248	1,417	2,648	3,137	3,490	3,767	4,611	5,368	4,947	4,435	3,842
Application of Funds												
Plant Investment	9,443	14,892	0	0	0	0	0	0	0	0	0	0
Pre-operation Cost	71	669	0	0	0	0	0	0	0	0	0	0
Interest during Const.												
Foreign Loan	78	348	0	0	0	0	0	0	0	0	0	0
Local Loan	38	236	0	0	0	0	0	0	0	0	0	0
Working Capital Move.												
Cash on Hand	0	63	0	0	0	0	0	0	0	0	0	0
Raw Material Inventory	0	40	0	0	0	0	0	0	0	0	0	0
Product Inventory	0	0	7	12	0	0	0	0	0	0	0	0
Account Receivable	0	0	326	83	16	3	4	3	3	3	3	3
Repayment												
Foreign Loan	0	0	0	0	0	0	0	660	660	660	660	660
Local Loan	0	0	1,084	1,084	1,084	1,084	1,084	1,084	1,084	0	0	0
Short-term Loan	0	0	0	1,468	2,037	2,403	2,679	2,864	3,621	4,284	3,772	3,179
Total	9,631	16,248	1,417	2,648	3,137	3,490	3,767	4,611	5,368	4,947	4,435	3,842
Cash Surplus	0	0	0	0	0	0	0	0	0	0	0	0

Table 16-12 Fund Flow Table (Case-2)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Total
Source of Funds											
Profit after Tax	284	379	478	577	660	744	659	527	581	638	1,975
Depreciation	1,148	1,148	1,148	1,148	1,148	1,148	1,148	1,148	1,148	1,148	23,708
Equity	0	0	0	0	0	0	0	0	0	0	8,393
Foreign Loan	0	0	0	0	0	0	0	0	0	0	9,896
Local Loan	0	0	0	0	0	0	0	0	0	0	7,590
Short-term Loan	1,733	870	0	0	0	0	0	0	0	0	31,413
Account Payable Move.	0	0	0	0	0	0	0	0	0	-181	0
Total	3,165	2,397	1,626	1,726	1,809	1,892	1,807	1,675	1,729	1,605	82,975
Application of Funds											
Plant Investment	0	0	0	0	0	0	0	0	0	0	24,334
Pre-operation Cost	0	0	0	0	0	0	0	0	0	0	741
Interest during Const.											
Foreign Loan	0	0	0	0	0	0	0	0	0	0	426
Local Loan	0	0	0	0	0	0	0	0	0	0	274
Working Capital Move.											
Cash on Hand	0	0	0	0	0	0	0	0	0	0	63
Raw Material Inventory	0	0	0	0	0	0	0	0	0	-40	0
Product Inventory	0	0	0	0	0	0	0	0	0	-19	0
Account Receivable	4	4	4	4	4	5	5	5	5	-487	0
Repayment											
Foreign Loan	660	660	660	660	660	660	660	660	660	660	9,896
Local Loan	0	0	0	0	0	0	0	0	0	0	7,590
Short-term Loan	2,502	1,733	870	0	0	0	0	0	0	0	31,413
Total	3,165	2,397	1,534	664	664	664	664	665	665	113	74,738
Cash Surplus	0	0	93	1,062	1,144	1,228	1,143	1,011	1,064	1,492	8,237

Table 16 – 13 Projected Balance Sheet (Case – 2)

(1/2)

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Current Asset												
Cash on Hand & Bank	0	63	63	63	63	63	63	63	63	63	63	63
Raw Material Inventory	0	40	40	40	40	40	40	40	40	40	40	40
Product Inventory	0	0	7	20	19	19	19	19	19	19	19	19
Account Receivable	0	0	326	409	425	429	433	436	439	442	445	448
Total	0	103	436	532	548	552	556	559	561	565	568	571
Fixed Asset												
Land	674	674	674	674	674	674	674	674	674	674	674	674
Plant & Building	8,769	23,661	22,545	21,430	20,315	19,200	18,085	16,970	15,855	14,740	13,625	12,509
Pre-operation Cost	71	741	0	0	0	0	0	0	0	0	0	0
Interest during Const.	117	700	667	633	600	567	534	500	467	434	401	367
Total	9,631	25,775	23,886	22,738	21,589	20,441	19,293	18,144	16,996	15,848	14,699	13,551
Total Asset	9,631	25,878	24,323	23,270	22,138	20,993	19,848	18,703	17,557	16,412	15,267	14,122
Current Liability												
Short-term Loan	0	0	1,468	2,037	2,403	2,679	2,864	3,621	4,284	3,772	3,179	2,502
Account Payable	0	0	138	176	181	181	181	181	181	181	181	181
Total	0	0	1,606	2,213	2,584	2,860	3,046	3,803	4,465	3,953	3,360	2,683
Long-term Liability												
Foreign Loan	4,244	9,896	9,896	9,896	9,896	9,896	9,896	9,236	8,576	7,917	7,257	6,597
Local Loan	2,215	7,590	6,506	5,421	4,337	3,253	2,169	1,084	0	0	0	0
Total	6,460	17,486	16,401	15,317	14,233	13,149	12,064	10,320	8,576	7,917	7,257	6,597
Shareholders' Equity												
Capital	3,171	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393
Retained Earning	0	0	-2,078	-2,653	-3,072	-3,409	-3,654	-3,813	-3,877	-3,850	-3,743	-3,551
Total	3,171	8,393	6,315	5,739	5,321	4,984	4,738	4,580	4,516	4,542	4,650	4,842
Total Equity & Liability	9,631	25,878	24,323	23,270	22,138	20,993	19,848	18,703	17,557	16,412	15,267	14,122

Table 16-13 Projected Balance Sheet (Case-2)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20
Current Asset										
Cash on Hand	63	63	156	1,218	2,362	3,591	4,733	5,744	6,808	8,300
Raw Material Inventory	40	40	40	40	40	40	40	40	40	0
Product Inventory	19	19	19	19	19	19	19	19	19	0
Account Receivable	452	456	460	464	468	473	477	482	487	0
Total	575	579	675	1,741	2,890	4,123	5,270	6,285	7,355	8,300
Fixed Asset										
Land	674	674	674	674	674	674	674	674	674	674
Plant & Building	11,394	10,279	9,164	8,049	6,934	5,819	4,704	3,589	2,474	1,358
Pre-operation Cost	0	0	0	0	0	0	0	0	0	0
Interest during Const.	334	301	268	234	201	168	135	101	68	35
Total	12,403	11,254	10,106	8,958	7,809	6,661	5,513	4,364	3,216	2,067
Total Asset	12,978	11,833	10,781	10,699	10,699	10,783	10,782	10,650	10,571	10,368
Current Liability										
Short-term Loan	1,733	870	0	0	0	0	0	0	0	0
Account Payable	181	181	181	181	181	181	181	181	181	0
Total	1,915	1,051	181	181	181	181	181	181	181	0
Long-term Liability										
Foreign Loan	5,938	5,278	4,618	3,958	3,299	2,639	1,979	1,319	660	0
Local Loan	0	0	0	0	0	0	0	0	0	0
Total	5,938	5,278	4,618	3,958	3,299	2,639	1,979	1,319	660	0
Shareholders' Equity										
Capital	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393	8,393
Retained Earning	-3,267	-2,889	-2,411	-1,834	-1,174	-430	229	756	1,337	1,975
Total	5,125	5,504	5,982	6,559	7,219	7,963	8,622	9,149	9,730	10,368
Total Equity & Liability	12,978	11,833	10,781	10,699	10,699	10,783	10,782	10,650	10,571	10,368

Table 16－14 Ungeared Cash Flow Table (Case－2)

(1/2)

ROI(b/tax)= 2.9%　　ROI(a/tax)= 1.5%

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Cash Inflow												
Sales Revenue	0	0	3,909	4,910	5,104	5,145	5,194	5,228	5,263	5,304	5,342	5,381
Account Payable Move.	0	0	138	38	5	0	0	0	0	0	0	0
Total	0	0	4,047	4,948	5,109	5,145	5,194	5,228	5,263	5,304	5,342	5,381
Cash Outflow												
Cost of Sales	0	0	3,316	3,567	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639
Plant Investment	9,443	14,892	0	0	0	0	0	0	0	0	0	0
Pre-operation Cost	71	669	0	0	0	0	0	0	0	0	0	0
Working Capital Move.												
Cash on Hand	0	63	0	0	0	0	0	0	0	0	0	0
Raw Material Inventory	0	40	0	0	0	0	0	0	0	0	0	0
Product Inventory	0	0	7	12	0	0	0	0	0	0	0	0
Account Receivable	0	0	326	83	16	3	4	3	3	3	3	3
Income Tax	0	0	0	0	0	0	62	202	216	234	250	266
Total	9,514	15,664	3,649	3,663	3,655	3,642	3,705	3,843	3,858	3,876	3,892	3,909
Cash Flow(before/tax)	-9,514	-15,664	398	1,285	1,454	1,503	1,551	1,587	1,621	1,662	1,700	1,739
Cash Flow(after/tax)	-9,514	-15,664	398	1,285	1,454	1,503	1,489	1,385	1,405	1,428	1,450	1,472

Table 16-14 Ungeared Cash Flow Table (Case-2)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Total
Cash Inflow											
Sales Revenue	5,425	5,471	5,518	5,565	5,618	5,672	5,727	5,786	5,849	5,937	107,348
Account Payable Move.	0	0	0	0	0	0	0	0	0	-181	0
Total	5,425	5,471	5,518	5,565	5,618	5,672	5,727	5,786	5,849	5,756	107,348
Cash Outflow											
Cost of Sales	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,656	72,402
Plant Investment	0	0	0	0	0	0	0	0	0	0	24,334
Pre-operation Cost	0	0	0	0	0	0	0	0	0	0	741
Working Capital Move.											
Cash on Hand	0	0	0	0	0	0	0	0	0	-63	0
Raw Material Inventory	0	0	0	0	0	0	0	0	0	-40	0
Product Inventory	0	0	0	0	0	0	0	0	0	-19	0
Account Receivable	4	4	4	4	4	5	5	5	5	-487	0
Income Tax	285	305	325	345	367	390	413	438	465	495	5,059
Total	3,928	3,947	3,967	3,988	4,011	4,034	4,057	4,082	4,110	3,542	102,536
Cash Flow(before/tax)	1,783	1,828	1,875	1,922	1,975	2,029	2,083	2,142	2,205	2,710	9,871
Cash Flow(after/tax)	1,497	1,523	1,550	1,577	1,608	1,639	1,670	1,703	1,739	2,214	4,812

Table 16－15 Geared Cash Flow Table (Case－2)

(1/2)

ROE(b/tax)= 0.9%   ROE(a/tax)= -0.1%

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Cash Inflow												
Sales Revenue	0	0	3,909	4,910	5,104	5,145	5,194	5,228	5,263	5,304	5,342	5,381
Foreign Loan	4,244	5,651	0	0	0	0	0	0	0	0	0	0
Local Loan	2,215	5,375	0	0	0	0	0	0	0	0	0	0
Short-term Loan	0	0	1,468	2,037	2,403	2,679	2,864	3,621	4,284	3,772	3,179	2,502
Account Payable Move.	0	0	138	38	5	0	0	0	0	0	0	0
Total	6,460	11,026	5,515	6,985	7,512	7,824	8,059	8,850	9,547	9,076	8,521	7,883
Cash Outflow												
Cost of Sales	0	0	3,316	3,567	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639
Plant Investment	9,443	14,892	0	0	0	0	0	0	0	0	0	0
Pre-operation Cost	71	669	0	0	0	0	0	0	0	0	0	0
Interest during Const.	117	583	0	0	0	0	0	0	0	0	0	0
Working Capital Move.												
Cash on Hand	0	63	0	0	0	0	0	0	0	0	0	0
Raw Material Inventory	0	40	0	0	0	0	0	0	0	0	0	0
Product Inventory	0	0	7	12	0	0	0	0	0	0	0	0
Account Receivable	0	0	326	83	16	3	4	3	3	3	3	3
Interest												
Foreign Loan	0	0	445	445	445	445	445	438	408	379	349	319
Local Loan	0	0	337	287	237	187	137	87	37	0	0	0
Short-term Loan	0	0	0	38	53	62	70	74	94	111	98	83
Repayment												
Foreign Loan	0	0	0	0	0	0	0	660	660	660	660	660
Local Loan	0	0	1,084	1,084	1,084	1,084	1,084	1,084	1,084	0	0	0
Short-term Loan	0	0	0	1,468	2,037	2,403	2,679	2,864	3,621	4,284	3,772	3,179
Income Tax	0	0	0	0	0	0	0	0	0	0	0	0
Total	9,631	16,248	5,515	6,985	7,512	7,824	8,059	8,850	9,547	9,076	8,521	7,883
Cash Flow(before/tax)	-3,171	-5,221	0	0	0	0	0	0	0	0	0	0
Cash Flow(after/tax)	-3,171	-5,221	0	0	0	0	0	0	0	0	0	0

Table 16－15 Geared Cash Flow Table (Case－2)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Total
Cash Inflow											
Sales Revenue	5,425	5,471	5,518	5,565	5,618	5,672	5,727	5,786	5,849	5,937	107,348
Foreign Loan	0	0	0	0	0	0	0	0	0	0	9,896
Local Loan	0	0	0	0	0	0	0	0	0	0	7,590
Short-term Loan	1,733	870	0	0	0	0	0	0	0	0	31,413
Account Payable Move.	0	0	0	0	0	0	0	0	0	-181	0
Total	7,159	6,341	5,518	5,565	5,618	5,672	5,727	5,786	5,849	5,756	156,247
Cash Outflow											
Cost of Sales	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,639	3,656	72,402
Plant Investment	0	0	0	0	0	0	0	0	0	0	24,334
Pre-operation Cost	0	0	0	0	0	0	0	0	0	0	741
Interest during Const.	0	0	0	0	0	0	0	0	0	0	700
Working Capital Move.											
Cash on Hand	0	0	0	0	0	0	0	0	0	-63	0
Raw Material Inventory	0	0	0	0	0	0	0	0	0	-40	0
Product Inventory	0	0	0	0	0	0	0	0	0	-19	0
Account Receivable	4	4	4	4	4	5	5	5	5	-487	0
Interest											
Foreign Loan	289	260	230	200	171	141	111	82	52	22	5,678
Local Loan	0	0	0	0	0	0	0	0	0	0	1,309
Short-term Loan	65	45	23	0	0	0	0	0	0	0	817
Repayment											
Foreign Loan	660	660	660	660	660	660	660	660	660	660	9,896
Local Loan	0	0	0	0	0	0	0	0	0	0	7,590
Short-term Loan	2,502	1,733	870	0	0	0	0	0	0	0	31,413
Income Tax	0	0	0	0	0	0	169	390	429	472	1,460
Total	7,159	6,341	5,425	4,503	4,474	4,444	4,584	4,775	4,785	4,200	156,339
Cash Flow(before/tax)	0	0	93	1,062	1,144	1,228	1,312	1,400	1,493	2,028	1,368
Cash Flow(after/tax)	0	0	93	1,062	1,144	1,228	1,143	1,011	1,064	1,556	-92

Chapter 17 Economic Analysis

Chapter 17 Economic Analysis

17–1 Introduction

In this chapter the appropriateness of the project for producing citric acid using cornstarch made in Zimbabwe is evaluated in terms of the national economy.

In the previous Chapter 16, the viability and profitability of the project have been studied financially based on market prices and costs. Many of these prices are considered to be distorted by taxes, subsidies, exchange rates, etc., but not on market theory functions. In other words, the market prices can be greatly altered by policy changes made by the government, and the profitability of the project can often be affected by such changes. Therefore, by removing such distorted parts of the prices, the project is also evaluated to see if it is suitable for the national economy, not just for a private company. In this economic analysis, the appropriateness of the project is studied in the following way:

(1) Economic benefits and costs are evaluated and an economic internal rate of return is calculated.

(2) The balance of foreign currency resulting from the project is evaluated.

17–2 Economic Internal Rate of Return

17–2–1 Economic Parameters

In calculating the economic internal rate of return, sales and costs used in the financial analysis must be converted to economic prices by introducing economic parameters specific to Zimbabwe. In this study, the following parameters are used:

- Shadow exchange rates
- Shadow wages

(1) Shadow exchange rate

In many developing countries, there is a large difference between the official exchange rate and the real exchange rate. If domestic costs and prices are converted to US dollars by using the official exchange rate, the costs are overvalued. So a shadow exchange rate is employed in the economic analysis taking into account a foreign exchange premium, which is multiplied by the official exchange rate to calculate the shadow exchange rate. The foreign exchange premium is calculated by the following formula:

$$FEP = \frac{IMP\,(1 + Tax^{imp} + TQ^{imp}) + EXP\,(1 - Tax^{exp})}{IMP + EXP}$$

here,

FEP	:	Foreign Exchange Premium
IMP	:	Total amount of imports (cif)
EXP	:	Total amount of exports (fob)
Tax^{imp}	:	Weighted average value of import tax rate
TQ^{imp}	:	Import tax equivalent to import restriction values
Tax^{exp}	:	Weighted average value of export tax rate

According to the World Bank's data (real Figures in 1987 based on 1980 constant prices), the foreign exchange premium can be calculated as follows:

$$FEP = \frac{990 \times (1 + 0.16 + 0.63) + 1{,}400 \times (1 - 0.00)}{990 + 1{,}400} = 1.33$$

Recently, it is quoted that the foreign exchange premium usually lies between 1.5 and 2.0 for Zimbabwe. This study adopts the minimum figure of 1.5 for the following reasons:

(a) The above formula is a simple method to supplement the lack of statistical data.

(b) A larger figure than 1.33 is considered reasonable when applied only to equipment and materials which are necessary for plant construction, although statistical data are not available.

(c) Zimbabwean materials for citric acid production are generally more expensive than international ones. Thus a larger premium value than 1.33 is necessary for the ratio between the official and shadow exchange rates.

(d) If a different shadow exchange rate is used, comparison with other projects becomes difficult.

(2) Shadow wages

Employees in the proposed citric acid plant are classified into skilled workers and unskilled workers. There are not many skilled workers in Zimbabwe. Hence the wage of the skilled worker is considered to be properly determined according to the supply/demand balance of the market. So, these wages are used without any conversion in this study. Many unskilled workers, however, are unemployed and the wages for the unskilled workers used in the financial analysis must be modified for the economic analysis. Of the whole labor force population, only 37% of them earn cash according to a labor force study conducted in 1986/87. The remaining 63% of the population are communal peasant farmers or unemployed persons. By assuming the opportunity cost for them is zero, the shadow wage rate is calculated as follows:

$SWR = 1 \times 0.37 + 0 \times 0.63 = 0.37$

17–2–2 Economic Profits

The direct benefit brought by the project is the proceeds of the sale of citric acid. As citric acid is a traded commodity, the economic price of citric acid is equivalent to its border price. The economic price of citric acid to be sold in each market is determined as follows:

(1) Domestic price

The economic price of citric acid in Zimbabwe (cif) is 1.53 US$/kg which is obtained by adding ocean freight and insurance costs from Europe to the Republic of South Africa (0.1 US$/kg) and the inland transportation cost (0.03 US$/kg) onto the European fob price of 1.4 US$/kg.

(2) Export prices

The economic prices for exports are calculated by deducting the transportation cost between the project site and an export market from the cif border price for each country. This is the same method as is used in the financial analysis. So these prices are also used in the economic analysis as shown below:

- Republic of South Africa : 1.47 US$/kg
- Zambia/Malawi : 1.54 US$/kg
- Mozambique/Madagascar : 1.40 US$/kg

17–2–3 Economic Capital Requirements

Capital costs required during the construction of the plant are plant costs, pre-operation costs, and initial working capital. Economic costs for these items are discussed below:

(1) Plant costs

Plant costs consist of a foreign currency portion and a domestic currency portion. As the foreign currency portion was estimated on the basis of free competition, the costs mentioned in the financial analysis are determined to be also the economic costs. Economic costs for the domestic currency portion are calculated as follows:

(a) Import tax

Surtax levied on imported equipment and materials is transferred from the project to the government account in Zimbabwe. This is a transfer item and is to be evaluated at zero in the economic analysis.

(b) Construction costs

For the calculation of economic construction costs, such as installation and fabrication costs for equipment, piping, electrical and instrument work, the construction costs are first separated into material costs and labor costs. The material costs are modified using the shadow exchange rate. The labor costs for unskilled workers are modified using the shadow wage rate and converted to the economic labor cost in US dollars using the shadow exchange rate. The cost ratios of materials, skilled workers and unskilled workers are shown in Table 17–1 for each work item.

Table 17–1 Breakdown of Construction Cost, %

Item	Material	Skilled Labour	Unskilled Labour
Installation and Piping	68.9	15.0	16.1
Electrical and Instrument	88.8	5.7	5.5
Civil and Building	70.0	11.3	18.7
Insulation and Painting	69.1	11.5	19.4

(c) Others

Equipment costs used in the financial analysis are modified using the shadow exchange rate.

(d) Summary

The above economic construction costs are summarized in Table 17–2.

Table 17–2 Total Economic Plant Cost, US$

Item	Foreign	Local	Total
Land Aquisition & Site Preparation Cost	0	427,926	427,926
License Fee	1,000,000	0	1,000,000
Engineering Fee	1,072,000	199,333	1,271,333
Machinery & Equipment	6,369,000	2,591,333	8,960,333
Spare Parts and Spare Pumps	191,000	102,667	293,667
Inland Transportation Cost	0	135,333	135,333
Installation & Piping Cost	0	1,640,789	1,640,789
Electrical & Instrument Cost	0	920,300	920,300
Civil & Building Cost	0	1,965,519	1,965,519
Insulation & Painting Cost	0	186,089	186,089
Supervision	429,000	66,000	495,000
Contingency	196,800	391,731	588,531
TOTAL	9,257,800	8,627,022	17,884,822

(2) Pre-operation costs

Economic costs for the foreign currency portion of the pre-operation costs are the same as the financial costs. The domestic currency portion is as follows:

– The labor cost for guards is modified in the economic costs using the shadow wage rate.

– The labor cost after modification and other relevant costs are converted to economic costs using the shadow exchange rate.

(3) Initial working capital

As cash and inventories are considered to be transfer items, their values are zero in the economic analysis.

(4) Interest during construction

The interest during construction is a transfer item and is not involved in the economic analysis.

(5) Total capital requirement

The total economic capital costs are summarized in Table 17–3.

Table 17–3 Total Economic Investment Cost, US$

Project Year	–2	–1	Total
Plant Construction Cost	7,185,468	10,699,354	17,884,822
Pre-operation Cost	47,619	513,244	560,863
Total	7,233,087	11,212,598	18,445,685

17–2–4 Economic Operating Costs

(1) Raw material cost

As described in Chapter 16, prices of subsidiary materials made in Zimbabwe are more expensive than international prices. The domestic market prices should be converted to economic prices using the shadow exchange rate. The cornstarch price shown in the financial analysis can be used in the economic analysis because it is assumed that the price is based on the production cost under free competition in international markets. The prices of imported subsidiary materials are determined to be the same as those used in the financial analysis.

(2) Utility costs

Costs for water and coal are converted to economic costs using the shadow exchange rate. As the cost of electricity is quite low in Zimbabwe compared to the international cost, the current market price is used for economic analysis without conversion by the shadow exchange rate.

(3) Fixed operating costs

Fixed operating costs consist of the personnel expenses, administration cost, maintenance cost and insurance cost. The cost of the guards in the personnel expenses is modified using the shadow wage rate, as the guards are considered to be unskilled workers, and then the cost is converted to US dollar using the shadow exchange rate. The economic administration cost is taken to be 25% of the calculated economic personnel costs. The economic maintenance cost is taken to be 2% of the plant cost, excluding land and land preparation costs, that is shown in Table 17–2. The insurance cost is not considered in the economic analysis as this is a transfer item.

(4) By-product credit

The price of gypsum, a by-product resulting from citric acid production, is converted to its economic price using the shadow exchange rate. Other by-products or wastes are not considered in the economic analysis as were also the case in the financial analysis.

(5) Interest and principle repayments

Interest and principle repayments are transfer items, so they are not considered in the economic analysis.

(6) Corporate tax

Corporate tax is a transfer item from a private company to a government account. It is not considered in the economic analysis.

17–2–5 Results

Economic benefits and costs are summarized in Table 17–4. An economic internal rate of return (EIRR) is calculated by the discounted cash flow method on the basis of the difference between the economic benefits and the economic costs shown in the table. The calculated EIRR is 5.5% which is better than the financial internal rate of return.

Table 17–4 Economic Benefits and Costs (1/2)

EIRR = 5.5%

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Cash Inflow												
Sales Revenue												
for Domestic Market	0.0	0.0	1,075.6	1,237.8	1,318.9	1,403.0	1,494.8	1,560.6	1,629.5	1,702.9	1,777.9	1,855.9
for Zambia	0.0	0.0	161.7	166.3	170.9	174.0	178.6	183.3	187.9	194.0	198.7	203.3
for Malawi	0.0	0.0	81.6	84.7	87.8	89.3	92.4	95.5	97.0	100.1	103.2	106.3
for RSA/SACU	0.0	0.0	1,862.5	2,610.7	2,897.4	2,809.2	2,715.1	2,644.5	2,571.0	2,494.6	2,413.7	2,330.0
for Mozambique	0.0	0.0	67.2	68.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
for Madagascar	0.0	0.0	147.0	151.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Inflow	0.0	0.0	3,395.6	4,319.3	4,475.0	4,475.5	4,480.9	4,483.9	4,485.4	4,491.6	4,493.4	4,495.4
Cash Outflow												
Operation Cost												
Cornstarch	0.0	0.0	554.3	707.0	727.4	727.4	727.4	727.4	727.4	727.4	727.4	727.4
Sulfuric Acid	0.0	0.0	295.1	376.5	387.3	387.3	387.3	387.3	387.3	387.3	387.3	387.3
Slaked Lime	0.0	0.0	167.6	213.8	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0
Filter Aid	0.0	0.0	73.4	93.7	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4
Activated Carbon	0.0	0.0	6.4	8.1	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
Ammonium Nitrate	0.0	0.0	6.0	7.7	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Potassium Diphosphate	0.0	0.0	8.6	11.0	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Other Nutrients	0.0	0.0	1.7	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Amylase	0.0	0.0	22.4	28.5	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
Bag	0.0	0.0	19.4	24.7	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4
Electricity	0.0	0.0	173.3	221.1	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4
Water	0.0	0.0	35.1	44.7	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0
Coal	0.0	0.0	77.4	98.7	101.6	101.6	101.6	101.6	101.6	101.6	101.6	101.6
Labour	0.0	0.0	683.6	504.6	504.6	504.6	504.6	504.6	504.6	504.6	504.6	504.6
Overhead	0.0	0.0	126.2	126.2	126.2	126.2	126.2	126.2	126.2	126.2	126.2	126.2
Maintenance	0.0	0.0	349.1	349.1	349.1	349.1	349.1	349.1	349.1	349.1	349.1	349.1
Total Operation Cost	0.0	0.0	2,599.6	2,817.7	2,870.6	2,870.6	2,870.6	2,870.6	2,870.6	2,870.6	2,870.6	2,870.6
By-product Credit	0.0	0.0	-22.5	-28.7	-29.5	-29.5	-29.5	-29.5	-29.5	-29.5	-29.5	-29.5
Investment	7,233.1	11,212.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Outflow	7,233.1	11,212.6	2,577.1	2,789.0	2,841.1	2,841.1	2,841.1	2,841.1	2,841.1	2,841.1	2,841.1	2,841.1
Net Cashflow	-7,233.1	-11,212.6	818.5	1,530.3	1,633.8	1,634.4	1,639.8	1,642.8	1,644.3	1,650.5	1,652.3	1,654.3

Table 17–4 Economic Benefits and Costs (2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Total
Cash Inflow											
Sales Revenue											
for Domestic Market	1,938.5	2,025.7	2,116.0	2,209.3	2,308.8	2,412.8	2,519.9	2,633.1	2,752.5	2,876.4	38,849.8
for Zambia	209.4	214.1	220.2	226.4	231.0	237.2	243.3	249.5	257.2	263.3	4,170.3
for Malawi	109.3	112.4	115.5	118.6	123.2	126.3	129.4	134.0	137.1	141.7	2,185.3
for RSA/SACU	2,243.2	2,152.1	2,056.5	1,956.6	1,853.7	1,744.9	1,631.7	1,512.6	1,389.2	1,283.3	43,172.4
for Mozambique	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	135.8
for Madagascar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	298.2
Total	4,500.5	4,504.3	4,508.2	4,510.9	4,516.6	4,521.1	4,524.3	4,529.2	4,535.9	4,564.7	88,811.8
Cash Outflow											
Operation Cost											
Cornstarch	727.4	727.4	727.4	727.4	727.4	727.4	727.4	727.4	727.4	727.4	14,354.3
Sulfuric Acid	387.3	387.3	387.3	387.3	387.3	387.3	387.3	387.3	387.3	387.3	7,643.0
Slaked Lime	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	4,341.5
Filter Aid	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	1,902.0
Activated Carbon	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	165.4
Ammonium Nitrate	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	156.2
Potassium Diphosphate	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	223.7
Other Nutrients	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	44.7
Amylase	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	578.9
Bag	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	501.2
Electricity	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4	227.4	4,488.1
Water	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0	908.4
Coal	101.6	101.6	101.6	101.6	101.6	101.6	101.6	101.6	101.6	101.6	2,004.5
Labour	504.6	504.6	504.6	504.6	504.6	504.6	504.6	504.6	504.6	504.6	10,271.1
Overhead	126.2	126.2	126.2	126.2	126.2	126.2	126.2	126.2	126.2	126.2	2,523.0
Maintenance	349.1	349.1	349.1	349.1	349.1	349.1	349.1	349.1	349.1	349.1	6,982.8
Total Operation Cost	2,870.6	2,870.6	2,870.6	2,870.6	2,870.6	2,870.6	2,870.6	2,870.6	2,870.6	2,870.6	57,088.7
By-product Credit	-29.5	-29.5	-29.5	-29.5	-29.5	-29.5	-29.5	-29.5	-29.5	-29.5	-582.6
Investment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18,445.7
Total Outflow	2,841.1	2,841.1	2,841.1	2,841.1	2,841.1	2,841.1	2,841.1	2,841.1	2,841.1	2,841.1	74,951.7
Net Cashflow	1,659.4	1,663.2	1,667.1	1,669.7	1,675.5	1,680.0	1,683.2	1,688.1	1,694.8	1,723.6	13,860.0

17–3 Sensitivity Analysis

Based on the above case, sensitivity analyses are conducted by changing the following parameters:

- Economic benefit : changed by plus and minus 20%
- Foreign exchange premium : 1.33 and 2.0 instead of 1.5

The sensitivity analysis is summarized below:

(1) Changes in economic benefit

Market prices of citric acid change according to the supply and demand balance of the market as described in the financial analysis. It is probable that the economic benefits will be changed by plus or minus 20% with the fluctuation of the citric acid price in international markets. When the economic benefit is changed by plus 20%, the economic internal rate of return is increased by 5.5% to 11.0%. On the other hand, when the economic benefit is changed by minus 20%, the economic internal rate of return is decreased by 7.5% to minus 2.0%.

(2) Changes in the foreign exchange premium

The foreign exchange premium is calculated based on certain conditions; it is calculated to be 1.33 by the study team, while standards in Zimbabwe are between 1.5 and 2.0 as described. Thus, in this sensitivity analysis, the minimum of 1.33 and the maximum of 2.0 were adopted as premiums. The economic internal rates of return are calculated to be 3.7 % in the case of a premium of 1.33 and 9.4% in the case of a premium of 2.0.

17–4 Foreign Exchange Balance

The effects of this project on the foreign exchange balance of Zimbabwe are evaluated by the following method:

(1) This project will contribute to the saving of foreign currency as citric acid sold domestically is an import substitute. The economic import price of citric acid is equivalent to the border price as described.

(2) Exports of citric acid will directly contribute to the earning of foreign currency. The economic export prices of citric acid are equivalent to the border prices as described.

(3) The costs of imported subsidiary materials and foreign supervisors in the operating costs are an outflow of foreign currency. The economic import prices of the subsidiary materials are to be the same as those used in the financial analysis.

(4) The foreign currency portion of plant maintenance costs is taken to be US$ 95,500 per annum which is equivalent to the cost of one year's spare parts as included in the plant costs.

(5) Repayment of the principle and payment of interest arising from a foreign long term loan are an outflow of foreign currency.

(6) A foreign long term loan introduced during the construction period is an inflow of foreign currency. However, it goes out of the country for the payment of foreign equipment and so the inflow is offset. Thus, the foreign currency flow during the construction period is not considered.

Based on the above, the foreign currency balance of this project is indicated in Table 17–5 (for Case 1) and Table 17–6 (for Case 2). Case 1 assumes a commercial bank loan and the foreign currency balance is calculated to be plus US$ 56.83 million at the end of project life. Case 2 assumes a soft loan and the foreign currency balance is calculated to be plus US$ 63.92 million.

17–5 Conclusion

The economic benefits brought by this project will be the saving of foreign currency for domestic citric acid consumption and the earning of foreign currency from the exports. The amount of foreign currency earned and saved will be US$56.83 million or 2.3 times the plant costs in the case of a commercial bank loan and US$63.92 million or 2.6 times in the case of a soft loan.

The resulting economic internal rate of return does not show that this project will bring in a large profit.

Table 17-5 Foreign Currency Balance Table (Case 1) (1/2)

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Foreign Currency Inflow												
Foreign Currency Saving	0.0	0.0	1,075.6	1,237.8	1,318.9	1,403.0	1,494.8	1,560.6	1,629.5	1,702.9	1,777.9	1,855.9
Foreign Currency Earning	0.0	0.0	2,320.0	3,081.5	3,156.1	3,072.5	2,986.1	2,923.3	2,855.9	2,788.7	2,715.6	2,639.5
Total Inflow	0.0	0.0	3,395.6	4,319.3	4,475.0	4,475.5	4,480.9	4,483.9	4,485.4	4,491.6	4,493.4	4,495.4
Foreign Currency Outflow												
Operation Cost												
Slaked Lime	0.0	0.0	167.6	213.8	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0
Filter Aid	0.0	0.0	73.4	93.7	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4
Activated Carbon	0.0	0.0	6.4	8.1	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
Potassium Diphosphate	0.0	0.0	8.6	11.0	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Other Nutrients	0.0	0.0	1.7	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Amylase	0.0	0.0	22.4	28.5	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
Labour	0.0	0.0	155.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance	0.0	0.0	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5
Total Operation Cost	0.0	0.0	530.7	452.9	463.2	463.2	463.2	463.2	463.2	463.2	463.2	463.2
Interest(Foreign Loan)	0.0	0.0	1,130.0	1,130.0	1,130.0	1,111.2	1,035.8	960.5	885.2	809.8	734.5	659.2
Repayment(Foreign Loan)	0.0	0.0	0.0	0.0	0.0	700.8	700.8	700.8	700.8	700.8	700.8	700.8
Total Outflow	0.0	0.0	1,660.7	1,582.9	1,593.2	2,275.1	2,199.8	2,124.5	2,049.1	1,973.8	1,898.5	1,823.1
Cash Balance	0.0	0.0	1,734.9	2,736	2,882	2,200	2,281	2,359	2,436	2,518	2,595	2,672

Table 17–5 Foreign Currency Balance Table (Case 1)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Total
Foreign Currency Inflow											
Foreign Currency Saving	1,938.5	2,025.7	2,116.0	2,209.3	2,308.8	2,412.8	2,519.9	2,633.1	2,752.5	2,876.4	38,849.8
Foreign Currency Earning	2,562.0	2,478.6	2,392.3	2,301.5	2,207.9	2,108.3	2,004.4	1,896.1	1,783.4	1,688.3	49,962.0
Total Inflow	4,500.5	4,504.3	4,508.2	4,510.9	4,516.6	4,521.1	4,524.3	4,529.2	4,535.9	4,564.7	88,811.8
Foreign Currency Outflow											
Operation Cost											
Slaked Lime	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	4,341.5
Filter Aid	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	1,902.0
Activated Carbon	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	165.4
Potassium Diphosphate	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	223.7
Other Nutrients	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	44.7
Amylase	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	578.9
Labour	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	155.0
Maintenance	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	1,910.0
Total Operation Cost	463.2	463.2	463.2	463.2	463.2	463.2	463.2	463.2	463.2	463.2	9,321.1
Interest(Foreign Loan)	583.8	508.5	433.2	357.8	282.5	207.2	131.8	56.5	0.0	0.0	12,147.5
Repayment(Foreign Loan)	700.8	700.8	700.8	700.8	700.8	700.8	700.8	700.8	0.0	0.0	10,511.6
Total Outflow	1,747.8	1,672.5	1,597.1	1,521.8	1,446.5	1,371.1	1,295.8	1,220.5	463.2	463.2	31,980.1
Cash Balance	2,753	2,832	2,911	2,989	3,070	3,150	3,228	3,309	4,073	4,102	56,831.6

Table 17-6 Foreign Currency Balance Table (Case 2) (1/2)

(Unit: US$ in Thousand)

Project Year	-2	-1	1	2	3	4	5	6	7	8	9	10
Foreign Currency Inflow												
Foreign Currency Saving	0.0	0.0	1,075.6	1,237.8	1,318.9	1,403.0	1,494.8	1,560.6	1,629.5	1,702.9	1,777.9	1,855.9
Foreign Currency Earning	0.0	0.0	2,320.0	3,081.5	3,156.1	3,072.5	2,986.1	2,923.3	2,855.9	2,788.7	2,715.6	2,639.5
Total Inflow	0.0	0.0	3,395.6	4,319.3	4,475.0	4,475.5	4,480.9	4,483.9	4,485.4	4,491.6	4,493.4	4,495.4
Foreign Currency Outflow												
Operation Cost												
Slaked Lime	0.0	0.0	167.6	213.8	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0
Filter Aid	0.0	0.0	73.4	93.7	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4
Activated Carbon	0.0	0.0	6.4	8.1	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
Potassium Diphosphate	0.0	0.0	8.6	11.0	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Other Nutrients	0.0	0.0	1.7	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Amylase	0.0	0.0	22.4	28.5	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
Labour	0.0	0.0	155.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance	0.0	0.0	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5
Total Operation Cost	0.0	0.0	530.7	452.9	463.2	463.2	463.2	463.2	463.2	463.2	463.2	463.2
Interest(Foreign Loan)	0.0	0.0	445.3	445.3	445.3	445.3	445.3	437.9	408.2	378.5	348.8	319.1
Repayment(Foreign Loan)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	659.7	659.7	659.7	659.7	659.7
Total Outflow	0.0	0.0	976.0	898.2	908.5	908.5	908.5	1,560.8	1,531.1	1,501.4	1,471.7	1,442.1
Cash Balance	0.0	0.0	2,419.6	3,421	3,566	3,567	3,572	2,923	2,954	2,990	3,022	3,053

Table 17–6 Foreign Currency Balance Table (Case 2)

(2/2)

(Unit: US$ in Thousand)

Project Year	11	12	13	14	15	16	17	18	19	20	Total
Foreign Currency Inflow											
Foreign Currency Saving	1,938.5	2,025.7	2,116.0	2,209.3	2,308.8	2,412.8	2,519.9	2,633.1	2,752.5	2,876.4	38,849.8
Foreign Currency Earning	2,562.0	2,478.6	2,392.3	2,301.5	2,207.9	2,108.3	2,004.4	1,896.1	1,783.4	1,688.3	49,962.0
Total Inflow	4,500.5	4,504.3	4,508.2	4,510.9	4,516.6	4,521.1	4,524.3	4,529.2	4,535.9	4,564.7	88,811.8
Foreign Currency Outflow											
Operation Cost											
Slaked Lime	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	4,341.5
Filter Aid	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	1,902.0
Activated Carbon	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	165.4
Potassium Diphosphate	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	223.7
Other Nutrients	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	44.7
Amylase	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	578.9
Labour	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	155.0
Maintenance	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	1,910.0
Total Operation Cost	463.2	463.2	463.2	463.2	463.2	463.2	463.2	463.2	463.2	463.2	9,321.1
Interest(Foreign Loan)	289.5	259.8	230.1	200.4	170.7	141.0	111.3	81.6	52.0	22.3	5,677.8
Repayment(Foreign Loan)	659.7	659.7	659.7	659.7	659.7	659.7	659.7	659.7	659.7	659.7	9,895.9
Total Outflow	1,412.4	1,382.7	1,353.0	1,323.3	1,293.6	1,263.9	1,234.2	1,204.6	1,174.9	1,145.2	24,894.7
Cash Balance	3,088	3,122	3,155	3,188	3,223	3,257	3,290	3,325	3,361	3,420	63,917.0

Chapter 18 Conclusion and Recommendations

Chapter 18 Conclusion and Recommendations

It became clear that the production of citric acid is technically possible using cornstarch made in Zimbabwe from the results of the fermentation tests. Also, there are no obstacles to establishing a citric acid industry in Zimbabwe in terms of technical transfer, supplies of materials and utilities, environmental measures and plant construction.

In technical terms, for the implementation of the project, care should be taken for the following:

(1) Raw materials

Even a small amount of impurities in the raw material will have a large effects on the production yield of citric acid in the fermentation process. Also variable purity of the raw material will often make the control of the process difficult. Thus, raw materials with little impurities and stable quality must be provided. Impurities contained in subsidiary materials used in the separation process will also have a large effect on the recovery rate and purification of citric acid.

To enlarge the market share in the region, good quality materials must be used as citric acid is a food additive and its standard is strictly specified by major multinational users such as Coca Cola.

(2) Control of Fungi

Citric acid producing mold will be purely cultured in test tubes. Since the production capability of the fungi naturally tends to degenerate during the culturing period, it is necessary to select better fungi for the citric acid production through fermentation tests. There are several plants which have needed licenser's instructions for a few years after the commencement of operation, because the designed production yield could not be obtained due to improper control of fungi. Therefore, sufficient instruction should be received from a licenser about the control of fungi.

(3) Plant

Citric acid plant processes can be divided into two main parts, the fermentation process and the separation process. Equipment installed in the separation process is widely used in other chemical plants, whereas equipment in the fermentation process is specially designed for biochemical technology. For instance, a main fermenters for citric acid production is basically different from other brewing fermenters such as those for beer or wine production and high grade techniques are required for the design and fabrication. In piping work, special design and installation techniques are also required for control of purity in the process. Hence, it is recommended to hire a contractor who has sufficient experience and capabilities for procurement of equipment and piping work.

(4) Electric power

Even a short period of power failure will affect a total production plan as the citric acid producing fungi will change its nature due to lack of aeration in the fermentation process and sometimes equipment in the separation process will be broken. Therefore, measures should be taken to avoid electric power failures and to rapidly restart the process after the restoration of power.

(5) Education and training

A certain level of knowledge and techniques is required for plant operators. Appropriate education and training programs will be necessary both before and after the commencement of operation.

(6) Environmental control

The proposed citric acid plant is an intrinsically environmentally safe plant as its raw material is a food, cornstarch. However, as waste water with relatively high BOD and COD values is discharged from the plant, the biological treatment described in the study report should be carried out.

Estimated annual demands for citric acid in the middle of the 1990s (1996) will be 6,200 tons in total in southern Africa; 900 tons in Zimbabwe, 4,700 tons in the Republic of South Africa, 110 tons in Zambia and so on. As European citric acid producers are well entrenched with major citric acid consumers in the Republic of South Africa, more than half of the market in South Africa cannot be considered as being accessible to a proposed Zimbabwean citric acid producer. Also, exports to Europe cannot be considered because of the geographical location of Zimbabwe. So the plant capacity of this project has to be 3,000 tons, which is far smaller than the minimum size of a commercial plant which is said to be around 10,000 tons.

The world citric acid industry is now under the pressure of very fierce competition and restructuring of the industry is underway because major producers have established large, capital intensive, facilities and producers in developing countries have entered into the market. Major citric acid producers in the world tend to be changing from chemical companies to grain processing companies, which can provide the raw material cheaply. Recently, even in China, which supplies citric acid cheaply, small scale producers have stopped their production because of a cut in export subsidies by the government. Under the circumstances, it is said that only large scale plants of a few tens of thousand tons capacity, of which the facilities are already depreciated, or plants, where very cheap raw materials and labor costs are available, can make reasonable or marginal profits in the citric acid business.

The results of the financial analysis do not show such a good profitability for the project. This is mainly attributed to the following inherent features of the industry in Zimbabwe, as well as the world market situations and limited market size mentioned above:

(1) Zimbabwean industry is diversified since the economy of Zimbabwe has been headed towards self-sufficiency. Most of the industry, however, has a monopolistic or oligopolistic structure and prices of materials for citric acid production are considerably higher than international prices. For instance, the sulfuric acid price in Zimbabwe (194 US$/ton) is as much as 2.59 times that in USA, the slaked lime price in Zimbabwe (98 US$/ton, imported from Zambia) 2.04 times that in USA, and the coal price (42.32 US$/ton) 4.45 times that in the Republic of South Africa.

(2) Transportation of equipment and materials is expensive because of the inland location.

(3) Personnel wages in Zimbabwe are not necessarily low when compared to those in other developing countries.

Thus, the entry of a new Zimbabwean company into the citric acid industry with a 3,000 ton plant will not be so easy and careful consideration and evaluation must be given to the implementation of the project.

On the other hand, regarding the sales in the domestic market, when this project is considered for the purpose of import substitution, expensive transportation costs and a high rate of commission charged by the domestic suppliers act favorably to maintain domestic citric acid prices at a high level. However, the sales volume of this portion is about one third of the total sales and the remaining two thirds have to be sold competitively in foreign market.

To make the project financially feasible, the following measures can be considered:

(a) To exempt surtaxes on imported equipment and materials used for the plant construction.

(b) To reduce interest costs by the government having a share of the equity capital or by a government loan.

(c) To receive the most beneficial loan conditions from abroad.

(d) To find the best method for the supply of the equipment and materials necessary for the plant construction.

(e) To make the raw material costs close to international market costs by further promoting corporate rationalization through the ongoing trade liberalization program and price decontrol.

(f) To provide a subsidy for citric acid exports to neighboring countries, if necessary.

(g) To consider capital sharing from consumers in other Southern African countries to make the citric acid industry stable in the region.

However, it will be very difficult to realize all of the above measures. It is concluded that the project is not feasible.

<Appendix－I> Members of the Study Team and Field Survey Schedule

<Appendix–I>

Members of the Study Team and Field Survey Schedule

(1) Members of the Study Team

Name			Responsible Job
(Field survey and analyses in Japan)			
Nobuo Ishii	(*1)	:	Leader
Masayuki Harayama	(*1)	:	Economic development policy and industrial development program
Yasushi Goto	(*2)	:	Agricultural economic development program
Kazuo Yamane	(*1)	:	Raw material and utilities
Miyoshi Nishimaru	(*1)	:	Market and distribution study
Makoto Natori	(*2)	:	Plant site and environmental control
Takeshi Shigeta	(*1)	:	Process design
Akira Ogi	(*1)	:	Production facility and cost estimation
Yoshitaka Imaeda	(*2)	:	Financial and economic analysis

(*1).......... First group

(*2).......... Second group

(Fermentation tests in Japan)		
Nobuo Minezaki	:	Solid culture fermentation process
Miyaji Terada	:	Submerged culture fermentation process
Shoji Usami	:	Semi-solid culture fermentation process

(Market study for neighboring countries)

R Bryan Parker

(2) Field Survey Schedule

Field survey was carried out from May 28th in 1991 to June 28th in 1991 (including traveling days) as shown below:

FIELD SURVEY SCHEDULE

DATE	PROGRESS (A group)	 (B group)	 (C group)
May 30 Thu.	Arrival to Harare (1st group: L/E/M/RM/PD/PC) by BA–053, Visit to Embassy of Japan		
31 fri.	– MFEPD and MIC (L/E/M/RM/PD/PC)		
June 1 Sat.	– University of Zimbabwe (L/E/M/RM/PD/PC)		
2 Sun.	Internal meeting		
3 Mon.	– IDC (discussions and explanation of schedule and inception report: L/E/RM/M/PD/PC) – CSO (E/M)		
4 Tue.	– Bio-mass user's network (L/RM/PD/PC) – JETRO (E/RM/PD/PC)	– Gov. Publication Office (E/M)	
5 Wed.	– Food and Industrial (L/RM/PD/PC/E/M) – Standards Association of Zimbabwe (PD/PC/M) – Stewart Scott NCL (PD/PC/M)	– ARDA (L/RM/E)	
6 Thu.	***2nd group (A/PS/F) arrival*** – Stainless Steel Ind. (RM/PD/PC) – Grain Marketing Board (L/RM)	– Schweppes Ltd. (E/M) – Gov. Publication Office (PD/PC)	– Collection of Sweet Potato (M/E)
7 Fri.	– Zimbabwe Sugar Refinery (L/RM/PC)	– Bush Boake Allen (E/M) – United Bottlers (L/M/F)	– Zimbabwe Electricity Supply Authority: ZESA (PD/PS/F) – National Food (E/PD/PC)
8 Sat.	Internal meeting	– Sweet Potato drying	
9 Sun.	Internal meeting		**Trip to Masvingo by Car** (RM/PS/A: Stay at Great Zimbabwe Hotel in Masvingo)
10 Mon.	– Dep't of Research & Specialist Services (Min. of Agriculture: L/PD/PC) – High Field Bag (L/PD/PC)	– Lever Brothers Ltd. (E/M/F) – National Planning Agency (E/M/F)	– Triangle Limited (RM/PS/A) – Hippo Valley (RM/PS/A: Stay Tambuti Lodge Hotel in Chiredzi)
11 Tue.	– Young Bamu Jennings (L/PD/PC) – P. Nueve (Architect: L/PD/PC) – Ove Arup & Partners (L/PD/PC) – ICZ (Contractor: L/PD/PC)	– Tax Dep't (F/E) – CSO (M) – Reserve Bank of Zimbabwe (E/M/F)	– Chisumbanje Agri. Develop. (RM/PS/A: Stay at same Hotel)
12 Wed.	– Al Davis (M/PD/PC) – Protea Chemical(M/PD/PC)	– CAPS (phamaceutical) (E/F) – Commercial Farmers Union (L) – IDC (F) – UNDP (E)	**Trip to Harare** (RM/PS/A)
13 Thu.	**Trip to Bulawayo** – Zimbabwe Engineering Co. ZECO (PD/PC/F) – National Railway of Zimbabwe (PD/PC/F)	– Univ. of Zimbabwe (M) – Investment Center (E)	– Zim Phos (L/RM) – Dep't of Chemistry & Soils (Min. of Agri.) (A/RM)
14 Fri.	– Arenel (PD/PC/F) – Zimbabwe Grain Bag Ltd. (PD/PC/F)	– Lyons & Brooke Bond (E) – Cairns Holding Ltd. (M) – Univ. of Zimbabwe (L/M)	– National Farmers Union (A/RM/PS) – Water Resources and Develop. (A/RM/PS)
15 Sat.	**Trip to Harare** (PD/PC/F)	– Chem System (L/M)	– Project site survey (RM/PS/A)
16 Sun.	Internal meeting		
17 Mon.	– Ove Arup & Partners (PD/PC) – Swift (transportation) (F)	– Min. of Health (PS/E) – Commercial Import Control Office	– National Farmers Union (A/RM)
18 Tue.	– Hunyani Paper & Packaging (PD/PC)	CSO (M)	– G & W (RM/A/PS) – Commercial Grain Products Association (A/RM/PS)
19 Wed.	Meeting with IDC and discussions on the Progress Report (specifically, project schemes)		
20 Thu.	Ditto	– Shipment of samples by air (QF24)	– City of Harare
21 Fri.	Ditto		
22 Sat.	Internal meeting		
23 Sun.	Internal meeting		
24 Mon.	Signing Minutes of Meeting		
25 Tue.	Visit to Embassy of Japan, Departure for Japan (ETD 2115 by BA–052)		

Note:

- L ...... Leader
- A ...... Agricultural Development Program
- M ..... Market and Distribution Study
- PD ... Process Design
- F ...... Financial and Economic Analysis
- E ...... Economic Dev. Policy
- RM .. Raw Material and Utilities
- PS .... Plant Site & Environment
- PC .... Plant Design/Cost Estimation

(3) List of Interviewees

I. Zimbabwe Side

(1) Ministry of Finance, Economic Planning and Development

– Mr. O.M. Matshalaga	Under Secretary, Domestic and International Finance
– Miss Gunduza	Acting Assistant Secretary
– Mr. Sigobodla	National Planning Agency
– Miss. E.T. Ruparanganda	Desk Officer for Japan

(2) Ministry of Industry and Commerce

– Dr. M. Nziramasanga	Secretary
– Mr. S.J. Chitanje	Under Secretary
– Mr. T. Kanyowa	Acting Under Secretary (Planning & Policy)
– Mr. J. Mafu	Chief Technical Officer
– Mr. A. Mushaninga	Administrative Officer (Technology Division)
– Mr. Chabata	Senior Administrative Officer (Food & Drink)
– Miss G. Chikodzore	

(3) Industrial Development Corporation of Zimbabwe Limited

– Mr. Ndudzo	General Manager
– Mr. L.A. Munyawarara	Deputy General Manager
– Mr. T. Sain	Legal Consultant
– Mrs. E. Ndlovu	Research Economist

(4) Central Statistical Office

– Mr. Dhlineayo
– Mr. Muzorori
– Mr. Taruvinga
– Miss. Gladys Mufakose

(5) Bio-mass User's Network

– Mr. C.E. Chimombe	Director
– Dr. Maya	Technical Manager

(6) Food and Industrial

– Mr. S.P. Kulpa	Managing Director
– Mr. P.C. Chapoterera	Production Manager
– Mr. Muchine Chigwedere	Operations Manager
– Mr. Sam Katsaruware	Wet Products Manager
– Mr. Chris Sakuringwa	Gem Products Manager
– Mr. Richard Mazhetese	Product & Development Technician

(7) Standards Association of Zimbabwe

– Mr. K. George Godwin	Assistant Director General

(8) Stewart Scott NCL

– Mr. M.F. Norman
– Mr. Hazelden

(9) Stainless Steel Industry

– Mr. Marcus Sambaza	Managing Director
– Mr. S. Gowara	Personal Assistant
– Mr. N. Adams	Production Manager

(10) Grain Marketing Board

– Mr. Reson M. Gasela	General Manager

(11) Schweppes Ltd.

– Mr. T. Hind	General Manager

(12) Zimbabwe Suger Refinery

– Dr. J.M. Tannock

(13) Bush Boake Allen

– Mr. D.L. Hatch	Managing Director

(14) United Bottlers

– Mr. Peter Karimatsenga	Production Manager

(15) Zimbabwe Electricity Supply Authority

– Mr. David D. Madzikanda	Chief Engineer

(16) National Foods Limited

– Mr. Ian F. Kind

(17) Department of Research & Specialist Services (Ministry of Agriculture)

– Mr. Lewis Machida	Maize Breeder

(18) High Field (Pvt) Bag

– Mr. S.L. Shumba	Group Project Manager
– Mr. Chris Zharare	Project Manager
– Mr. J. Chisango	Factory Manager

(19) Lever Brothers (Pvt) Ltd.

– Mr. Elloud H. Mazhawidza	Senior Supplies Manager

(20) National Planning Agency

– Mr. Vunguza R.M. Nyathi	Deputy Director
– Mr. S. Nhando	Assistant Chief Planner
– Mr. I. Zizhou	Assistant Chief Planner
– Mr. M. Chihota	Assistant Chief Planner

(21) Triangle Lilmited

– Dr. Stan Graham	Mill Manager

(22) Hippo Valley Estate Co.

– Mr. Barry R. Burbidge	General Manager
– Mr. E.K. Griffith	Technical Manager

(23) Young Bamu Jennings

– Mr. Alan Young	Managing Partner
– Mr. Philip Bamu	Partner

(24) Frank Lincoln and Peter Nueve

– Mr. Peter Naude

(25) Ove Arup & Partners

– Mr. Stuart Perry

– Mr. Jeff Casson

(26) International Construction Zimbabwe	
– Mr. K.G. Butterfield	Managing Director
(27) Tax Departmant	
– Mrs J. Banda	Senior Assessor
(28) Reserve Bank of Zimbabwe	
– Mr. Willard L. Manungo	Principal Economist
– Mr. M. Shadaya	Senior Economist
– Mr. T.Kanhema	Economist
(29) Chisumbanje Agricultural Development	
– Mr. Martin Zuirawa	Field Manager
– Mr. Bradden Ngwerume	Estate Secretary
(30) AI Davis & Co. (Pvt) Ltd.	
– Mr. William Davis	Director
(31) Protea Chemical Services (Pvt) Ltd.	
– Mr. Alex O'fee	Managing Director
(32) Central African Pharmaceutical Society (CAPS)	
– Mr. Pardie M. Moyo	Group Engineer
– Mr. Washington Mandebvu	Shipping/Purchasing Manager
– Mr. Stephen Magwenzi	R & D Pharmacist
(33) Commercial Farmers' Union of Zimbabwe	
– Mr. Anthony Swire-Thompson	Vice President
(34) UNDP	
– Mr. A. Klap	Assistant General Manager
(35) Zimbabwe Engineering Co. (ZECO)	
– Mr. Ian Drummond	Marketing Manager
(36) Zimbabwe Grain Bag (Pvt) Ltd.	
– Mr. Eugene V. Matikiti	General Manager
– Mr. Nkosana Mpofu	Technical Manager
(37) Lyons & Brooke Bond	
– Mr. Jim Clampit	Purchasing Manager
(38) Cairns Holdings Limited	
– Mr. Philip Chigumira	Technical Director
(39) National Railway of Zimbabwe	
– Mr. J.R. Mtunzie	Traffic Manager
– Mr. C. Mazzimbanuto	Planning Officer
– Mr. S. Muchena	Traffic Manager
(40) Ministry of Energy and Water Resources and Development	
– Mr. D.S. Durham	Deputy Director Planning
– Mr. Blessing Chiworeso	Water Pollution Control Officer
(41) Arenel (Pvt) Ltd.	
– Mr. Lepar	Chairman
(42) Zimbabwe Phosphate Industries	
– Mr. T.A. Mashingaidze	Technical Manager

(43) Swift

– Mr. D.L. Cruttenden — Managing Director

(44) Ministry of Health

– Mr. R. Gurajenp — Air Pollution Control Officer

– Mr. M.S. Mushambadope — Hazardous Substances Control Officer

(45) Investment Center

– Mr. R.G.M. Kahari — Economist

(46) National Farmers Association of Zimbabwe

– Mr. R.L. Gapare — President

(47) Agricultural Economist National Farmers Association of Zimbabwe

– Mr. M. Chikowore

(48) Chemistry and Soil Research Institute

– Mr. Fanuel Tagwira

(49) G & W Industrial Minerals Ltd.

– Mr. Philemon Nhachi — General Manager

(50) Commercial Grain Products Association

– Mrs. Patricia Henson — Chief Executive

(51) Hunyani Paper & Packaging Limited

– Mr. Aggripa Makadzange — Factory Manager

– Mr. Matwell D. Phakati — Sales Manager

(52) City of Harare

– Mr. Simon M. Chikwavaire — Mayor of Harare

– Mr. E.C.M. Kanengoni — Town Clerk

– Mr. T.S. Mabachi — Director of Works

(53) University of Zimbabwe

– Dr. M.A. Benhura — Chairman, Department of Biochemistry Faculty of Science

II. Japan Side

(1) Embassy of Japan

– H.E. Mr. Mitsuo Iijima — Ambassador

– Mr. Yukio Rokujo — Counselor

– Mr. Toshiaki Saito — First Secretary

(2) Japan International Cooperation Agency in Harare

– Mr. Takeshi Inada — Resident Representative

– Mr. Housui Sasaki — Coordinator

(3) JETRO

– Hironobu Kamei — Director